

NFPA® 2001

Standard on Clean Agent Fire Extinguishing Systems

2025 Edition



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NFPA® 2001

Standard on

Clean Agent Fire Extinguishing Systems

2025 Edition

This edition of NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems*, was prepared by the Technical Committee on Gaseous Fire Extinguishing Systems. It was issued by the Standards Council on November 16, 2024, with an effective date of December 6, 2024, and supersedes all previous editions.

This edition of NFPA 2001 was approved as an American National Standard on December 6, 2024.

Origin and Development of NFPA 2001

The Technical Committee on Halon Alternative Protection Options was organized in 1991 and immediately started work to address the new total flooding clean agents that were being developed to replace Halon 1301. A need existed for an explanation of how to design, install, maintain, and operate systems using these new clean agents, and NFPA 2001 was established to address that need. The 1994 edition was the first edition of NFPA 2001. The standard was revised in 1996, 2000, and 2004.

In January 2005, the technical committees responsible for NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems*; NFPA 12A, *Standard on Halon 1301 Fire Extinguishing Systems*; and NFPA 2001 were combined into the Technical Committee on Gaseous Fire Extinguishing Systems to better address and resolve issues among those documents. This action was intended to facilitate correlation and consistency as requested by the US Environmental Protection Agency.

The 2008 edition added requirements for local application systems.

The 2012 edition included a complete rewrite of Annex C. In addition, more information on the environmental impact of clean agents was added to Annex A.

The 2015 edition added new content regarding recycling and the disposal of clean agents and new system design criteria for 200 bar and 300 bar IG-01 systems. A sample system acceptance report was added to aid in conformance with commissioning practices. The committee also completed an update of all the references and reviewed the pipe design criteria against the referenced piping code. That edition also revised the requirements for cylinder location, enclosure integrity, and unoccupied spaces.

For the 2018 edition, the chapter on inspection, testing, maintenance, and training was completely reorganized to improve usability of the standard and comply with the *Manual of Style for NFPA Technical Committee Documents*. As part of this revision, the content was split into two distinct chapters: Chapter 7, Approval of Installations, and Chapter 8, Inspection, Servicing, Testing, Maintenance, and Training. Definitions of *inspection*, *maintenance*, and *service* were added, as well as a requirement for integrated fire protection and life safety systems to be tested in accordance with NFPA 4, *Standard for Integrated Fire Protection and Life Safety System Testing*. In addition, the standard required an egress time study for all clean agent systems, not just those where the design concentration is greater than the NOAEL. A definition of *abort switch* was added, and the definition of *clean agent* was revised. The requirements for pipe and fittings were reviewed and updated in accordance with the latest reference standards. In addition, a new section on pipe hangers and supports was added.

The 2022 edition incorporated several major structural changes and new chapters. Requirements were moved from Chapter 1 to a new Chapter 4 on General Requirements to comply with the NFPA *Manual of Style*. Information on Toxicological and Physiological Effects of Clean Agents was moved from Annex A to a new, standalone annex. The system design requirements pertaining only to total flooding systems were moved from the system design chapter to a new, standalone chapter, similar to

the local application systems chapter, to identify which requirements apply more clearly to both types of systems. The requirements for detection, actuation, alarm, and control systems were moved from the components chapter to a new, standalone chapter to better address the systematic nature of these requirements. A new chapter on impairment was also added. In addition, a new annex on storage containers for vaporizing-liquid agents is added.

Several technical updates were also included in this edition, including design criteria for a new clean agent (Halocarbon Blend 55, or HB-55) and 60-bar FK-5-1-12 systems. This edition also clarified terminology and requirements for clean agent design concentrations, added a new definition of deep-seated fire, added new information on clean agent purity and the potential toxicity of impurities, updated pressure curves for HFC-125, and updated total flooding quantity tables for inert gas agents. In addition, requirements were added for designers to consider the potential effects of acoustic noise produced by the clean agent system where noise-sensitive equipment is present.

For the 2025 edition, clarification has been provided for when time delay is to be utilized.

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

Chapter 1 Administration

1.1* Scope.

1.1.1* This standard contains minimum requirements for the design, installation, approval, and maintenance of total-flooding and local-application fire-extinguishing systems that use one of the gaseous agents in Table 1.1.1.

1.1.2 The scope of this standard does not include fire-extinguishing systems that use carbon dioxide or water as the primary extinguishing media, which are addressed by other NFPA documents.

1.2* Purpose. This standard is prepared for use by and guidance of those charged with purchasing, designing, installing, testing, inspecting, approving, listing, operating, and maintaining engineered or pre-engineered clean agent extinguishing systems.

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 maintenance requirements of Chapter 4 through Chapter 8 and Chapter 10 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 9 shall apply to new and existing facilities, equipment, structures, or installations.

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

1.3.4 Requirements that are retroactively applied in accordance with this standard shall be permitted to be modified if both of the following conditions are met in the judgment of the authority having jurisdiction:

- (1) Application of the original, full requirement would be impractical.
- (2) An equivalent level of safety is provided by the modified requirement.

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.

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

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

1.5.2.3 Where text extracted from a source document contains values expressed in only one system of units, the values in the extracted text have been retained without conversion.

1.5.3 Measurements 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.

Table 1.1.1 Agents Addressed in NFPA 2001

Agent Designation	Chemical Name	Chemistry
FK-5-1-12	Dodecafluoro-2-methylpentan-3-one	$\text{CF}_3\text{CF}_2\text{C}(\text{O})\text{CF}(\text{CF}_3)_2$
HCFC Blend A	Dichlorotrifluoroethane HCFC-123 (4.75%)	CHCl_2CF_3
	Chlorodifluoromethane HCFC-22 (82%)	CHClF_2
	Chlorotetrafluoroethane HCFC-124 (9.5%)	$\text{CHClF}_2\text{CF}_3$
	Isopropenyl-1-methylcyclohexene (3.75%)	
HCFC-124	Chlorotetrafluoroethane	$\text{CHClF}_2\text{CF}_3$
HFC-125	Pentafluoroethane	CHF_2CF_3
HFC-227ea	Heptafluoropropane	$\text{CF}_3\text{CHF}_2\text{CF}_3$
HFC-23	Trifluoromethane	CHF_3
HFC-236fa	Hexafluoropropane	$\text{CF}_3\text{CH}_2\text{CF}_3$
FIC-131I	Trifluoroiodide	CF_3I
IG-01	Argon	Ar
IG-100	Nitrogen	N_2
IG-541	Nitrogen (52%)	N_2
	Argon (40%)	Ar
	Carbon dioxide (8%)	CO_2
	Nitrogen (50%)	N_2
IG-55	Argon (50%)	Ar
	Tetrafluoroethane (86%)	CH_2FCF_3
	Pentafluoroethane (9%)	CHF_2CF_3
HFC Blend B	Carbon dioxide (5%)	CO_2
	Trans-1-Chloro-3,3,3-trifluoropropene (50%)	$\text{CF}_3\text{-CH=CHCl}$
Halocarbon Blend 55 (HB-55)	Dodecafluoro-2-methylpentan-3-one (50%)	$\text{CF}_3\text{CF}_2\text{C}(\text{O})\text{CF}(\text{CF}_3)_2$

Notes:

(1) Other agents could become available at later dates. Such agents could be added via the NFPA process in future editions or by amendments to the standard.

(2) Composition of inert gas agents is given in percent by volume. Compositions of halocarbon blends are given in percent by weight.

(3) The full analogous ASHRAE nomenclature for FK-5-1-12 is FK-5-1-12mm².

Table 1.5.2.2 Metric Conversion Factors

Name of Unit	Unit Symbol	Conversion Factor
millimeter	mm	1 in. = 25.4 mm
liter	L	1 gal = 3.785 L
cubic meter	m ³	1 ft ³ = 0.028317 m ³
kilogram	kg	1 lb = 0.4536 kg
kilograms per cubic meter	kg/m ³	1 lb/ft ³ = 16.0185 kg/m ³
pascal	Pa	1 psi = 6895 Pa
bar	bar	1 psi = 0.0689 bar
bar	bar	1 bar = 10 ⁵ Pa

Notes:

For additional conversions and information, see [IEEE/ASTM SI10](#), *American National Standard for Metric Practice*.

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 4, *Standard for Integrated Fire Protection and Life Safety System Testing*, 2024 edition.

NFPA 70®, *National Electrical Code*®, 2023 edition.

NFPA 72®, *National Fire Alarm and Signaling Code*®, 2025 edition.

2.3 Other Publications.

2.3.1 ANSI Publications. American National Standards Institute, Inc., 1180 Avenue of the Americas, 10th Floor, New York, NY 10036.

ANSI Z535.2, *Standard for Environmental and Facility Safety Signs*, 2023.

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

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

ASME B31.1, *Power Piping Code*, 2022.

Boiler and Pressure Vessel Code, 2023.

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

ASTM A120-84, *Specification for Pipe, Steel, Black and Hot-Dipped (Galvanized) Welded and Seamless for Ordinary Uses*, 1984 (withdrawn 1987).

IEEE/ASTM SI10, *American National Standard for Metric Practice*, 2016.

2.3.4 CGA Publications. Compressed Gas Association, 8484 Westpark Drive, Suite 220, McLean, VA 22102.

CGA C-6, *Standard for Visual Inspection of Steel Compressed Gas Cylinders*, 2022.

2.3.5 IEEE Publications. IEEE Operations Center, 445 Hoes Lane, Piscataway, NJ 08854-4141.

IEEE C2, *National Electrical Safety Code*, 2022.

2.3.6 IMO Publications. International Maritime Organization, 4 Albert Embankment, London, SE1 7SR, United Kingdom.

IMO MSC/Circ. 848, *Revised Guidelines for the Approval of Equivalent Fixed Gas Fire-Extinguishing Systems as Referred to in SOLAS 74, for Machinery Spaces and Cargo Pump-Rooms*, 1998.

IMO MSC.1/Circ. 1267, *Amendments to Revised Guidelines for the Approval of Equivalent Fixed Gas Fire-Extinguishing Systems, as Referred to in SOLAS 74, for Machinery Spaces and Cargo Pump-Rooms (MSC/Circ.848)*, 2008.

2.3.7 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 Designation*, 1994 (R2020).

2.3.8 TC Publications. Transport Canada, 330 Sparks Street, Ottawa, ON K1A 0N5, Canada.

TP 127 E, *Ship Safety Electrical Standards*, 2018.

2.3.9 UL Publications. Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062-2096.

ANSI/CAN/UL/ULC 2127, *Inert Gas Clean Agent Extinguishing System Units*, 2024.

ANSI/CAN/UL/ULC 2166, *Halocarbon Clean Agent Extinguishing System Units*, 2017 (R2021).

2.3.10 US Government Publications. US Government Publishing Office, 732 North Capitol Street, NW, Washington, DC 20401.

OSHA, Title 29, Code of Federal Regulations, Part 1910, Subpart S, “Electrical.”

US Coast Guard, Title 46, Code of Federal Regulations, Part 72, “Construction and Arrangement.”

US Coast Guard, Title 46, Code of Federal Regulations, Subchapter J, “Electrical Engineering.”

DOT Title 49, Code of Federal Regulations, Parts 170–190, “Transportation.”

2.3.11 Other Publications.

Merriam-Webster’s Collegiate Dictionary, 11th edition, Merriam-Webster, Inc., Springfield, MA, 2020.

2.4 References for Extracts in Mandatory Sections.

NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems*, 2025 edition.

Chapter 3 Definitions

3.1 General.

3.1.1 The definitions contained in this chapter shall apply to the terms used in this standard.

3.1.2 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.

3.1.3 *Merriam-Webster’s Collegiate Dictionary*, 11th edition, shall be the source for the ordinarily accepted meaning.

3.2 NFPA Official Definitions.

3.2.1* Approved. Acceptable to the authority having jurisdiction.

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

3.2.3* Listed. Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of

production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or service meets appropriate designated standards or has been tested and found suitable for a specified purpose.

3.2.4 Shall. Indicates a mandatory requirement.

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

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

3.3 General Definitions.

3.3.1* Abort Switch. A system control that, when operated during the releasing panel’s release delay countdown, extends the delay in accordance with a predetermined effect.

3.3.2 Adjusted Minimum Design Quantity (AMDQ). The minimum design quantity of agent that has been adjusted in consideration of design factors.

3.3.3 Agent Concentration. The portion of agent in an agent-air mixture expressed in volume percent.

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

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

3.3.6 Class C Fire. A fire that involves energized electrical equipment.

3.3.7* Clean Agent. Volatile or gaseous fire extinguishant that is electrically nonconducting and that does not leave a residue upon evaporation.

3.3.8 Clearance. The air distance between extinguishing system equipment, including piping and nozzles, and unenclosed or uninsulated live electrical components not at ground potential.

3.3.9 Control Room and Electronic Equipment Space. A space containing electronic or electrical equipment, such as that found in control rooms or electronic equipment rooms, where only Class A surface fires or Class C electrical hazards are present.

3.3.10* Deep-Seated Fire. Combustion that occurs within a fuel mass and has restricted access to ambient air where the configuration of the fuel restricts heat flow from the combustion zone to the surroundings.

3.3.11 Design Concentration.

3.3.11.1* Final Design Concentration (FDC). The actual concentration of agent discharged into the enclosure.

3.3.11.2 Inerting Concentration. The agent concentration at which an atmosphere containing a stoichiometric mixture of air and fuel is rendered nonflammable.

3.3.11.3* Minimum Design Concentration (MDC). The target agent concentration determined by applying a safety factor to the minimum extinguishing concentration or inerting concentration for the hazard(s) to be protected.

3.3.11.4* Minimum Extinguishing Concentration (MEC). The agent concentration at which extinguishment is achieved for a given fuel, as determined in accordance with 7.2.2.1.1, 7.2.2.2.1, or 7.2.2.4 for Class A, Class B, or Class C fires, respectively.

3.3.12 Design Factor (DF). A fraction of the agent minimum design quantity (MDQ) added thereto deemed appropriate due to a specific feature of the protection application or design of the suppression system.

3.3.13 Discharge Time. The time required to discharge from the nozzles 95 percent of the agent mass [at 70°F (21°C)] necessary to achieve the minimum design concentration based on a 20 percent safety factor for flame extinguishment.

3.3.14 Engineered System. A system requiring individual calculation and design to determine the flow rates, nozzle pressures, pipe size, area or volume protected by each nozzle, quantity of agent, and the number and types of nozzles and their placement in a specific system.

N 3.3.15 Extended Discharge. A continued discharge of clean agent provided in order to maintain the design concentration over a specified period of time after the completion of the initial discharge.

3.3.16 Fill Density. Mass of agent per unit of container volume (the customary units are lb/ft³ or kg/m³).

3.3.17 Final Design Quantity (FDQ). The quantity of agent determined from the agent minimum design quantity as adjusted to account for design factors and pressure adjustment.

3.3.18* Halocarbon Agent. An agent that contains as primary components one or more organic compounds containing one or more of the elements fluorine, chlorine, bromine, or iodine.

3.3.19* 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.

3.3.19.1 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.

3.3.19.2 Preplanned Impairment. A condition where a fire protection system or a portion thereof is out of service due to work planned in advance.

3.3.20 Inert Gas Agent. An agent that contains one or more of the following gases as components: helium, neon, argon, or nitrogen, and that can also contain carbon dioxide as a minor component.

3.3.21 Initial Discharge. The discharge of clean agent for the purpose of achieving design concentration.

3.3.22 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.

3.3.23 Local Application System. A system consisting of a supply of extinguishing agent arranged to discharge directly on the burning material. [12, 2025]

3.3.24 Lockout Valve. A manually operated valve in the discharge pipe between the nozzles and the agent supply that can be locked in the closed position to prevent flow of agent to the protected area.

3.3.25 Lowest Observable Adverse Effect Level (LOAEL). The lowest concentration at which an adverse physiological or toxicological effect has been observed.

3.3.26 Machinery Space. A space containing the main and auxiliary propulsion machinery.

3.3.27 Maintenance. Work performed to ensure that the equipment operates as directed by the manufacturer.

3.3.28 Manual Release. A manually operated initiating device used to initiate release of fire suppression agent.

3.3.28.1 Electrical Manual Release. A manual release that is electrically monitored and supervised by a releasing service fire alarm control unit and that, when activated, results in electrical actuation of the fire extinguishing system.

3.3.28.2 Mechanical Manual Release. A manual release connected directly or pneumatically to the actuating valve.

3.3.29 Marine Systems. Systems installed on ships, barges, offshore platforms, motorboats, and pleasure craft.

3.3.30 Minimum Design Quantity (MDQ). The quantity of agent required to achieve the minimum design concentration as calculated using the method in 7.3.1 or 7.3.2, as appropriate.

3.3.31 Minimum Design Temperature. The minimum anticipated temperature within the protected enclosure.

3.3.32 No Observed Adverse Effect Level (NOAEL). The highest concentration at which no adverse physiological or toxicological effect has been observed.

3.3.33* Normally Occupied Enclosure or Space. An enclosure or space where one or more persons are present under normal conditions.

3.3.34 Normally Unoccupied Enclosure or Space. An enclosure or space not normally occupied but one that could be entered occasionally by one or more persons for brief periods.

3.3.35 Occupiable Enclosure or Space. An enclosure or space that has dimensions and physical characteristics such that it could be entered by a person.

3.3.36 Pre-engineered System. A system having predetermined flow rates, nozzle pressures, and quantities of agent. These systems have the specific pipe size, maximum and minimum pipe lengths, flexible hose specifications, number of fittings, and number and types of nozzles prescribed by a testing laboratory. The hazards protected by these systems are specifically limited as to type and size by a testing laboratory based upon actual fire tests. Limitations on hazards that can be

protected by these systems are contained in the manufacturer's installation manual, which is referenced as part of the listing.

3.3.37 Pump Room. A space that contains mechanical equipment for handling, pumping, or transferring flammable or combustible liquids as a fuel.

3.3.38 Recovered Agent. Agent that has been removed from a system and kept for future use or until it is destroyed, without necessarily testing or processing it in any way.

3.3.39 Recycled Agent. Agent that has been recovered, tested, and processed as necessary and found to be in compliance with the quality requirement of 5.1.2.

3.3.40 Safety Factor (SF). A multiplier of the minimum extinguishing concentration or inerting concentration to determine the agent minimum design concentration.

3.3.41 Sea Level Equivalent of Agent. The agent concentration (volume percent) at sea level for which the partial pressure of agent matches the ambient partial pressure of agent at a given altitude.

3.3.42 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.

3.3.43 Service. Performance of maintenance, recharge, or testing.

3.3.44 Superpressurization. The addition of gas to a fire extinguishing agent container to achieve a specified pressure therein.

3.3.45 Total Flooding. The act and manner of discharging an agent for the purpose of achieving a specified minimum agent concentration throughout a hazard volume.

3.3.46 Total Flooding System. A system consisting of an agent supply and distribution network designed to achieve a total flooding condition in a hazard volume.

3.3.47 Unoccupiable Enclosure or Space. An enclosure or space that has dimensions and physical characteristics such that it could not be entered by a person.

Chapter 4 General Requirements

4.1 Personnel Qualifications and Training. The design, installation, service, and maintenance of clean agent systems shall be performed by those skilled in clean agent fire-extinguishing-system technology.

4.1.1 Persons who inspect, test, maintain, or operate fire-extinguishing systems shall be trained in all aspects of safety related to the systems.

4.1.2 Persons who inspect, test, maintain, or service clean agent systems shall be qualified and trained in accordance with 11.1.2.

4.2* Use and Limitations of Clean Agent Systems.

4.2.1 Pre-engineered Systems. All pre-engineered systems shall be installed to protect hazards within the limitations that have been established by the listing.

4.2.1.1 Pre-engineered systems shall be listed to one of the following types:

- (1) Those consisting of system components designed to be installed according to pre-tested limitations by a testing laboratory.
- (2) Automatic extinguishing units incorporating special nozzles, flow rates, methods of application, nozzle placement, actuation techniques, piping materials, discharge times, mounting techniques, and pressurization levels that could differ from those detailed elsewhere in this standard.

Δ 4.2.1.2 Pre-engineered systems of the type described in 4.2.1.1(1) shall be permitted to incorporate special nozzles, flow rates, methods of application, nozzle placement, and pressurization levels that could differ from those detailed elsewhere in this standard.

Δ 4.2.1.3 Pre-engineered systems of the type described in 4.2.1.1(1) and having a special arrangement in accordance with 4.2.1.2 shall comply with all other requirements of this standard.

4.2.2 Incompatible Hazards. Clean agents shall not be used on fires involving the following materials unless the agents have 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) Reactive metals such as lithium, sodium, potassium, magnesium, titanium, zirconium, uranium, and plutonium
- (3) Metal hydrides
- (4) Chemicals capable of undergoing autothermal decomposition, such as certain organic peroxides, pyrophoric materials, and hydrazine

4.2.3* High-Temperature Applications. The effects of agent decomposition on fire protection effectiveness and equipment shall be considered where clean agents are used in hazards with high temperatures (e.g., furnaces and ovens).

4.2.4* Potential Effects of Acoustical Noise. The potential effects of acoustical noise produced by activation of a clean agent fire-extinguishing system shall be considered where such systems are used in an occupancy containing noise-sensitive equipment.

4.3* Hazards to Personnel.

4.3.1* Clean Agent Evaluation. Any agent that is to be recognized by this standard or proposed for inclusion in this standard shall first be evaluated in a manner equivalent to the process used by the US Environmental Protection Agency (EPA) Significant New Alternatives Policy (SNAP) Program for total flooding agents.

4.3.2* Exposure to Halocarbon Agents. Unnecessary exposure to halocarbon clean agents — including exposure at and below the no observable adverse effects level (NOAEL) — and halocarbon decomposition products shall be avoided.

4.3.2.1 Means shall be provided to limit exposure to halocarbon agents to no longer than 5 minutes.

4.3.2.2 Unprotected personnel shall not enter a protected space during or after agent discharge.

N 4.3.2.3 A pre-discharge alarm and time delay shall be provided in accordance with the provisions of Section 9.7 of this standard.

Δ 4.3.2.4* The following additional provisions shall apply:

- (1) Halocarbon systems for spaces that are normally occupied and designed to concentrations up to the NOAEL [see Table 4.3.2.4(a)] shall be permitted.
- (2) Halocarbon systems for spaces that are normally occupied and designed to concentrations above the NOAEL [see Table 4.3.2.4(a)] shall be permitted if means are provided to limit exposure to the design concentrations shown in Table 4.3.2.4(b) through Table 4.3.2.4(e) that correspond to an allowable human exposure time of 5 minutes.
- (3) Higher design concentrations associated with human exposure times less than 5 minutes as shown in Table 4.3.2.4(b) through Table 4.3.2.4(e) shall not be permitted in normally occupied spaces.
- (4) In spaces that are not normally occupied and that are protected by a halocarbon system designed to concentrations above the lowest observable adverse effects level (LOAEL) [see Table 4.3.2.4(a)] and where personnel could possibly be exposed, means shall be provided to limit exposure times using Table 4.3.2.4(b) through Table 4.3.2.4(e).
- (5) In spaces that are not normally occupied and in the absence of the information needed to fulfill the conditions in 4.3.2.4(4), the following provisions shall apply:
 - (a) Where egress takes longer than 30 seconds but less than 1 minute, the halocarbon agent shall not be used in a concentration exceeding its LOAEL.
 - (b) Concentrations exceeding the LOAEL shall be permitted provided that any personnel in the area can escape within 30 seconds.

Table 4.3.2.4(a) Information for Halocarbon Clean Agents

Agent	NOAEL (vol %)	LOAEL (vol %)
FK-5-1-12	10.0	>10.0
HCFC Blend A	10.0	>10.0
HCFC-124	1.0	2.5
HFC-125	7.5	10.0
HFC-227ea	9.0	10.5
HFC-23	30	>30
HFC-236fa	10	15
HFC Blend B*	5.0*	7.5*
HB-55	8.7%	>8.7%

*These values are for the largest component of the blend (HFC 134A).

Table 4.3.2.4(b) Time for Safe Human Exposure at Stated Concentrations for HFC-125

HFC-125 Concentration		Maximum Permitted Human Exposure Time (min)
vol %	ppm	
7.5	75,000	5.00
8.0	80,000	5.00
8.5	85,000	5.00
9.0	90,000	5.00
9.5	95,000	5.00
10.0	100,000	5.00

(continues)

Table 4.3.2.4(b) *Continued*

HFC-125 Concentration		Maximum Permitted Human Exposure Time (min)
vol %	ppm	
10.5	105,000	5.00
11.0	110,000	5.00
11.5	115,000	5.00
12.0	120,000	1.67
12.5	125,000	0.59
13.0	130,000	0.54
13.5	135,000	0.49

Notes:

(1) Data derived from the EPA-approved and peer-reviewed physiologically based pharmacokinetic (PBPK) model or its equivalent.

(2) Based on LOAEL of 10.0 percent in dogs.

Table 4.3.2.4(c) Time for Safe Human Exposure at Stated Concentrations for HFC-227ea

HFC-227ea Concentration		Maximum Permitted Human Exposure Time (min)
vol %	ppm	
9.0	90,000	5.00
9.5	95,000	5.00
10.0	100,000	5.00
10.5	105,000	5.00
11.0	110,000	1.13
11.5	115,000	0.60
12.0	120,000	0.49

Notes:

(1) Data derived from the EPA-approved and peer-reviewed PBPK model or its equivalent.

(2) Based on LOAEL of 10.5 percent in dogs.

Table 4.3.2.4(d) Time for Safe Human Exposure at Stated Concentrations for HFC-236fa

HFC-236fa Concentration		Maximum Permitted Human Exposure Time (min)
vol %	ppm	
10.0	100,000	5.00
10.5	105,000	5.00
11.0	110,000	5.00
11.5	115,000	5.00
12.0	120,000	5.00
12.5	125,000	5.00
13.0	130,000	1.65
13.5	135,000	0.92
14.0	140,000	0.79
14.5	145,000	0.64
15.0	150,000	0.49

Notes:

(1) Data derived from the EPA-approved and peer-reviewed PBPK model or its equivalent.

(2) Based on LOAEL of 15.0 percent in dogs.

Table 4.3.2.4(e) Time for Safe Human Exposure at Stated Concentrations for FIC-131I

FIC-131I Concentration		Maximum Permitted Human Exposure Time (min)
vol %	ppm	
0.20	2000	5.00
0.25	2500	5.00
0.30	3000	5.00
0.35	3500	4.30
0.40	4000	0.85
0.45	4500	0.49
0.50	5000	0.35

Notes:

(1) Data derived from the EPA-approved and peer-reviewed PBPK model or its equivalent.

(2) Based on LOAEL of 0.4 percent in dogs.

4.3.3* Exposure to Inert Gas Agents. Unnecessary personnel exposure to low-oxygen atmospheres resulting from discharge of inert gas agent systems shall be avoided.

4.3.3.1 Means shall be provided to limit personnel exposure to low-oxygen atmospheres to no longer than 5 minutes.

4.3.3.2 The atmospheric correction factors specified in Table 7.3.3.3 shall be considered when determining the inert gas design concentrations.

4.3.3.3* A pre-discharge alarm and time delay shall be provided in accordance with the provisions of Section 9.7 of this standard.

4.3.3.4 Personnel without proper personal protective equipment shall not enter the protected space during agent discharge or after agent discharge while a low-oxygen atmosphere still exists.

4.3.3.5 The following additional provisions shall apply:

- (1) Inert gas systems designed to concentrations below 43 percent (corresponding to an oxygen concentration of 12 percent, sea level equivalent of oxygen) shall be permitted where means are provided to limit personnel exposure to no longer than 5 minutes.
- (2) Inert gas systems designed to concentrations between 43 and 52 percent (corresponding to between 12 and 10 percent oxygen, sea level equivalent of oxygen) shall be permitted where means are provided to limit personnel exposure to no longer than 3 minutes.
- (3) Inert gas systems designed to concentrations between 52 and 62 percent (corresponding to between 10 and 8 percent oxygen, sea level equivalent of oxygen) shall be permitted given the following:
 - (a) The space is normally unoccupied.
 - (b) Where personnel could possibly be exposed, means are provided to limit the exposure to less than 30 seconds.
- (4) Inert gas systems designed to concentrations above 62 percent (corresponding to 8 percent oxygen or below, sea level equivalent of oxygen) shall be used only in unoccupied areas where personnel are not exposed to such oxygen depletion.

4.3.4* Egress Time Study. An egress time study shall be performed to verify that the maximum exposure time limits in 4.3.2 and 4.3.3 are achieved.

4.3.5* Safeguards. Suitable safeguards shall be provided to ensure prompt evacuation of, and prevent entry into, hazardous atmospheres and to provide means for prompt rescue of any trapped personnel.

4.3.6* Adjacent Areas. Consideration shall be given to the possibility of a clean agent migrating to adjacent areas outside of the protected space.

4.3.7* Occupiable Spaces. Systems protecting occupiable spaces where the clean agent design concentration and egress time exceeds the design concentration and corresponding egress time approved for use in normally occupied spaces in accordance with 4.3.2 for halocarbon agents or 4.3.3 for inert gas agents shall include the following:

- (1) Supervised system lockout valves
- (2) Pneumatic pre-discharge alarms
- (3) Pneumatic time delays
- (4) Warning signs

4.3.7.1* Pneumatic pre-discharge alarms shall be operated by an inert gas.

4.3.7.2 For an inert gas clean agent fire-extinguishing system, the quantity of inert gas discharged to operate a pneumatic pre-discharge alarm discharging into the protected space shall be considered, together with the quantity of agent discharged, when making a determination of post-discharge oxygen concentration with respect to compliance with the requirements of 4.3.3.

4.3.8 Warning Signs. Warning and instruction signs shall be provided at the following locations:

- (1) Entrances to protected areas
- (2) Inside protected areas
- (3) Outside each entrance to cylinder storage rooms

4.3.8.1 Warning and safety instruction signs shall be located such that they will be visible to personnel in the area.

4.3.8.2 The safety sign format and color and the letter style of the signal words shall be in accordance with ANSI Z535.2, *Standard for Environmental and Facility Safety Signs*.

4.4 System Technician Safety.

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

- (1) Anti-recoil devices shall be installed on cylinder outlets whenever the cylinder outlets are not connected to the system pipe inlet.
- (2) Cylinder caps, where applicable, and anti-recoil devices shall be installed before removing cylinders from the retaining devices.
- (3) Actuators shall be disabled or removed before cylinders are removed from retaining devices.

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

4.4.2.1 Equipment designed for transporting cylinders shall be used.

4.4.2.2 Where dollies or carts are used, cylinders shall be secured.

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

4.5 Electrical Clearances.

4.5.1 All system components shall be located to maintain no less than minimum clearances from energized electrical parts.

▲ **4.5.2** The following references shall be considered as the minimum electrical clearance requirements for the installation of clean agent systems:

- (1) IEEE C2, *National Electrical Safety Code*
- (2) NFPA 70
- (3) 29 CFR 1910, Subpart S, "Electrical"

4.5.3 Where the design basic insulation level (BIL) is not available and where nominal voltage is used for the design criteria, the highest minimum clearance for this group shall be used.

4.5.4 The selected clearance to ground shall satisfy the greater of the switching surge or BIL duty, rather than being based on nominal voltage.

4.5.5* The clearance between uninsulated, energized parts of the electrical system equipment and any portion of the clean agent system shall not be less than the minimum clearance provided elsewhere for electrical system insulation on any individual component.

4.5.6 Where BIL is not available and where nominal voltage is used for the design criteria, the highest minimum clearance for this group shall be used.

4.6* Environmental Factors. Selection of the appropriate fire suppression agent shall include consideration of the following items:

- (1) Potential environmental effect of a fire in the protected area
- (2) Potential environmental impacts, including, but not limited to, ozone depletion potential (ODP) and global warming potential (GWP) of the clean agents that could be used

4.7 Retrofit. Retrofit of any clean agent into an existing fire-extinguishing system shall result in a system that is listed or approved.

4.8 Compatibility with Other Agents.

4.8.1* Mixing of agents in the same container shall be permitted only if the system is listed.

4.8.2 Systems employing the simultaneous discharge of different agents to protect the same enclosed space shall not be permitted.

Chapter 5 Components

5.1 Agent Supply.

5.1.1 Quantity.

5.1.1.1 Primary Agent Supply. The quantity of agent in the system primary agent supply shall be at least sufficient for the largest single hazard to be protected or group of hazards to be protected simultaneously.

5.1.1.2* Reserve Agent Supply. Where required, a reserve agent supply shall consist of as many multiples of the primary agent supply as the authority having jurisdiction considers necessary.

5.1.1.3 Uninterrupted Protection. Where uninterrupted protection is required, both the primary and the reserve agent supplies shall be permanently connected to the distribution piping and arranged for easy changeover.

5.1.2* Quality. Agent, including recycled agent, shall meet the standards of quality given in Table 5.1.2(a) through Table 5.1.2(e).

Table 5.1.2(a) Halogenated Agent Quality Requirements

Property	Specification
Agent purity, mole %, minimum	99.0
Acidity, ppm (by weight HCl equivalent), maximum	3.0
Water content, weight %, maximum	0.001
Nonvolatile residues, g/100 ml maximum	0.05

Table 5.1.2(b) Inert Gas Agent Quality Requirements

Composition	Gas	IG-01	IG-100	IG-541	IG-55
Composition, % by volume	N ₂	Minimum	99.9%	52% ± 4%	50% ± 5%
	Ar	Minimum	99.9%	40% ± 4%	50% ± 5%
	CO ₂			8% + 1% - 0.0%	
Water content, % by weight		Maximum	Maximum	Maximum	Maximum
		0.005%	0.005%	0.005%	0.005%

Table 5.1.2(c) HCFC Blend A Quality Requirements

Component	Amount (weight %)
HCFC-22	82% ± 0.8%
HCFC-124	9.50% ± 0.9%
HCFC-123	4.75% ± 0.5%
Isopropenyl-1-methylcyclohexene	3.75% ± 0.5%

Table 5.1.2(d) HFC Blend B Quality Requirements

Component	Amount (weight %)
HFC-134a	86% ± 5%
HFC-125	9% ± 3%
CO ₂	5% ± 2%

Table 5.1.2(e) HB-55 Quality Requirements

Component	Amount (weight %)
HFO-1233zd	50% ± 3%
FK-5-1-12	50% ± 3%

5.1.2.1 Each batch of agent, both recycled and newly manufactured, shall be tested and certified to the specifications given in the tables.

5.1.2.2 Agent blends shall remain homogeneous in storage and use within the listed temperature range and conditions of service that they will encounter.

5.1.2.3* Upper limit threshold concentrations shall be established for any impurity that could result in acute toxicity at concentrations below the cardiac sensitization NOAEL.

5.1.2.4 The upper limit threshold concentrations of impurity, determined in accordance with 5.1.2.3, shall not be exceeded in the agent.

5.1.3 Storage Container Arrangement.

5.1.3.1 Storage containers and accessories shall be located and arranged so that inspection, testing, recharging, and other maintenance activities are facilitated and interruption of protection is held to a minimum.

5.1.3.2* Storage containers shall be permitted to be located within or outside the hazard or hazards they protect.

5.1.3.3 Agent storage containers shall not be located where they can be rendered inoperable or unreliable due to mechanical damage, exposure to chemicals or harsh weather conditions, or any other foreseeable cause. Where container exposure to such conditions is unavoidable, suitable enclosures or protective measures shall be employed.

5.1.3.4 Storage containers shall be installed and secured according to the manufacturer's listed installation manual and in a manner that provides for convenient individual servicing or content weighing.

5.1.3.5 Where storage containers are connected to a manifold, automatic means, such as a check valve, shall be provided to prevent agent loss and to ensure personnel safety if the system is operated when any containers are removed for maintenance.

5.1.4 Agent Storage Containers.

5.1.4.1* Agent shall be stored in containers designed to hold that specific agent at ambient temperatures.

5.1.4.1.1 Inert gas agent containers shall be charged to the pressure, corrected for temperature, specified in the manufacturer's listed manual.

5.1.4.1.2 Halocarbon agent containers shall be charged to a fill density and superpressurization level, corrected for temperature, within the range specified in the manufacturer's listed manual. (See Annex F.)

5.1.4.2* Each agent container shall have a permanent nameplate or other permanent marking that indicates the following:

- (1) For halocarbon agent containers, the agent, tare and gross weights, and superpressurization level (where applicable) of the container
- (2) For inert gas agent containers, the agent, pressurization level of the container, and nominal agent volume

5.1.4.3 The containers used in these systems shall be designed to meet the requirements of the US Department of Transportation or the Canadian Transport Commission, if used as shipping containers. If not shipping containers, they shall be designed, fabricated, inspected, certified, and stamped in

accordance with Section VIII of the ASME *Boiler and Pressure Vessel Code*; independent inspection and certification are recommended. The design pressure shall be suitable for the maximum pressure developed at 130°F (55°C) or at the maximum controlled temperature limit.

5.1.4.4 A means shall be provided to determine the pressure in containers of inert gas agents, superpressurized liquid agents, and superpressurized liquefied compressed gas agents.

5.1.4.5* Where a liquid-level indicator (LLI) is provided as a component of the container assembly, the LLI and method of measuring the agent quantity shall be listed.

5.1.4.6 The containers connected to a manifold shall meet the following criteria:

- (1) For halocarbon clean agents in a multiple container system, all containers supplying the same manifold outlet for distribution of the same agent shall be interchangeable and of one select size and charge.
- (2)* Inert gas agents shall be permitted to utilize multiple storage container sizes connected to a common manifold.

5.1.4.7* The temperature at which agent containers are stored shall be within the manufacturer's listed limits.

5.2 Distribution.

5.2.1* Pipe.

5.2.1.1* Pipe shall be of material having physical and chemical characteristics such that its integrity under stress can be predicted with reliability. Special corrosion-resistant materials or coatings shall be required in severely corrosive atmospheres. The thickness of the piping shall be calculated in accordance with ASME B31.1, *Power Piping Code*. The internal pressure used for this calculation shall not be less than the greater of the following values:

- (1) The normal charging pressure in the agent container at 70°F (21°C)
- (2) Eighty percent of the maximum pressure in the agent container at a maximum storage temperature of not less

than 130°F (55°C), using the equipment manufacturer's maximum allowable fill density, if applicable

- (3) For inert gas clean agents, the pressure for this calculation shall be as specified in 5.2.1.1.1 and 5.2.1.1.2

5.2.1.1.1 In no case shall the value used for the minimum pipe design pressure be less than that specified in Table 5.2.1.1.1(a) and Table 5.2.1.1.1(b) for the conditions shown.

5.2.1.1.1.1 For inert gas clean agents that employ the use of a pressure-reducing device, both of the following shall apply:

- (1) Table 5.2.1.1.1(a) shall be used for piping upstream of the pressure reducer.
- (2) Subparagraph 5.2.1.1.2 shall be used to determine minimum pipe design pressure for piping downstream of the pressure reducer.

5.2.1.1.1.2 For halocarbon clean agents, Table 5.2.1.1.1(b) shall be used.

5.2.1.1.1.3 If different fill densities, pressurization levels, or higher storage temperatures from those shown in Table 5.2.1.1.1(a) or Table 5.2.1.1.1(b) are approved for a given system, the minimum design pressure for the piping shall be adjusted to the maximum pressure in the agent container at maximum temperature, using the basic design criteria specified in 5.2.1.1(1) and 5.2.1.1(2).

5.2.1.1.2 For systems that employ the use of a pressure-reducing device, the minimum design pressure for piping downstream of the pressure-reducing device shall be determined from the maximum anticipated pressure in the downstream piping as predicted by system flow calculations.

5.2.1.1.3 Piping for pre-engineered systems shall be designed in accordance with the limitations of the manufacturer's listed installation manual.

5.2.1.2 Other than as allowed in 5.2.1.4, cast-iron pipe, steel pipe conforming to ASTM A120-84, *Specification for Pipe, Steel, Black and Hot-Dipped (Galvanized) Welded and Seamless for Ordinary Uses*, or nonmetallic pipe shall not be used.

Table 5.2.1.1.1(a) Minimum Design Working Pressure for Inert Gas Clean Agent System Piping

Agent	Agent Container Gauge Pressure at 70°F (21°C)		Agent Container Gauge Pressure at 130°F (55°C)		Minimum Design Pressure of Piping Upstream of Pressure Reducer	
	psi	kPa	psi	kPa	psi	kPa
IG-01	2370	16,341	2650	18,271	2370	16,341
	2964	20,436	3304	22,781	2964	20,436
	4510	31,097	5402	37,244	4510	31,097
IG-541	2175	14,997	2575	17,755	2175	14,997
	2900	19,996	3433	23,671	2900	19,996
	4351	30,000	5150	35,500	4351	30,000
IG-55	2175	15,000	2541	17,600	2175	15,000
	2900	20,000	3434	23,700	2900	20,000
	4350	30,000	5222	36,100	4350	30,000
IG-100	2404	16,575	2799	19,299	2404	16,575
	3236	22,312	3773	26,015	3236	22,312
	4061	28,000	4754	32,778	4061	28,000

Table 5.2.1.1.1(b) Minimum Design Working Pressure for Halocarbon Clean Agent System Piping

Agent	Agent Container Maximum Fill Density		Agent Container Charging Pressure at 70°F (21°C)		Agent Container Pressure at 130°F (55°C)		Minimum Piping Design Pressure	
	lb/ft ³	kg/m ³	psi	bar	psi	bar	psi	bar
HFC-227ea	79	1265	44*	3	135	9	416	29
	75	1201	150	10	249	17	200	14
	72	1153	360	25	520	36	416	29
	72	1153	600	41	1025	71	820	57
HCFC Blend A	56.2	900	600	41	850	59	680	47
	56.2	900	360	25	540	37	432	30
HFC 23	54	865	608.9†	42	2182	150	1746	120
	48	769	608.9†	42	1713	118	1371	95
	45	721	608.9†	42	1560	108	1248	86
	40	641	608.9†	42	1382	95	1106	76
	35	561	608.9†	42	1258	87	1007	69
	30	481	608.9†	42	1158	80	927	64
HCFC-124	74	1185	240	17	354	24	283	20
HCFC-124	74	1185	360	25	580	40	464	32
HFC-125	54	865	360	25	615	42	492	34
HFC 125	56	897	600	41	1045	72	836	58
HFC-236fa	74	1185	240	17	360	25	280	19
HFC-236fa	75	1201	360	25	600	41	480	33
HFC-236fa	74	1185	600	41	1100	76	880	61
HFC Blend B	58	929	360	25	586	40	469	32
	58	929	600	41	888	61	710	50
FK-5-1-12	90	1442	150	10	175	12	150	10
	90	1442	195	13	225	16	195	13
	90	1442	360	25	413	28	360	25
	75	1201	500	34	575	40	500	34
	90	1442	610	42	700	48	610	42
	70	1121	870	60	975	67	870	60
HB-55	75	1201.5	360	25	430	30	360	25
	75	1201.5	510	35	590	41	510	35
	75	1201.5	610	42	700	48	610	42
	70	1121.3	360	25	440	30	360	25
	70	1121.3	510	35	590	41	510	35
	70	1121.3	610	42	700	48	610	42

*Nitrogen delivered to agent cylinder through a flow restrictor upon system actuation. Nitrogen supply cylinder pressure is 1800 psi (124 bar) at 70°F (21°C).

†Not superpressurized with nitrogen.

5.2.1.3 Stenciled pipe identification shall not be painted over, concealed, or removed prior to approval by the authority having jurisdiction.

5.2.1.4 Where used, flexible pipe, flexible nonmetallic pipe, tubing, or hoses, including connections, shall be of approved materials and pressure ratings.

5.2.1.5 Each pipe section shall be cleaned internally after preparation and before assembly by means of swabbing, utilizing a suitable nonflammable cleaner. The pipe network shall

be free of particulate matter and oil residue before installation of nozzles or discharge devices.

5.2.1.6* In sections where valve arrangements introduce sections of closed piping, such sections shall be equipped with pressure relief devices, or the valves shall be designed to prevent entrapment of liquid. In systems using pressure-operated container valves, means shall be provided to vent any container leakage that could build up pressure in the pilot system and cause unwanted opening of the container valve. The means of pressure venting shall be arranged so as not to prevent reliable operation of the container valve.

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5.2.1.7 All pressure relief devices shall be designed and located so that the discharge from the device will not injure personnel or pose a hazard.

5.2.2 Pipe Connections.

5.2.2.1 Pipe joints other than threaded, welded, brazed, flared, compression, or flanged type shall be listed or approved.

5.2.2.2* Fittings shall have a minimum rated working pressure equal to or greater than the minimum design working pressure specified in 5.2.1.1, for the clean agent being used, or as otherwise listed or approved.

5.2.2.3 For systems that employ the use of a pressure-reducing device in the distribution piping, the fittings downstream of the device shall have a minimum rated working pressure equal to or greater than the maximum anticipated pressure in the downstream piping.

5.2.2.4 Cast-iron fittings shall not be used.

5.2.2.5 Class 150 fittings shall not be used.

5.2.2.6 All threads used in joints and fittings shall conform to ASME B1.20.1, *Standard on Pipe Threads, General Purpose, Inch*, or ISO 7-1, *Pipe Threads Where Pressure-Tight Joints Are Made on the Threads — Part 1: Dimensions, Tolerances and Designation*. Joint compound, tape, or thread lubricant shall be applied only to the male threads of the joint.

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

5.2.2.8 Welding shall be performed in accordance with Section IX, “Qualification Standard for Welding and Brazing Procedures, Welders, Brazers and Welding and Brazing Operators,” of the ASME *Boiler and Pressure Vessel Code*.

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

5.2.2.10 Where grooved fittings are used to join pipe, the manufacturer’s pressure and temperature ratings of the fitting shall not be exceeded.

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

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

5.2.3.2 All hangers and components shall be steel.

5.2.3.3 Ordinary cast-iron hangers/supports, conduit clamps, or “C” clamps shall not be used.

5.2.3.4 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.

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

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

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

5.2.4 Valves.

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

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

5.2.4.3* All gaskets, O-rings, sealants, and other valve components shall be constructed of materials that are compatible with the agent. Valves shall be protected against mechanical, chemical, or other damage.

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

5.2.4.5 Where directional valves are used for multihazard protection, the directional valves shall be listed or approved for use with the installed suppression system.

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

5.2.5 Discharge Nozzles.

5.2.5.1 Discharge nozzles shall be listed for the intended use. Listing criteria shall include flow characteristics, area coverage, height limits, and minimum pressures. Discharge orifices and discharge orifice plates and inserts shall be of a material that is corrosion resistant to the agent used and the atmosphere in the intended application.

5.2.5.2 Special corrosion-resistant materials or coatings shall be required in severely corrosive atmospheres.

5.2.5.3 Discharge nozzles shall be permanently marked to identify the manufacturer as well as the type and size of the orifice.

5.2.5.4 Where clogging by external foreign materials is likely, discharge nozzles shall be provided with frangible discs, blow-off caps, or other suitable devices. These devices shall provide an unobstructed opening upon system operation and shall be located so they will not injure personnel.

5.2.5.5* Nozzles shall be installed so as to be free of obstructions that could interfere with the proper distribution of the discharged agent in accordance with the manufacturer’s installation and maintenance manual.

Chapter 6 System Design

6.1 Specifications, Plans, and Approvals.

6.1.1 Specifications.

6.1.1.1 Specifications for total flooding and local application clean agent fire-extinguishing systems shall be prepared under the supervision of a person fully experienced and qualified in the design of such systems and with the advice of the authority having jurisdiction.

6.1.1.2 The specifications shall include all pertinent items necessary for the proper design of the system, such as the designation of the authority having jurisdiction, variances from the

standard to be permitted by the authority having jurisdiction, design criteria, system sequence of operations, the type and extent of the approval testing to be performed after installation of the system, and owner training requirements.

6.1.2 Working Plans.

6.1.2.1 Working plans and calculations shall be submitted for approval to the authority having jurisdiction before system installation or remodeling begins.

6.1.2.2 Working plans and calculations shall be prepared only by persons fully experienced and qualified in the design of total-flooding and local-application clean agent fire-extinguishing systems.

6.1.2.3 Deviation from working plans shall require permission of the authority having jurisdiction.

6.1.2.4 Working plans shall be drawn to an indicated scale.

6.1.2.5 Working plans shall show the following items that pertain to the design of the system:

- (1) Name of owner and occupant
- (2) Location, including street address
- (3) Point of compass and symbol legend
- (4) Location and construction of protected enclosure walls and partitions
- (5) Location of fire walls
- (6) Enclosure cross section, shown as a full-height or schematic diagram, including location and construction of building floor-ceiling assemblies above and below, raised access floor, and suspended ceiling
- (7) Agent being used
- (8) Agent concentration at the lowest temperature and the highest temperature for which the enclosure is protected
- (9) Description of occupancies and hazards being protected, designating whether the enclosure is normally occupied
- (10) For an enclosure protected by a clean agent fire-extinguishing system, an estimate of the maximum positive pressure and the maximum negative pressure, relative to ambient pressure, expected to be developed upon the discharge of agent
- (11) Description of exposures surrounding the enclosure
- (12) Description of the agent storage containers used, including internal volume, storage pressure, and nominal capacity expressed in units of agent mass or volume at standard conditions of temperature and pressure
- (13) Description of nozzle(s) used, including size, orifice port configuration, and equivalent orifice area
- (14) Description of pipe and fittings used, including material specifications, grade, and pressure rating
- (15) Description of wire or cable used, including classification, gauge [American Wire Gauge (AWG)], shielding, number of strands in conductor, conductor material, and color coding schedule; segregation requirements of various system conductors; and required method of making wire terminations
- (16) Description of the method of detector mounting
- (17) Equipment schedule or bill of materials for each piece of equipment or device showing device name, manufacturer, model or part number, quantity, and description
- (18) Plan view of protected area showing enclosure partitions (full and partial height); agent distribution system, including agent storage containers, piping, and nozzles; type of pipe hangers and rigid pipe supports; detection,

alarm, and control system, including all devices and schematic of wiring interconnection between them; end-of-line device locations; location of controlled devices such as dampers and shutters; and location of instructional signage

- (19) Isometric view of agent distribution system showing the length and diameter of each pipe segment; node reference numbers relating to the flow calculations; fittings, including reducers, strainers, and orientation of tees; and nozzles, including size, orifice port configuration, flow rate, and equivalent orifice area
- (20) Scale drawing showing the layout of the annunciator panel graphics if required by the authority having jurisdiction
- (21) Details of each unique rigid pipe support configuration showing method of securement to the pipe and to the building structure
- (22) Details of the method of container securement showing method of securement to the container and to the building structure
- (23) Complete step-by-step description of the system sequence of operations, including functioning of abort and maintenance switches, delay timers, and emergency power shutdown
- (24) Point-to-point wiring schematic diagrams showing all circuit connections to the system control panel and graphic annunciator panel
- (25) Point-to-point wiring schematic diagrams showing all circuit connections to external or add-on relays
- (26) Complete calculations to determine enclosure volume, quantity of clean agent, and size of backup batteries; method used to determine number and location of audible and visual indicating devices; and number and location of detectors
- (27) Details of any special features
- (28)* Pressure relief vent area, or equivalent leakage area, for the protected enclosure to prevent development, during system discharge, of a pressure difference across the enclosure boundaries that exceeds a specified enclosure pressure limit

6.1.2.6 The detail on the system shall include information and calculations on the quantity of agent; container storage pressure; internal volume of the container; the location, type, and flow rate of each nozzle, including equivalent orifice area; the location, size, and equivalent lengths of pipe, fittings, and hose; and the location and size of the storage facility.

6.1.2.6.1 Pipe size reduction and orientation of tees shall be indicated.

6.1.2.6.2 Information shall be submitted pertaining to the location and function of the detection devices, operating devices, auxiliary equipment, and electrical circuitry, if used.

6.1.2.6.3 Apparatus and devices used shall be identified.

6.1.2.6.4 Any special features shall be explained.

6.1.2.6.5 Pre-engineered systems shall not be required to specify an internal volume of the container, nozzle flow rates, equivalent lengths of pipe, fittings, and hose, or flow calculations, when used within their listed limitations.

6.1.2.6.6 For pre-engineered systems, the information required by the listed system design manual shall be made

available to the authority having jurisdiction for verification that the system is within its listed limitations.

6.1.2.7 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 on site.

6.1.2.8 Flow Calculations.

6.1.2.8.1 Flow calculations along with the working plans shall be submitted to the authority having jurisdiction for approval.

6.1.2.8.2 The version of the flow calculation program shall be identified on the computer calculation printout.

6.1.2.8.3 Where field conditions necessitate any material change from approved plans, the change shall be submitted for approval.

6.1.2.8.4 When material changes from approved plans are made, corrected “as-installed” plans shall be provided.

6.1.3 Approval of Plans.

6.1.3.1 Plans and calculations shall be approved prior to installation.

6.1.3.2 Where field conditions necessitate any significant change from approved plans, the change shall be approved prior to implementation.

6.1.3.3 When such significant changes from approved plans are made, the working plans shall be updated to accurately represent the system as installed.

6.2* System Flow Calculations.

6.2.1* System flow calculations shall be performed using a calculation method listed or approved by the authority having jurisdiction.

6.2.1.1 The system design shall be within the manufacturer’s listed limitations.

6.2.1.2 Designs involving pre-engineered systems shall not be required to be provided with flow calculations in accordance with 6.1.2.8 where used within their listed limitations.

6.2.2 Valves and fittings shall be rated for equivalent length in terms of pipe or tubing sizes with which they will be used.

6.2.2.1 The equivalent length of the container valve shall be listed.

6.2.2.2 The equivalent length of the container valve shall include the siphon tube, valve, discharge head, and flexible connector, if so equipped.

6.2.3 Piping lengths and orientation of fittings and nozzles shall be in accordance with the manufacturer’s listed limitations.

6.2.4 If the final installation varies from the prepared drawings and calculations, new drawings and calculations representing the “as-built” installation shall be prepared.

Chapter 7 Total Flooding Systems

7.1* Enclosure.

7.1.1 In the design of a total flooding system, the characteristics of the protected enclosure shall be considered.

7.1.2 The area of unclosable openings in the protected enclosure shall be kept to a minimum.

7.1.3 The authority having jurisdiction shall be permitted to require pressurization/depressurization of the protected enclosure or other tests to ensure performance that meets the requirements of this standard. (See Annex D.)

7.1.4 To prevent loss of agent through openings to adjacent hazards or work areas, openings shall be permanently sealed or equipped with automatic closures.

7.1.5 Where confinement of agent is not practicable, one of the following shall apply:

- (1) Protection shall be expanded to include the adjacent connected hazards or work areas.
- (2) Additional agent shall be introduced into the protected enclosure using an extended discharge configuration.

7.1.6 Where a clean agent total-flooding system is being provided for the protection of a room with a raised or sunken floor, the room and raised or sunken floor shall be simultaneously protected.

7.1.6.1* If only the space under the raised floor is to be protected by a total flooding system, an inert gas shall be used to protect that space.

7.1.6.2 Each volume, room, and raised or sunken floor to be protected shall be provided with detectors, piping network, and nozzles.

Δ 7.1.7* Forced-air ventilating systems, including self-contained air recirculation systems, shall be shut down or closed automatically where their continued operation would prevent the development and maintenance of the required agent concentration in a hazard or result in the propagation of fire.

Δ 7.1.7.1 Unless automatically isolated from the hazard prior to discharge of agent, the volume of ventilation system ducts and components shall be considered as part of the total hazard volume when determining the quantity of agent.

• Δ 7.1.7.2 Where a ventilation system is permitted to remain in operation, an extended agent discharge shall be provided, if required, to maintain the design concentration for the required duration of protection.

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

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

7.1.8.2 Designers shall consult the system manufacturer’s recommended procedures relative to enclosure venting. [For pressure relief vent area or equivalent leakage area, see 6.1.2.5(28).]

7.2 Design Concentration Requirements.

7.2.1 General.

7.2.1.1 The minimum extinguishing concentration or inerting concentrations shall be used in determining the minimum design concentration for the specific fuel.

7.2.1.2 For combinations of fuels, the minimum extinguishing concentration or inerting concentration for the fuel requiring the greatest concentration shall be used unless tests are made on the actual mixture.

7.2.2 Flame Extinguishment.

7.2.2.1 Class A Hazards.

7.2.2.1.1 The minimum extinguishing concentration for Class A fuels shall be determined by test as part of a listing program in accordance with 7.2.2.3.

7.2.2.1.2 The minimum design concentration for a Class A surface-fire hazard shall be determined by the greater of the following:

- (1) The extinguishing concentration, as determined in 7.2.2.1.1, times a safety factor of 1.2 for systems with automatic detection and actuation (*see* 9.1.2) or 1.3 for systems with manual-only actuation (*see* 9.1.1.1)
- (2) Equal to the minimum extinguishing concentration for heptane as determined from 7.2.2.2.1 (2)

7.2.2.1.3* The minimum design concentration for a deep-seated fire shall be determined by an application-specific test.

7.2.2.2 Class B Hazards.

7.2.2.2.1* The flame-extinguishing concentration for Class B fuels shall be determined by the greater of the following:

- (1) The Class B concentration as determined by a listing program in accordance with 7.2.2.3
- (2) The flame-extinguishing concentration for the specific fuel, as determined by the cup burner method (*see Annex B*)

CAUTION: Under certain conditions, it can be dangerous to extinguish a burning gas jet. As a first measure, shut off the gas supply.

7.2.2.2.2 Measurement equipment used in applying the cup burner method shall be calibrated.

7.2.2.2.3 The minimum design concentration for a Class B fuel hazard shall be the extinguishing concentration, as determined in 7.2.2.2.1, times a safety factor of 1.3.

7.2.2.3* Listing Program. As a minimum, the listing program shall conform to ANSI/CAN/UL/ULC 2127, *Inert Gas Clean Agent Extinguishing System Units*, or ANSI/CAN/UL/ULC 2166, *Halocarbon Clean Agent Extinguishing System Units*, or equivalent.

7.2.2.4 Class C Hazards.

7.2.2.4.1 The minimum design concentration for a Class C hazard shall be the Class A minimum extinguishing concentration, as determined in 7.2.2.1.1, times a safety factor of 1.35.

7.2.2.4.2 The minimum design concentration for spaces containing energized electrical hazards supplied at greater than 480 volts that remain powered during and after discharge shall be determined by a hazard analysis and testing, as necessary.

7.2.3 Inerting.

7.2.3.1* The inerting concentration shall be determined by test.

7.2.3.2* The inerting concentration shall be used in determining the agent design concentration where conditions for subsequent reflash or explosion exist.

7.2.3.3 The minimum design concentration used to inert the atmosphere of an enclosure where the hazard is a flammable

liquid or gas shall be the inerting concentration times a safety factor of 1.1.

7.2.3.4* The temperature of a protected volume in which inerting halocarbons are used shall be in accordance with the manufacturer's listed installation manual.

7.3 Total Flooding Quantity.

7.3.1* The quantity of halocarbon agent required to achieve the design concentration shall be calculated from the following equation:

[7.3.1]

$$W = \frac{V}{S} \left(\frac{C}{100 - C} \right)$$

where:

W = quantity of clean agent [lb (kg)]

V = net volume of hazard, calculated as the gross volume minus the volume of fixed structures impervious to clean agent vapor [ft^3 (m^3)]

C = agent design concentration (vol %)

s = specific volume of the superheated agent vapor at 1 atm and the minimum anticipated temperature [$^{\circ}\text{F}$ ($^{\circ}\text{C}$)] of the protected volume [ft^3/lb (m^3/kg)]

7.3.1.1 The concentration of halocarbon clean agent that will be developed in the protected enclosure shall be calculated at both the minimum and maximum design temperature using the following equation:

[7.3.1.1]

$$C = 100 \frac{\left(\frac{W \times s}{V} \right)}{\left(\frac{W \times s}{V} \right) + 1}$$

where:

C = agent concentration [vol %]

W = installed quantity of agent [lb (kg)]

s = specific volume of the gaseous agent at the minimum/maximum design temperature of the hazard [ft^3/lb (m^3/kg)]

V = volume of the as-built enclosure [ft^3 (m^3)]

7.3.1.2 Agent concentrations calculated based on as-built and as-installed data and the lowest and highest design temperatures of the protected space shall be recorded in accordance with the requirements of 6.1.2.7 and 6.2.4.

7.3.2* The quantity of inert gas agent required to achieve the design concentration shall be calculated using Equation 7.3.2, 7.3.2.1a, or 7.3.2.1b:

[7.3.2]

$$X = 2.303 \left(\frac{s_0}{s} \right) \log_{10} \left(\frac{100}{100 - C} \right)$$

where:

X = volume of inert gas added at standard conditions of 14.7 psi absolute, 70°F (1.013 bar absolute, 21°C) per volume of hazard space [ft^3/ft^3 (m^3/m^3)]

s_0 = specific volume of inert gas agent at 70°F (21°C) and 14.7 psi absolute (1.013 bar absolute)
 s = specific volume of inert gas at 14.7 psi absolute and the minimum design temperature [°F (°C)] of the protected volume [ft³/lb (m³/kg)]
 C = inert gas design concentration (vol %)

7.3.2.1* An alternative equation for calculating the inert gas clean agent concentrations shall be permitted, as follows:

[7.3.2.1a]

$$X = 2.303 \left(\frac{530}{460 + t} \right) \log_{10} \left(\frac{100}{100 - C} \right)$$

where:

t = minimum anticipated temperature of the protected volume (°F)

[7.3.2.1b]

$$X = 2.303 \left(\frac{294}{273 + t} \right) \log_{10} \left(\frac{100}{100 - C} \right)$$

where:

t = minimum anticipated temperature of the protected volume (°C)

7.3.2.2 The design quantity of inert gas agent in mass units shall be calculated as follows:

[7.3.2.2a]

$$W = 2.303 \left(\frac{V}{s} \right) \log_{10} \left(\frac{100}{100 - C} \right)$$

or

[7.3.2.2b]

$$W = \left(\frac{V}{s} \right) \ln \left(\frac{100}{100 - C} \right)$$

where:

W = quantity of inert gas agent [lb (kg)]

V = volume of the hazard [ft³ (m³)]

s = specific volume of the gaseous agent at the temperature of the hazard [ft³/lb (m³/kg)]

C = inert gas agent concentration [vol %]

▲ 7.3.2.3 The concentration of an inert gas clean agent that will be developed in the protected enclosure shall be calculated at both the minimum and maximum design temperature, using one of the following equations:

[7.3.2.3a]

$$C = 100 \frac{10^{\left(\frac{W \cdot s}{2.303 \cdot V} \right)} - 1}{10^{\left(\frac{W \cdot s}{2.303 \cdot V} \right)}}$$

or

[7.3.2.3b]

$$C = 100 \frac{e^{\left(\frac{W \cdot s}{V} \right)} - 1}{e^{\left(\frac{W \cdot s}{V} \right)}}$$

where:

C = agent concentration [vol %]

W = installed quantity of agent [lb (kg)]

s = specific volume of the gaseous agent at the minimum/maximum design temperature of the hazard [ft³/lb (m³/kg)]

V = volume of the as-built enclosure [ft³ (m³)]

7.3.3* Design Factors. Where special conditions could affect the extinguishing efficiency, the minimum quantity of agent shall be increased through the use of design factors.

7.3.3.1* Tee Design Factor. Other than as identified in 7.3.3.1.3, where a single agent supply is used to protect multiple hazards, a design factor from Table 7.3.3.1 shall be applied.

7.3.3.1.1 For the application of Table 7.3.3.1, the design factor tee count shall be determined for each hazard the system protects, using the following guidelines:

- (1) Starting from the point where the pipe system enters the hazard, the number of tees in the flow path returning to the agent supply shall be included (do not include tees used in a manifold) in the design factor tee count for the hazard.
- (2) Any tee within the hazard that supplies agent to another hazard shall be included in the design factor tee count for the hazard.

7.3.3.1.2 The hazard with the greatest design factor tee count shall be used in Table 7.3.3.1 to determine the design factor.

7.3.3.1.3 For systems that pass a discharge test, this design factor shall not apply.

Table 7.3.3.1 Design Factors for Piping Tees

Design Factor Tee Count	Halocarbon Design Factor	Inert Gas Design Factor
0–4	0.00	0.00
5	0.01	0.00
6	0.02	0.00
7	0.03	0.00
8	0.04	0.00
9	0.05	0.01
10	0.06	0.01
11	0.07	0.02
12	0.07	0.02
13	0.08	0.03
14	0.09	0.03
15	0.09	0.04
16	0.10	0.04
17	0.11	0.05
18	0.11	0.05
19	0.12	0.06

7.3.3.2* Additional Design Factors. The designer shall assign and document additional design factors for each of the following:

- (1) Unclosable openings and their effects on distribution and concentration (*see also* 7.6.3)
- (2) Control of acid gases
- (3) Re-ignition from heated surfaces
- (4) Fuel type, configurations, scenarios not fully accounted for in the extinguishing concentration, enclosure geometry, and obstructions and their effects on distribution

7.3.3.3* Design Factor for Enclosure Pressure. The design quantity of the clean agent shall be adjusted in accordance with Table 7.3.3.3 to compensate for ambient pressures that vary more than 11 percent [equivalent to approximately 3000 ft (915 m) of elevation change] from standard sea level pressures [29.92 in. Hg at 32°F (760 mm Hg at 0°C)].

7.4* Duration of Protection.

▲ **7.4.1** For flame-extinguishing systems, a minimum concentration of 85 percent of the minimum design concentration shall be held at the highest height of protected content within the hazard for a period of 10 minutes or for a period sufficient to allow for response by trained personnel.

▲ **7.4.2** For inerting systems, a minimum concentration not less than the inerting concentration determined in accordance with 7.2.3.1 shall be held throughout the protected space for a period sufficient to allow for response by trained personnel.

7.5 Distribution System.

7.5.1* Initial Discharge Time.

7.5.1.1* For halocarbon agents, the discharge time shall not exceed 10 seconds or as otherwise required by the authority having jurisdiction.

7.5.1.2 For inert gas agents, the discharge time shall not exceed 60 seconds for Class B fuel hazards, 120 seconds for Class A surface-fire hazards or Class C hazards, or as otherwise required by the authority having jurisdiction. (*See A.7.5.1.1.*)

7.5.1.3* Flow calculations performed in accordance with Section 6.2 or in accordance with the listed pre-engineered systems instruction manuals shall be used to demonstrate compliance with 7.5.1.1 or 7.5.1.2.

7.5.1.4 For explosion prevention systems, the discharge time for agents shall ensure that the minimum inerting design concentration is achieved before concentration of flammable vapors reach the flammable range.

7.5.2* Extended Discharge. Where an extended discharge is necessary to maintain the design concentration for the specified period of time, additional agent quantities shall be permitted to be applied at a reduced rate.

7.5.2.1 The initial discharge shall be completed within the limits specified in 7.5.1.1.

7.5.2.2 The performance of the extended discharge system shall be confirmed by a test, or as otherwise required by the authority having jurisdiction.

7.6 Nozzle Choice and Location.

7.6.1 Nozzles shall be of the type listed for the intended purpose.

7.6.2 Nozzles shall be placed within the protected enclosure in compliance with listed limitations with regard to spacing, floor coverage, and alignment.

7.6.3 The type of nozzles selected, their number, and their placement shall be such that the design concentration will be established in all parts of the hazard enclosure and such that the discharge will not unduly splash flammable liquids or create dust clouds that could extend the fire, create an explosion, or otherwise adversely affect the contents or integrity of the enclosure, or personnel.

Chapter 8 Local Application Systems

8.1 Description. A local application system shall consist of a fixed supply of clean agent permanently connected to a system of fixed piping with nozzles arranged to discharge directly into the fire.

8.1.1 Uses. Local application systems shall be used for the extinguishment of surface fires in flammable liquids, gases, and shallow solids where the hazard is not enclosed or where the enclosure does not conform to the requirements for total flooding.

8.1.2 General Requirements. Local application systems shall be designed, installed, tested, and maintained in accordance with the applicable requirements of this standard.

▲ **8.1.3* Safety Requirements.** The safety requirements of Section 4.3 shall apply to prevent exposure of personnel to high concentrations of agent.

8.2 Hazard Specifications.

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

8.2.1.1 The entire hazard shall be protected.

8.2.1.2 The hazard shall include all areas that are or can become coated by combustible liquids or shallow solid coat-

Table 7.3.3.3 Atmospheric Correction Factors

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

Shaded text = Revisions. ▲ = Text deletions and figure/table revisions.

• = Section deletions.

■ = New material



ings, such as areas subject to spillage, leakage, dripping, splashing, or condensation.

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

8.2.1.4 A series of interexposed hazards shall be permitted to be subdivided into smaller groups or sections with the approval of the authority having jurisdiction.

8.2.1.4.1 Systems for such hazards shall be designed to give immediate independent protection to adjacent groups or sections as needed.

8.2.2 Location of Hazard.

8.2.2.1 The hazard shall be permitted to be indoors, partly sheltered, or completely out of doors.

8.2.2.2 The clean agent discharge shall be such that winds or strong air currents do not impair the protection. It shall be the responsibility of the system designer to show that such conditions have been taken into account in the design of a system.

8.3 Clean Agent Requirements. The quantity of clean agent 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. The minimum design quantity shall be no less than 1.5 times the minimum quantity required for extinguishment at any selected system discharge rate.

8.4 Nozzles.

8.4.1 Nozzle Selection. The basis for nozzle selection shall be listed performance data that clearly depict the interrelationship of agent quantity, discharge rate, discharge time, area coverage, and the distance of the nozzle from the protected surface.

8.4.1.1* The maximum permitted time to extinguish a fire with a halocarbon agent shall be 10 seconds.

8.4.1.2* The maximum permitted time to extinguish a fire with an inert gas agent shall be 30 seconds.

8.4.1.3* Where flammable liquid fires of appreciable depth [over ¼ in. (6 mm)] are to be protected, a minimum freeboard of 6 in. (152 mm) shall be provided unless otherwise noted in approvals or listings of nozzles.

8.4.2 Nozzle Discharge Rates. The design discharge rate through individual nozzles shall be determined on the basis of location or projection distance in accordance with specific approvals or listings.

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

8.4.3 Discharge Time. The minimum design discharge time shall be determined by dividing the design quantity by the design rate.

8.4.3.1 The discharge time shall be increased to compensate for any hazard condition that would require a longer cooling period or for mechanical rundown time associated with ventilation equipment present to prevent re-ignition.

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

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

8.5 Location and Number of Nozzles.

8.5.1* A sufficient number of nozzles shall be used to cover the entire hazard area on the basis of the unit areas protected by each nozzle.

8.5.2* Local application nozzles shall be located in accordance with spacing and discharge rate limitations stated in nozzle listings.

8.5.3 Linear detection tubing shall be permitted to be used for agent discharge within the limitations of its listing.

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

Chapter 9 Detection, Actuation, Alarm, and Control Systems for Clean Agent Releasing Applications

9.1* General.

9.1.1 Control Panel for Releasing Service. Detection, actuation, alarm, and control systems shall be designed, installed, tested, and maintained in accordance with *NFPA 72*.

9.1.1.1 Systems operated by mechanical manual release only shall be permitted if acceptable to the authority having jurisdiction.

9.1.1.2 A dedicated primary power supply and 24-hour minimum standby power supply with a minimum 5-minute alarm current shall be used to provide for operation of the detection, signaling, control, and actuation requirements of the system.

9.1.1.3 A protected premises building fire alarm system shall be permitted to serve as a clean agent suppression system releasing control panel only if it is listed for release with the specific clean agent suppression system's releasing device, per 9.4.8 and 9.4.9.

9.1.1.4 If the clean agent suppression system releasing control panel is located in a protected premises having a separate building fire alarm system, the releasing control panel shall be monitored by the building fire alarm system for alarm, supervisory, and trouble signals.

9.1.1.5* If the releasing service fire alarm control unit is located in a protected premises having a separate fire alarm system, it shall be monitored for alarm, supervisory, and trouble signals, but shall not be dependent on or affected by the operation or failure of the protected premises fire alarm system.

9.1.2 Initiation and Actuation. Automatic detection and automatic actuation shall be used.

9.1.3* Wiring Methods. Initiating and releasing circuit wiring shall be installed in raceways.

9.1.3.1 Other than as permitted in 9.1.3.2, alternating current (ac) and direct current (dc) wiring shall not be combined in a common conduit or raceway.

9.1.3.2 It shall be permitted to combine ac and dc wiring in a common conduit or raceway where shielded and grounded.

9.2 Automatic Detection.

9.2.1* 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.

9.2.2* Where a new agent 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 and will respond to a fire situation in accordance with system design objectives.

9.3 Manual Release. A means of manual release of the system shall be provided, except where permitted to be omitted in accordance with 9.3.4.

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

9.3.2 A discharge pressure switch that provides an alarm-initiating signal to the releasing panel shall be required where a mechanical manual release is utilized and mechanical system actuation is possible.

Δ 9.3.3* Where a releasing panel is not used, the discharge pressure switch shall initiate electrical functions that are required upon system actuation, including notification.

9.3.4 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.

9.3.5 The manual release(s) shall be accessible at all times, including at the time of a fire.

9.3.6 The manual release(s) shall be recognizable for the purpose intended.

9.3.7 Operation of any manual control shall cause the complete system to operate as designed.

9.3.8 Manual controls shall not require a pull of more than 40 lb (178 N) nor a movement of more than 14 in. (356 mm) to secure operation.

9.3.9 At least one manual control for activation shall be located not more than 4 ft (1.2 m) above the floor.

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

9.4 Operating Devices and Control Equipment for Agent Release, Discharge Control, and Equipment Shutdown.

9.4.1 Operation of agent-releasing devices or valves, discharge controls, and shutdown equipment necessary for successful performance of the system shall be by listed mechanical, electrical, or pneumatic means.

9.4.2 Operating devices shall be suitable for application in the environment in which they are employed.

9.4.3 Operating equipment shall not readily be rendered inoperative or susceptible to accidental operation.

9.4.4 Devices normally shall be designed to function properly from -20°F to 130°F (-29°C to 54°C) or marked to indicate temperature limitations.

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

9.4.6 Where gas pressure from the system or pilot containers is used as a means for releasing the agent storage remaining containers, the supply and discharge rate shall be designed for releasing all the remaining containers.

9.4.7 All devices for shutting down supplementary equipment shall function with the system operation as integral parts of the system.

9.4.8 The control equipment shall be specifically listed for the number and type of actuating devices utilized.

9.4.9 The control equipment and actuating devices shall be listed for compatibility.

9.4.10 Supervision of Electric Actuator Removal.

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

9.4.10.2 Subsection 9.4.10.1 shall not apply to systems covered under Chapter 13 of this standard with the exception of those systems included under Section 13.6.

9.4.11 The control equipment shall supervise the actuating devices and associated wiring and, as required, cause actuation.

9.4.12 Removal of the primary agent container actuating device from the discharge valve or selector valve shall cause a trouble or supervisory signal at the releasing control unit.

9.4.13* Where pneumatic control equipment is used, the lines shall be protected against loss of integrity.

9.5 Operating Alarms, Notification Appliances, and Indicators.

9.5.1 Notification appliances or control panel indicators shall be used to indicate the operation of the system, hazards to personnel, or failure of any supervised device.

9.5.2* The type (e.g., audible, visual), number, and location of notification appliances and indicators shall be such that their purpose is accomplished, fulfilling all requirements.

9.5.3 The notification appliances shall be designed to operate in accordance with the requirements of the building's emergency response plan.

9.5.4 Audible and visual pre-discharge notification shall be provided within the protected area of occupiable spaces to give positive warning of impending discharge.

9.5.5 The operation of the notification appliances shall be continued after agent discharge until positive action has been taken to acknowledge the alarm and to proceed with appropriate action.

9.6 Abort Switches. Abort switches shall be permitted to be installed for clean agent releasing systems.

9.6.1 Abort switches, where provided, shall be located within the protected area and near the means of egress for the area.

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

9.6.3 The manual release shall override the abort function.

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

9.6.5 Abort switches shall be recognizable for the purpose intended.

9.7 Time Delays.

9.7.1 A pre-discharge alarm and time delay sufficient to allow personnel evacuation prior to discharge shall be provided.

▲ 9.7.2* For hazard areas where the provision of a time delay would increase the threat to life and property, a time delay shall be permitted to be eliminated.

N 9.7.3 Where time delays are omitted, provisions shall be made to ensure that the clean agent system is locked out by a supervised system lockout valve any time personnel are present in the protected area or space.

9.7.4 Time delays shall be used only for personnel evacuation or to prepare the hazard area for discharge.

9.7.5 Time delays shall not be used as a means of confirming operation of a detection device before automatic actuation occurs.

9.8* Disconnect Switch.

9.8.1 To avoid unwanted discharge of an electrically actuated clean agent system, a supervised disconnect switch shall be provided.

9.8.2 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

9.8.3* When the disconnect switch requires a key for activation, the access key shall not be removable while the releasing circuit is disconnected.

9.8.4 Disarming the suppression system release sequence via software programming shall not be acceptable for use in lieu of a physical disconnect switch.

9.8.5 The disconnect switch shall be listed.

9.9 Lockout Valves. If a lockout valve is installed, the releasing panel shall indicate a supervisory signal when the lockout valve is not in the fully open position.

Chapter 10 Approval of Installations

10.1* Safety. Safe procedures shall be observed during installation, servicing, maintenance, testing, handling, and recharging of clean agent systems and agent containers.

10.2* General.

10.2.1 The completed system shall be reviewed and tested by personnel that have knowledge and experience of the require-

ments contained in this standard, of the installed equipment, and of the manufacturer's design, installation, and maintenance manual.

10.2.2 Only listed equipment and devices shall be used in the systems.

10.2.3 System Acceptance Testing.

10.2.3.1 The system shall be tested in accordance with the requirements of this standard and the manufacturer's design, installation, and maintenance manual.

10.2.3.2 Equipment shall be inspected to verify that it is installed in accordance with the manufacturer's instructions and the system design documents.

10.2.3.3 The actual hazard dimensions shall be checked against those indicated on the system drawings to verify the quantity of agent.

10.2.3.4* If a discharge test is to be conducted, containers for the agent to be used shall be weighed before and after the discharge test.

10.2.3.5 The weight of agent in the containers shall be verified by weighing or other approved methods.

10.2.3.6 For inert gas clean agents, container pressure shall be recorded before and after the discharge test.

10.2.3.7 When applicable for system operation, fan coastdown and damper closure time shall be verified that they are in accordance with the system design criteria.

10.2.4 When required by project specifications, integrated fire protection and life safety system testing shall be in accordance with NFPA 4.

10.3 Acceptance Test Report.

10.3.1* The acceptance testing required by 10.2.3 shall be documented in a test report.

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

10.4 Review of Mechanical Components.

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

10.4.2 Nozzles and pipe size shall be in accordance with system drawings.

10.4.3 Means of pipe size reduction and attitudes of tees shall be checked for conformance to the design.

10.4.4 Piping joints, discharge nozzles, and piping supports shall be securely fastened to prevent unwanted vertical or lateral movement during discharge.

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

10.4.6 During assembly, the piping distribution system shall be inspected internally to detect the possibility of any oil or particulate matter soiling the hazard area or affecting the agent distribution due to a reduction in the effective nozzle orifice area.

10.4.7 The discharge nozzle shall be oriented in accordance with the nozzle listing.

10.4.8 If nozzle deflectors are installed, they shall be positioned per the equipment listing.

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

10.4.10 Agent shall not directly impinge on areas where personnel could be found in the normal work area.

10.4.11 Agent shall not directly impinge on any loose objects or shelves, cabinet tops, or similar surfaces where loose objects could be present and become projectiles.

10.4.12 All agent storage containers shall be located in accordance with an approved set of system drawings.

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

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

10.4.14.1 The pipe shall be pressurized to at least 40 psi (276 kPa).

10.4.14.2 After removing the source of pressurizing gas, the pressure in the pipe shall not be less than 80 percent of the test pressure after 10 minutes.

10.4.14.3 The pressure test shall be permitted to be omitted if the total piping contains no more than one change in direction fitting between the storage container and the discharge nozzle and if all piping has been physically checked for tightness.

10.4.15* A flow test using nitrogen or an inert gas shall be performed on the piping network to verify that flow is continuous.

10.5 Review of Enclosure Integrity.

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

10.5.2 All total flooding systems shall have the enclosure examined and tested to locate and then effectively seal any significant air leaks that could result in a failure of the enclosure to hold the specified agent concentration level for the specified holding period.

10.5.3* Quantitative results shall be obtained and recorded to indicate that the specified agent concentration for the specified duration of protection is in compliance with Section 7.4, using an approved blower fan unit or other means as approved by the authority having jurisdiction. (*For guidance, see Annex D.*)

10.6 Review of Electrical Components.

10.6.1 All wiring systems shall be installed in compliance with local codes and the system drawings.

10.6.2 Alternating current (ac) and direct current (dc) wiring shall not be combined in a common conduit or raceway unless shielded and grounded.

10.6.3 All field circuits shall be free of ground faults and short circuits.

10.6.3.1 Where field circuitry is being measured, all electronic components, such as smoke and flame detectors or special electronic equipment for other detectors or their mounting bases, shall be removed and jumpers shall be installed to prevent the possibility of damage within these devices.

10.6.3.2 Components removed in accordance with 10.6.3.1 shall be replaced after measuring.

10.6.4 Power shall be supplied to the control unit from a separate dedicated source that will not be shut down upon system operation.

10.6.5 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.

10.6.6* All auxiliary functions such as alarm-sounding or displaying devices, remote annunciators, air-handling shutdown, and power shutdown shall be checked for operation in accordance with system requirements and design specifications.

10.6.7 Silencing of alarms, if permitted, shall not affect other auxiliary functions.

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

10.6.9* Detectors shall not be located near obstructions or air ventilation and cooling equipment that would affect their response characteristics.

10.6.10* The design of the detection system must take into consideration the volume of air changes within the protected area.

10.6.11 The detectors shall be installed in accordance with the manufacturer's technical data and the requirements of *NFPA 72*.

10.6.12 Manual Pull Stations.

10.6.12.1 Manual pull stations shall be securely mounted.

10.6.12.2 The operable part of a manual pull station shall be not less than 42 in. (1.07 m) and not more than 48 in. (1.22 m) from the finished floor.

10.6.12.3 Manual pull stations shall be installed so that they are conspicuous, unobstructed, and accessible.

10.6.12.4* All manual pull stations shall be identified as to the hazard they protect, the function they perform, and their method of operation.

10.6.12.5 All manual stations used to release agents shall require two separate and distinct actions for operation.

10.6.13 Systems with Main/Reserve Capability. For systems with a main/reserve capability, the main/reserve switch shall be installed in accordance with the system manufacturer's design, installation, and maintenance manual and the system drawings.

10.6.13.1 For systems with a main/reserve capability, the main/reserve switch shall be installed in accordance with the system manufacturer's design, installation, and maintenance manual and the system drawings.

10.6.13.2 If installed, the main/reserve switch shall be identified.

10.6.14 Systems Using Abort Switches.

10.6.14.1 Abort switches shall be of the deadman type requiring constant manual pressure.

10.6.14.2 Switches that remain in the abort position when released shall not be used for this purpose.

10.6.14.3 Abort switches shall be installed so that they are readily accessible within the hazard.

10.6.14.4 Abort switches shall be securely mounted.

10.6.14.5 Abort stations shall be installed so they are conspicuous, unobstructed, and accessible.

10.6.14.6 The operable part of an abort switch shall be not less than 42 in. (1.07 m) and not more than 48 in. (1.22 m) from the finished floor.

10.6.14.7 Manual pull stations shall always override abort switches.

10.6.15 The releasing control unit shall be installed in accordance with the system documentation and readily accessible.

10.7 Functional Testing.

10.7.1 Preliminary Functional Tests.

10.7.1.1 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 or alarm station personnel is not desired.

10.7.1.2 All personnel in areas that could be affected by the testing at the end user's facility shall be notified that a test is to be conducted.

10.7.1.3* All personnel in areas that could be affected by the testing at the end user's facility shall be instructed as to events that could occur during testing of the fire extinguishing system.

10.7.1.4* Each agent storage container release mechanism shall be disabled or replaced with a functional device so that activation of the release circuit will not release agent.

10.7.1.5 Each detector shall be tested for operation.

10.7.1.6 All polarized alarm devices and auxiliary relays shall be checked for polarity in accordance with the manufacturer's instructions.

10.7.1.7 Initiating and notification circuits shall be checked for end-of-line devices, if required.

10.7.1.8 All supervised circuits shall be tested for trouble response.

10.7.2 System Functional Operational Test.

10.7.2.1 Each detection initiating circuit shall be operated to verify that all alarm functions occur according to design specifications.

10.7.2.2 Each manual release shall be operated to verify that manual release functions occur according to design specifications.

10.7.2.3 Each abort switch circuit shall be operated to verify that abort functions occur according to design specifications

and that visual and audible supervisory signals are annunciated at the control panel.

10.7.2.4 All automatic valves shall be tested to verify operation unless testing the valve will release agent or damage the valve (destructive testing).

10.7.2.5 Pneumatic equipment, where installed, shall be tested for integrity to ensure operation.

10.7.3 Remote Monitoring Operations.

10.7.3.1 Each type of initiating device shall be operated while on standby power to verify that an alarm signal is received at the remote panel after the device is operated.

10.7.3.2 A fault condition shall be applied to each initiating or notification circuit to verify receipt of a trouble condition at the remote station.

10.7.3.3 Each supervised device shall be operated to verify receipt of a supervisory condition at the remote station.

10.7.4 Control Panel Primary Power Source. A primary power failure shall be initiated in accordance with the manufacturer's specification to verify that the system operates on standby power.

10.7.5 Return of System to Operational Condition.

10.7.5.1 When functional testing is completed, the system shall be returned to its fully operational condition.

10.7.5.2 The alarm-receiving office and all concerned personnel at the end user's facility shall be notified that the fire system test is complete and that the system has been returned to full service condition.

10.8 Owner's Documentation.

10.8.1 Paper or electronic copies of all test reports and related documentation shall be provided to the system owner.

10.8.2 The system owner shall maintain these reports for the life of the system.

10.9 Training.

10.9.1 All persons who could be expected to operate fire extinguishing systems shall be trained and kept trained in the functions they are expected to perform.

10.9.2* Personnel working in an enclosure protected by a clean agent shall receive training regarding agent safety issues.

Chapter 11 Inspection, Servicing, Testing, Maintenance, and Training

11.1 General. The responsibility for inspection, testing, maintenance, and recharging of the fire protection system shall ultimately be that of the owner(s) of the system, provided that this responsibility has not been transferred in written form to a management company, tenant, or other party.

11.1.1 Safety. Safe procedures shall be observed during inspection, servicing, maintenance, testing, handling, and recharging of clean agent systems and agent containers. (See A.10.1.)

11.1.2 Fire Protection Service Technician. Personnel that inspect, service, test, and maintain clean agent fire extinguish-

ing systems shall have knowledge and experience of the maintenance and servicing requirements contained in this standard, of the equipment being serviced or maintained, and of the servicing or maintenance methods and requirements contained in the manufacturer's design, installation, and maintenance manual and any applicable bulletins.

11.2* **Monthly Inspection.**

11.2.1 At least monthly, a visual inspection shall be conducted in accordance with the manufacturer's listed maintenance manual or owner's manual.

11.2.2 At a minimum, the inspection shall include verification of the following, as applicable:

- (1) Releasing panel is powered and is free of supervisory, trouble, or alarm conditions.
- (2) Manual controls are unobstructed.
- (3) System shows no physical damage or condition that could prevent operation.
- (4) Pressure gauges are in the operable range.
- (5) Protected equipment and/or hazard has not been changed or modified.
- (6) Any previously noted deficiencies have been corrected.

11.2.3 If any deficiencies are found, appropriate corrective action shall be taken immediately.

11.2.4 Where the corrective action involves maintenance or repair, it shall be conducted by a fire protection service technician, in accordance with 11.1.2.

11.2.5 When inspections are conducted, a record verifying that the inspection was completed shall be maintained by the owner.

11.2.5.1 The record shall include the date the inspection was performed and the initials of the person performing the inspection.

11.2.5.2 The record shall include any deficiencies that were found.

11.2.5.3 The records shall be retained until the next semiannual service and inspection.

11.3* Semiannual Service and Inspection. At least semiannually, the agent quantity and pressure of containers shall be checked.

11.3.1 For halocarbon clean agents with a means of pressure indication, if a container shows a loss in agent quantity of more than 5 percent or a loss in pressure (adjusted for temperature) of more than 10 percent, it shall be refilled or replaced.

11.3.2 For halocarbon agent containers without a means of pressure indication, if a container shows a loss in agent quantity of more than 5 percent, it shall be refilled or replaced.

11.3.3* Halocarbon clean agent removed from containers during service or maintenance procedures shall be recovered and recycled or disposed of in accordance with any applicable laws and regulations.

11.3.4* For inert gas clean agents, if a container shows a loss in pressure (adjusted for temperature) of more than 5 percent, it shall be refilled or replaced.

11.3.5 Where the quantity of agent in the container is determined by special measuring devices, these devices shall be listed.

11.3.6 The following information shall be recorded on a tag attached to the container:

- (1) Date of inspection
- (2) Person and organization performing the inspection
- (3) Type of agent
- (4) Gross weight of the container and net weight of agent (*halocarbon clean agents only*)
- (5) Container pressure and temperature (*halocarbon clean agents with a gauge and inert gas clean agents*)

11.4 Annual Inspection and Service. At least annually, all systems shall be inspected, serviced, and tested for operation by qualified personnel, in accordance with 11.1.2.

11.4.1 Discharge tests shall not be required.

11.4.2* A service report with recommendations shall be filed with the owner of the system.

11.4.3 The service report shall be permitted to be stored and accessed using paper or electronic media.

11.4.4 **System Hoses.**

11.4.4.1 All system hoses shall be examined annually for damage.

11.4.4.2 If visual examination shows any deficiency, the hose shall be immediately replaced or tested as specified in Section 11.7.

11.4.5 **Enclosure Inspection.**

11.4.5.1 The protected enclosure shall be inspected annually or monitored by a documented administrative program for changes in barrier integrity or enclosure dimensions.

11.4.5.2* Where changes could result in the inability of the enclosure to maintain the clean agent concentration, the conditions shall be corrected.

11.5* **Maintenance.**

11.5.1 These systems shall be maintained in full operating condition at all times.

11.5.2 Actuation of the clean agent system shall be reported immediately to the authority having jurisdiction.

11.5.3 Impairments shall be addressed in accordance with Chapter 12.

11.5.4 **Enclosure Maintenance.**

11.5.4.1* Any penetrations made through the enclosure protected by the clean agent shall be sealed immediately.

11.5.4.2 The method of sealing shall restore the original fire resistance rating of the enclosure.

11.6* **Container Test.**

11.6.1* **US** Department of Transportation (DOT), Canadian Transport Commission (CTC), or similar design clean agent containers shall not be recharged without retesting if the requalification period specified by the regulating authority for the container has elapsed since the date of the last test and inspection.

11.6.1.1 For halocarbon agent storage containers, the retest shall be permitted to consist of a complete visual inspection as described in 49 CFR.

11.6.1.2 A cylinder shall be permitted to be requalified at any time during or before the month and year that the requalification is due.

11.6.1.3 A cylinder filled before the requalification becomes due shall be both of the following:

- (1) Permitted to remain in service
- (2) Periodically inspected in accordance with 11.6.2

11.6.1.4 A cylinder with a specified service life shall not be refilled and offered for transportation after its authorized service life has expired.

11.6.2* Containers continuously in service without need for refill or repair shall be given a complete external visual inspection every 5 years, or more frequently if required.

11.6.2.1 The visual inspection shall be in accordance with Section 3 of CGA C-6, *Standard for Visual Inspection of Steel Compressed Gas Cylinders*, except that the containers need not be stamped while under pressure.

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

- (1) A record tag permanently attached to each container
- (2) A suitable inspection report

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

11.6.2.4 These records shall be retained by the owner for the life of the system.

11.6.2.5 Where external visual inspection indicates that the container has been damaged, additional strength tests shall be required in accordance with applicable transportation regulations.

11.7 Hose Test.

11.7.1 All hoses shall be tested or replaced every 5 years.

11.7.2 A test pressure equal to 1½ times the maximum container pressure at 130°F (54.4°C) shall be applied within 1 minute and maintained for 1 minute.

11.7.3 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.

11.7.4 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

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

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

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

11.8 Training. All persons who could be expected to inspect, service, test, or maintain fire extinguishing systems shall be trained and kept trained in the functions they are expected to perform.

Chapter 12 Impairment

12.1* General.

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

12.1.2 Measures shall be taken during the impairment to ensure that increased risks are minimized and the duration of the impairment is limited.

12.2 Impairment Coordinator.

12.2.1 The property owner or designated representative shall assign an impairment coordinator to comply with the requirements of this chapter.

12.2.2 In the absence of a specific designee, the property owner or designated representative shall be considered the impairment coordinator.

12.2.3 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.

12.3 Tag Impairment System.

12.3.1* A tag shall be used to indicate that a system, or part thereof, has been removed from service.

12.3.2* A tag shall be posted at the clean agent system component causing the impairment, the system releasing control unit, the building fire alarm control unit if applicable, and other locations required by the authority having jurisdiction, indicating which system, or part thereof, has been removed from service.

12.4 Preplanned Impairment Programs.

12.4.1 All preplanned impairments shall be authorized by the impairment coordinator.

12.4.2* The need for temporary fire protection, termination of all hazardous operations, and frequency of inspections in the areas involved shall be determined.

12.4.3 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 clean agent fire protection system provides primary protection and is out of service for more than 10 hours in a 24-hour period, arrangements are made 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 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, 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 12.3.*)
- (9) All necessary tools and materials have been assembled on the impairment site.

12.5 Emergency Impairments.

12.5.1 Emergency impairments shall include, but are not limited to, interruption of clean agent supply, ruptured or damaged piping, equipment failure, and loss of enclosure integrity, and include impairments found during inspection, testing, or maintenance activities.

12.5.2 In the case of an emergency impairment, the coordinator shall implement the steps outlined in 12.4.2 and 12.4.3.

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

12.6 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.
- (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 if applicable, and other authorities having jurisdiction have been advised that protection is restored.
- (5) All impairment tags have been removed.

Chapter 13 Marine Systems

13.1 General. This chapter outlines the deletions, modifications, and additions that are necessary for marine applications. All other requirements of NFPA 2001 shall apply to shipboard systems except as modified by this chapter. Where the provisions of Chapter 13 conflict with the provisions of Chapter 1 through Chapter 11, the provisions of Chapter 13 shall take precedence.

13.1.1 Scope. This chapter is limited to marine applications of clean agent fire extinguishing systems on commercial and

government vessels. Explosion inerting systems were not considered during development of this chapter.

13.2 Use and Limitations.

13.2.1* Total flooding clean agent fire extinguishing systems shall be used primarily to protect hazards that are in enclosures or equipment that, in itself, includes an enclosure to contain the agent.

13.2.2* In addition to the limitations given in 4.2.2, clean agent fire extinguishing systems shall not be used to protect the following:

- (1) Dry cargo holds
- (2) Bulk cargo

13.2.3 The effects of agent decomposition products and combustion products on fire protection effectiveness and equipment shall be considered where using clean agents in hazards with high ambient temperatures (e.g., incinerator rooms, hot machinery and piping).

13.3 Hazards to Personnel.

13.3.1 Other than the engine rooms identified in 13.3.1.1, all other main machinery spaces shall be considered normally occupied spaces.

13.3.1.1 Engine rooms of 6000 ft³ (170 m³) or less that are accessed for maintenance only shall not be required to comply with 13.3.1.

13.3.2* For marine systems, electrical clearances shall be in accordance with 46 CFR, Subchapter J, "Electrical Engineering."

13.4 Agent Supply.

13.4.1 Reserve quantities of agent shall not be required by this standard.

13.4.2* Storage container arrangement shall be in accordance with 5.1.3.1 and 5.1.3.3 through 5.1.3.5. Where equipment is subject to extreme weather conditions, the system shall be installed in accordance with the manufacturer's design and installation instructions.

13.4.2.1 Except in the case of systems with storage cylinders located within the protected space, pressure containers required for the storage of the agent shall be in accordance with 13.4.2.2.

13.4.2.2 Where the agent containers are located outside a protected space, they shall be stored in a room that shall be situated in a safe and readily accessible location and shall be effectively ventilated so that the agent containers are not exposed to ambient temperatures in excess of 130°F (55°C). Common bulkheads and decks located between clean agent container storage rooms and protected spaces shall be protected with A-60 class structural insulation as defined by 46 CFR 72. Agent container storage rooms shall be accessible without having to pass through the space being protected. Access doors shall open outward, and bulkheads and decks, including doors and other means of closing any opening therein, that form the boundaries between such rooms and adjoining spaces shall be gastight.

13.4.3 Where agent containers are stored in a dedicated space, doors at exits shall swing outward.

13.4.4 Where subject to moisture, containers shall be installed such that a space of at least 2 in. (51 mm) between the deck and the bottom of the container is provided.

13.4.5 In addition to the requirements of 5.1.3.4, containers shall be secured with a minimum of two brackets to prevent movement from vessel motion and vibration.

13.4.6* For marine applications, all piping, valves, and fittings of ferrous materials shall be protected inside and out against corrosion except as permitted in 13.4.6.1.

13.4.6.1 Closed sections of pipe and valves and fittings within closed sections of pipe shall be required to be protected against corrosion only on the outside.

13.4.6.2 Other than as permitted in 13.4.6.1, prior to acceptance testing, the inside of the piping shall be cleaned without compromising its corrosion resistance.

13.4.7* Pipes, fittings, nozzles, and hangers, including welding filling materials, within the protected space shall have a melting temperature greater than 1600°F (871°C). Aluminum components shall not be used.

13.4.8 Piping shall extend at least 2 in. (51 mm) beyond the last nozzle in each branch line to prevent clogging.

13.5 Detection, Actuation, and Control Systems.

13.5.1 General.

13.5.1.1 Detection, actuation, alarm, and control systems shall be installed, tested, and maintained in accordance with the requirements of the authority having jurisdiction.

13.5.1.2* For spaces greater than 6000 ft³ (170 m³), automatic release of the fire extinguishing agent shall not be permitted where actuation of the system can interfere with the safe navigation of the vessel. Automatic release of the fire extinguishing agent shall be permitted for any space where actuation of the system will not interfere with the safe navigation of the vessel.

13.5.1.2.1 Automatic release shall be permitted for any space of 6000 ft³ (170 m³) or less.

13.5.2 Automatic Detection.

13.5.2.1 Electrical detection, signaling, control, and actuation system(s) shall have at least two sources of power. The primary source shall be from the vessel's emergency bus. For vessels with an emergency bus or battery, the backup source shall be either the vessel's general alarm battery or an internal battery within the system. Internal batteries shall be capable of operating the system for a minimum of 24 hours. All power sources shall be supervised.

13.5.2.1.1 For vessels without an emergency bus or battery, the primary source shall be permitted to be the main electrical supply.

13.5.2.2 In addition to the requirements set forth in Section 9.3, actuation circuits shall not be routed through the protected space where manual electrical actuation is used in marine systems.

13.5.2.2.1 For systems complying with 13.5.2.4, actuation circuits shall be permitted to be routed through the protected space.

13.5.2.3* Manual actuation for systems shall not be capable of being put into operation by any single action. Other than as identified in 13.5.2.3.1, manual actuation stations shall be housed in an enclosure.

13.5.2.3.1 Manual actuation shall be permitted to be local manual actuation at the cylinder(s) location.

13.5.2.4 Systems protecting spaces larger than 6000 ft³ (170 m³) shall have a manual actuation station located in the main egress route outside the protected space. In addition, systems protecting spaces larger than 6000 ft³ (170 m³) having cylinders within the protected space and systems protecting unattended main machinery spaces shall have an actuation station in a continuously monitored control station outside the protected space.

13.5.2.4.1 Systems protecting spaces of 6000 ft³ (170 m³) or less shall be permitted to have a single actuation station at either of the locations described in 13.5.2.4.

13.5.2.5 Emergency lighting shall be provided for remote actuation stations serving systems protecting main machinery spaces. All manual operating devices shall be labeled to identify the hazards they protect. In addition, the following information shall be provided:

- (1) Operating instructions
- (2) Length of time delay
- (3) Actions to take if system fails to operate
- (4) Other actions to take such as closing vents and taking a head count

13.5.2.5.1 For systems having cylinders within the protected space, a means of indicating system discharge shall be provided at the remote actuation station.

13.6 Additional Requirements for Systems Protecting Class B Hazards Greater Than 6000 ft³ (170 m³) with Stored Cylinders Within the Protected Space.

13.6.1* An automatic fire detection system shall be installed in the protected space to provide early warning of fire to minimize potential damage to the fire extinguishing system before it can be manually actuated. The detection system shall initiate audible and visual alarms in the protected space and on the navigating bridge upon detection of fire. All detection and alarm devices shall be electrically supervised for continuity, and trouble indication shall be annunciated on the navigating bridge.

13.6.2* Electrical power circuits connecting the containers shall be monitored for fault conditions and loss of power. Visual and audible alarms shall be provided to indicate this, and the alarms shall be annunciated on the navigating bridge.

13.6.3* Within the protected space, electrical circuits essential for the release of the system shall be heat resistant, such as mineral-insulated cable compliant with Article 332 of *NFPA 70*, or the equivalent. Piping systems essential for the release of systems designed to be operated hydraulically or pneumatically shall be of steel or other equivalent heat-resistant material.

13.6.4* The arrangements of containers and the electrical circuits and piping essential for the release of any system shall be such that in the event of damage to any one power release line through fire or explosion in a protected space (i.e., a single-fault concept) the entire fire extinguishing charge required for that space can still be discharged.

13.6.5* The containers shall be monitored for decrease in pressure due to leakage and discharge. Visual and audible signals in the protected area and either on the navigating bridge or in the space where the fire control equipment is centralized shall be provided to indicate a low-pressure condition.

13.6.6* Within the protected space, electrical circuits essential for the release of the system shall be Class A rated in accordance with *NFPA 72*.

13.7 Enclosure.

13.7.1* To prevent loss of agent through openings to adjacent hazards or work areas, openings shall be one of the following designs:

- (1) Permanently sealed
- (2) Equipped with automatic closures
- (3) Equipped with manual closures outfitted with an alarm circuit to indicate when these closures are not sealed upon activation of the system

13.7.1.1 Where confinement of agent is not practical, or if the fuel can drain from one compartment to another, such as via a bilge, protection shall be extended to include the adjacent connected compartment or work areas.

13.7.2* Prior to agent discharge, all ventilating systems shall be closed and isolated to preclude passage of agent to other compartments or the vessel exterior. Automatic shutdowns or manual shutdowns capable of being closed by one person from a position co-located with the agent discharge station shall be used.

13.8 Design Concentration Requirements.

13.8.1 Combinations of Fuels. For combinations of fuels, the design concentration shall be derived from the flame extinguishment value for the fuel requiring the greatest concentration.

13.8.2 Design Concentration. For a particular fuel, the design concentration referred to in 13.8.3 shall be used.

13.8.3 Flame Extinguishment. The minimum design concentration for Class B flammable and combustible liquids shall be as determined following the procedures described in IMO MSC/Circ. 848, *Revised Guidelines for the Approval of Equivalent Fixed Gas Fire-Extinguishing Systems as Referred to in SOLAS 74, for Machinery Spaces and Cargo Pump-Rooms*, as amended by IMO MSC.1/Circ. 1267, *Amendments to Revised Guidelines for the Approval of Equivalent Fixed Gas Fire-Extinguishing Systems, as Referred to in SOLAS 74, for Machinery Spaces and Cargo Pump-Rooms (MSC/Circ. 848)*.

13.8.4* Total Flooding Quantity. The quantity of agent shall be based on the net volume of the space and shall be in accordance with the requirements of paragraph 5 of IMO MSC/Circ. 848, *Revised Guidelines for the Approval of Equivalent Fixed Gas Fire-Extinguishing Systems as Referred to in SOLAS 74, for Machinery Spaces and Cargo Pump-Rooms*, Annex.

13.8.5* Duration of Protection. It is important that the agent design concentration not only shall be achieved, but also shall be maintained for a sufficient period of time to allow effective emergency action by trained ship's personnel. In no case shall the hold time be less than 15 minutes.

13.9 Distribution System.

13.9.1 Rate of Application. The minimum design rate of application shall be based on the quantity of agent required for the desired concentration and the time allowed to achieve the desired concentration.

13.9.2 Discharge Time.

13.9.2.1 The discharge time for halocarbon agents shall not exceed 10 seconds or as otherwise required by the authority having jurisdiction.

13.9.2.2 For halocarbon agents, the discharge time period shall be defined as the time required to discharge from the nozzles 95 percent of the agent mass [at 70°F (21°C)] necessary to achieve the minimum design concentration.

13.9.2.3 The discharge time for inert gas agents shall not exceed 120 seconds for 85 percent of the design concentration or as otherwise required by the authority having jurisdiction.

13.10 Nozzle Choice and Location. For spaces other than those identified in 13.10.1, nozzles shall be of the type listed for the intended purpose. Limitations shall be determined based on testing in accordance with IMO MSC/Circ. 848, *Revised Guidelines for the Approval of Equivalent Fixed Gas Fire-Extinguishing Systems as Referred to in SOLAS 74, for Machinery Spaces and Cargo Pump-Rooms*. Nozzle spacing, area coverage, height, and alignment shall not exceed the limitations.

13.10.1 For spaces having only Class A fuels, nozzle placement shall be in accordance with the nozzles' listed limitations.

13.11 Inspection and Tests. At least annually, all systems shall be inspected and tested for proper operation by competent personnel. Discharge tests shall not be required.

13.11.1 An inspection report with recommendations shall be filed with the vessel's master and the owner's agent. The report shall be available for inspection by the authority having jurisdiction.

13.11.2 At least annually, the agent quantity of refillable containers shall be checked by competent personnel. The container pressure shall be verified and logged at least monthly by the vessel's crew.

13.11.3* For halocarbon clean agents, if a container shows a loss in agent of more than 5 percent or a loss in pressure, adjusted for temperature, of more than 10 percent, it shall be refilled or replaced.

13.11.3.1* If an inert gas clean agent container shows a loss in pressure, adjusted for temperature, of more than 5 percent, it shall be refilled or replaced. Where container pressure gauges are used for this purpose, they shall be compared to a separate calibrated device at least annually.

13.11.4 The installing contractor shall provide instructions for the operational features and inspection procedures specific to the clean agent system installed on the vessel.

13.12 Approval of Installations. Prior to acceptance of the system, technical documentation, such as the system design manual, test reports, or the listing report, shall be presented to the authority having jurisdiction. This documentation shall show that the system and its individual components are compatible, employed within tested limitations, and suitable for marine use.

13.12.1 The listing organization shall perform the following functions:

- (1) Verify that fire tests were conducted in accordance with a predetermined standard
- (2) Verify that component tests were conducted in accordance with a predetermined standard
- (3) Review the component quality assurance program
- (4) Review the design and installation manual
- (5) Identify system and component limitations
- (6) Verify flow calculations
- (7) Verify the integrity and the reliability of system as a whole
- (8) Have a follow-up program
- (9) Publish a list of equipment

13.13 Periodic Puff Testing. A test in accordance with 10.4.15 shall be performed at 24-month intervals. The periodic test program shall include a functional test of all alarms, controls, and time delays.

13.14 Compliance. Electrical systems shall be in accordance with 46 CFR Subchapter J. For Canadian vessels, electrical installations shall be in accordance with TP 127 E, *Ship Safety Electrical Standards*.

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.1.1 The designer is cautioned that this standard is not to be used as a design handbook. Clean agent fire extinguishing systems are complex, with new technology in this area being developed continuously. The designer will need to apply engineering judgement in conjunction with this standard when designing clean agent fire extinguishing systems.

A designer is expected to be granted some latitude when encountering special or unusual design problems, as long as the designer applies a complete and rigorous analysis to the situation. In such cases, the designer is responsible for demonstrating the validity of the approach.

A.1.1.1 The designations for perfluorocarbons (FCs), hydrochlorofluorocarbons (HCFCs), hydrofluorocarbons (HFCs), fluoriodocarbons (FICs), fluoroketones (FKs), and hydrofluoroolefins (HFOs) are an extension of halocarbon designations in ANSI/ASHRAE 34, prepared by the American National Standards Institute, Inc. (ANSI) and ASHRAE. HCFC Blend A is a designation for a blend of HCFCs and a hydrocarbon. HB-55 is a designation for a blend of HFO-1233zd and fluoroketone FK-5-1-12 (50 percent each). The designation IG-541 is used in this standard for a blend of three inert gases — nitrogen, argon, and carbon dioxide (52 percent, 40 percent, and 8 percent, respectively). The designation IG-01 is used in this standard for argon, an unblended inert gas. The designation IG-100 is used in this standard for nitrogen, an unblended inert gas. The designation IG-55 is used in this standard for a blend of two inert gases — nitrogen and argon (50 percent each).

The clean agents in Table 1.1.1 possess the physical properties as detailed in Table A.1.1.1(a) through Table A.1.1.1(d). These data will be revised from time to time as new information becomes available. Additional background information and data on these agents can be found in several references:

Fernandez (1991), Hanauska (1991), Robin (1991), and Sheinson (1991).

A.1.2 The agents in this standard were introduced in response to international restrictions on the production of certain halon fire-extinguishing agents under the Montreal Protocol signed September 16, 1987, as amended.

The Fire Suppression Systems Association (FSSA) has published a *Guide to Clean Fire Extinguishing Agents and Their Use in Fixed Systems*, which offers a user-friendly presentation of the essential properties of the agents.

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.

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

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

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

Table A.1.1.1(a) Physical Properties of Halocarbon Agents (US Units)

Physical Property	Units	FIC-131I	FK-5-1-12	HCFC Blend A	HFC Blend B	HCFC-124	HFC-125	HFC-227ea	HFC-23	HFC-236fa	HB-55
Molecular weight	N/A	195.9	316.04	92.9	99.4	136.5	120.0	170	70.01	152	184.72
Boiling point at 760 mm Hg	°F	-8.5	120.2	-37	-14.9	10.5	-54	2.4	-115.6	29.5	69.3
Freezing point	°F	-166	-162.4	161	-153.9	-326	-153	-204	-247.4	-153.4	-161
Critical temperature	°F	252	335.6	256	219.9	252.5	150.8	214	79.1	256.9	319.8
Critical pressure	psi	586	270.44	964	588.9	527	525	424	700	464.1	419.4
Critical volume	ft ³ /lbm	0.0184	0.0251	0.028	0.031	0.0286	0.0279	0.0280	0.0304	0.02905	0.0307
Critical density	lbm/ft ³	54.38	39.91	36	32.17	34.96	35.81	35.77	32.87	34.42	32.6
Specific heat, liquid at 77°F	Btu/lb-°F	0.141	0.2634	0.3	0.339	0.271	0.354	0.281	0.987 at 68°F	0.3012	0.2800
Specific heat, vapor at constant pressure (1 atm) and 77°F	Btu/lb-°F	0.86	0.2127	0.16	0.203	0.18	0.19	0.193	0.175 at 68°F	0.201	0.2033
Heat of vaporization at boiling point	Btu/lb	48.1	37.8	97	93.4	71.3	70.5	56.6	103	68.97	62.23
Thermal conductivity of liquid at 77°F	Btu/hr-ft-°F	0.04	0.034	0.052	0.0478	0.0395	0.0343	0.034	0.0305	0.0421	0.0390
Viscosity, liquid at 77°F	lb/ft-hr	0.473	1.27	0.508	0.485	0.622	0.338	0.579	0.107	0.6906	1.214
Relative dielectric strength at 1 atm at 734 mm Hg, (N ₂ = 1)	N/A	1.41 at 77°F	2.3 at 77°F	1.32 at 77°F	1.014 at 77°F	1.55 at 77°F	0.955 at 70°F	2 at 77°F	1.04 at 77°F	1.0166 at 77°F	N/A
Solubility of water in agent	wt%	0.01 at 70°F	<0.001 at 70°F	0.12 at 70°F	0.11 at 70°F	770 at 77°F	770 at 77°F	0.06 at 70°F	500 at 50°F	740 at 68°F	N/A

Table A.1.1.1(b) Physical Properties of Inert Gas Agents (US Units)

Physical Property	Units	IG-01	IG-100	IG-541	IG-55
Molecular weight	N/A	39.9	28.0	34.0	33.95
Boiling point at 760 mm Hg	°F	-302.6	-320.4	-320	-310.2
Freezing point	°F	-308.9	-346.0	-109	-327.5
Critical temperature	°F	-188.1	-232.4	N/A	-210.5
Critical pressure	psia	711	492.9	N/A	602
Specific heat, vapor at constant pressure (1 atm) and 77°F	Btu/lb °F	0.125	0.445	0.195	0.187
Heat of vaporization at boiling point	Btu/lb	70.1	85.6	94.7	77.8
Relative dielectric strength at 1 atm at 734 mm Hg, 77°F (N ₂ = 1.0)	N/A	1.01	1.0	1.03	1.01
Solubility of water in agent at 77°F	N/A	0.006%	0.0013%	0.015%	0.006%

Shaded text = Revisions. **Δ** = Text deletions and figure/table revisions. • = Section deletions. **N** = New material

Table A.1.1.1(c) Physical Properties of Halocarbon Agents (SI Units)

Physical Property	Units	FIC-131I	FK-5-1-12	HCFC Blend A	HFC Blend B	HCFC-124	HFC-125	HFC-227ea	HFC-23	HFC-236fa	HB-55
Molecular weight	N/A	195.91	316.04	92.90	99.4	136.5	120	170	70.01	152	184.72
Boiling point at 760 mm Hg	°C	-22.5	49	-38.3	-26.1	-12.0	-48.1	-16.4	-82.1	-1.4	20.7
Freezing point	°C	-110	-108	<107.2	-103	-198.9	-102.8	-131	-155.2	-103	-107
Critical temperature	°C	122	168.66	124.4	101.1	122.6	66	101.7	26.1	124.9	159.2
Critical pressure	kPa	4041	1865	6647	4060	3620	3618	2912	4828	3200	2892
Critical volume	cc/mole	225	494.5	162	198	243	210	274	133	276*	354.2
Critical density	kg/m ³	871	639.1	577	515.3	560	574	621	527	551.3	521.6
Specific heat, liquid at 25°C	kJ/kg - °C	0.592 at 25°C	1.103 at 25°C	1.256 at 25°C	1.44 at 25°C	1.153 at 25°C	1.407 at 25°C	1.184 at 25°C	4.130 at 20°C	1.264 at 25°C	1.1717
Specific heat, vapor at constant pressure (1 atm) and 25°C	kJ/kg - °C	0.3618 at 25°C	0.891 at 25°C	0.67 at 25°C	0.848 at 25°C	0.742 at 25°C	0.797 at 25°C	0.808 at 25°C	0.731 at 20°C	0.840 at 25°C	0.8512
Heat of vaporization at boiling point	kJ/kg	112.4	88	225.6	217.2	165.9	164.1	132.6	239.3	160.4	144.5
Thermal conductivity of liquid at 25°C	W/m - °C	0.07	0.059	0.09	0.082	0.0684	0.0592	0.069	0.0534	0.0729	0.0675
Viscosity, liquid at 25°C	centipoise	0.196	0.524	0.21	0.202	0.257	0.14	0.184	0.044	0.286	0.502
Relative dielectric strength at 1 atm at 734 mm Hg (N ₂ = 1.0)	N/A	1.41 at 25°C	2.3 at 25°C	1.32 at 25°C	1.014 at 25°C	1.55 at 25°C	0.955 at 21°C	2 at 25°C	1.04 at 25°C	1.0166 at 25°C	N/A
Solubility of water in agent	ppm	1.0062% by weight	<0.001	0.12% by weight	0.11% by weight	700 at 25°C	700 at 25°C	0.06% by weight	500 at 10°C	740 at 20°C	N/A

Table A.1.1.1(d) Physical Properties of Inert Gas Agents (SI Units)

Physical Property	Units	IG-01	IG-100	IG-541	IG-55
Molecular weight	N/A	39.9	28.0	34.0	33.95
Boiling point at 760 mm Hg	°C	-189.85	-195.8	-196	-190.1
Freezing point	°C	-189.35	-210.0	-78.5	-199.7
Critical temperature	°C	-122.3	-146.9	N/A	-134.7
Critical pressure	kPa	4,903	3,399	N/A	4,150
Specific heat, vapor at constant pressure (1 atm) and 25°C	kJ/kg °C	0.519	1.04	0.574	0.782
Heat of vaporization at boiling point	kJ/kg	163	199	220	181
Relative dielectric strength at 1 atm at 734 mm Hg, 25°C (N ₂ = 1.0)	N/A	1.01	1.0	1.03	1.01
Solubility of water in agent at 25°C	N/A	0.006%	0.0013%	0.015%	0.006%

A.3.3.1 Abort Switch. The effect of an abort switch is typically a programmable configuration of the releasing panel, such that any of several modes of operation can be used. Typical options include the following:

- (1) Engaging the abort switch pauses the countdown for as long as the switch remains engaged. The countdown resumes when the switch is released.
- (2) Engaging the abort switch resets the timer to a predetermined value (e.g., the initial value or 30 seconds) and pauses the countdown for as long as the switch remains engaged. The countdown restarts when the switch is released.
- (3) Engaging the switch permits the timer to continue counting down until it reaches a predetermined value (e.g., 10 seconds), then it pauses for as long as the switch remains engaged. The countdown resumes from the predetermined value when the switch is released.

Where an abort switch is installed, the selected mode should be approved by the authority having jurisdiction. (*See Section 9.6 and 10.6.14.*)

A.3.3.7 Clean Agent. The word *agent* as used in this document means clean agent unless otherwise indicated.

A.3.3.10 Deep-Seated Fire. A characteristic of this type of combustion is the slow rate of heat loss from the reaction zone. Thus, the fuel remains hot enough to exothermically react with oxygen, even though the rate of reaction, which is controlled by diffusion processes, is extremely slow. Deep-seated fires can continue to burn for many weeks, for example, in bales of cotton and jute and heaps of sawdust. A deep-seated 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.

Deep-seated fires are usually extinguished by reducing the fuel temperature either directly via the application of a heat-absorbing medium, such as water, or by blanketing it with an inert gas. The medium slows the reaction rate to the point where heat generated by oxidation is less than heat loss in the surroundings. This causes the temperature to fall below the level necessary for re-ignition after removal of the inert atmosphere.

A.3.3.11.1 Final Design Concentration (FDC). The FDC is equal to or greater than the minimum design concentration.

A.3.3.11.3 Minimum Design Concentration (MDC). This term is also referred to as simply *design concentration* throughout this document. When determining the duration of protection it is 85 percent of the MDC that must be held for the duration of the retention time (*see Section 7.4*).

A.3.3.11.4 Minimum Extinguishing Concentration (MEC). For Class C fires where the protected equipment is energized at less than 480 volts, the MEC is taken to be the Class A MEC.

A.3.3.18 Halocarbon Agent. Examples are hydrofluorocarbons (HFCs), hydrochlorofluorocarbons (HCFCs), perfluorocarbons (PFCs or FCs), fluoriodocarbons (FICs), and fluoroketones (FKs).

A.3.3.19 Impairment. Temporarily shutting down a clean agent 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.

A.3.3.33 Normally Occupied Enclosure or Space. Areas considered not normally occupied include spaces occasionally visited by personnel, such as transformer bays, switch houses, pump rooms, vaults, engine test stands, cable trays, tunnels, microwave relay stations, flammable liquid storage areas, and enclosed energy systems.

A.4.2 Clean agent fire-extinguishing systems are useful within the limits of this standard for extinguishing fires in specific hazards or equipment and in occupancies where an electrically nonconductive medium is essential or desirable or where cleanup of other media presents a problem.

Total-flooding clean agent fire-extinguishing systems are used primarily to protect hazards that are in enclosures or equipment that, in itself, includes an enclosure to contain the agent. Some typical hazards that could be suitable include, but are not limited to, the following:

- (1) Electrical and electronic hazards
- (2) Subfloors and other concealed spaces
- (3) Flammable and combustible liquids and gases
- (4) Other high-value assets
- (5) Telecommunications facilities

Clean agent systems could also be used for explosion prevention and suppression where flammable materials could collect in confined areas.

A.4.2.3 This provision provides consideration for using a clean agent in an environment that could result in an inordinate amount of products of decomposition (e.g., within an oven).

A.4.2.4 Information can be found in the following references:

- (1) Brian P. Rawson and Kent C. Green, "Inert Gas Data Center Fire Protection and Hard Disk Drive Damage," *Data Center Journal*, August 27, 2012 (<http://www.datacenterjournal.com/it/inert-gas-data-center-fire-protection-and-hard-disk-drive-damage/>).
- (2) Eurofeu, "Fixed Extinguishing Installation Section, Guidance paper on Impact of noise on Computer hard drives," October 2012.
- (3) FSSA White Paper, "Effect of Sound Waves on Data Storage Devices," Fire Suppression Systems Association, Baltimore, MD, 2018.
- (4) Juan Jose Merlo Latorre, "Hard Drive Damage," *Industrial Fire Journal*, Autumn 2013, issue no. 93, pp 12–14.
- (5) Sandahl, D., A. Elder, and A. Barnard, "Impact of Sound on Computer Hard Disk Drives and Risk Mitigation Measures," Johnson Controls Form No. T-2016367-01, 2018.
- (6) Section D.3 of NFPA 75.
- (7) Siemens White Paper, "Potential damage to hard disk drives during discharges of dry extinguishing systems," Siemens, September 2012.

A.4.3 Potential hazards to be considered for individual systems are the following:

- (1) *Noise.* Discharge of a system can cause noise loud enough to be startling but ordinarily insufficient to cause traumatic injury.
- (2) *Turbulence.* High-velocity discharge from nozzles could be sufficient to dislodge substantial objects directly in the path. System discharge can cause enough general turbu-

lence in the enclosures to move unsecured paper and light objects.

- (3) *Cold temperature.* Direct contact with the vaporizing liquid being discharged from a system will have a strong chilling effect on objects and can cause frostbite burns to the skin. The liquid phase vaporizes rapidly when mixed with air and thus limits the hazard to the immediate vicinity of the discharge point. In humid atmospheres, minor reduction in visibility can occur for a brief period due to the condensation of water vapor.

A.4.3.1 The discharge of clean agent systems to extinguish a fire could create a hazard to personnel from the natural form of the clean agent or from the products of decomposition that result from exposure of the agent to the fire or hot surfaces. Unnecessary exposure of personnel either to the natural agent or to the decomposition products should be avoided.

The SNAP Program was originally outlined in the *Federal Register*, "EPA SNAP Program."

A.4.3.2 See Section B.1 for information on the toxicological effects of halocarbon agents.

A.4.3.2.4 One objective of pre-discharge alarms and time delays is to prevent human exposure to agents.

A.4.3.3 See Section B.2 for information on the physiological effects of inert gas agents.

A.4.3.3.3 One objective of pre-discharge alarms and time delays is to prevent human exposure to agents.

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*, 5th edition. Various approaches are described, which can be used by the 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 required safe egress time (RSET), which is the maximum allowed exposure time limit in 4.3.2 and 4.3.3. The ASET value should be less than the RSET value. If the ASET value is initially determined to be equal to or exceed the RSET value, egress facilities should be modified so that the ASET value is less than the RSET value. Alternatively, an egress study involving the time recording of an actual 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 The steps and safeguards necessary to prevent injury or death to personnel in areas whose atmospheres will be made hazardous by the discharge or thermal decomposition of clean agents can include the following:

- (1) Provision of adequate aisleways and routes of exit and procedures to keep them clear at all times.
- (2) Provision of emergency lighting and directional signs as necessary to ensure quick, safe evacuation.
- (3) Provision of alarms within such areas that will operate immediately upon detection of the fire.
- (4) Provision of only outward-swinging, self-closing doors at exits from hazardous areas and, where such doors are latched, provision of panic hardware.
- (5) Provision of continuous alarms at entrances to such areas until the atmosphere has been restored to normal.
- (6) Provision of warning and instruction signs at entrances to and inside such areas. These signs should inform persons in or entering the protected area that a clean agent system is installed and should contain additional instructions pertinent to the conditions of the hazard.
- (7) Provision for the prompt discovery and rescue of persons rendered unconscious in such areas. This should be accomplished by having such areas searched immediately by trained personnel equipped with proper breathing equipment. Self-contained breathing equipment and personnel trained in its use and in rescue practices, including artificial respiration, should be readily available.
- (8) Provision of instruction and drills for all personnel within or in the vicinity of such areas, including maintenance or construction people who could be brought into the area, to ensure their correct action when a clean agent system operates.
- (9) Provision of means for prompt ventilation of such areas. Forced ventilation will often be necessary. Care should be taken to readily dissipate hazardous atmospheres and not merely move them to another location.
- (10) Prohibition against smoking by persons until the atmosphere has been determined to be free of the clean agent.
- (11) Provision of such other steps and safeguards that a careful study of each particular situation indicates is necessary to prevent injury or death.

A.4.3.6 A certain amount of leakage from a protected space to adjacent areas is anticipated during and following agent discharge. Consideration should be given to agent concentration (when above NOAEL), decomposition products, products of combustion, and relative size of adjacent spaces. Additional consideration should be given to exhaust paths when opening or venting the enclosure after a discharge.

A.4.3.7 In applying this provision of the standard, it is important to understand the relationship between agent concentration and egress time. The agent concentration permitted for human exposure is linked to the amount of time for which a person could be exposed to the agent concentration. For example, exposure to an HFC-227ea concentration up to and including 10.5 percent is permitted if the maximum exposure time (egress time) is limited to not more than 5 minutes, but exposure to a concentration of 11 percent would be permitted only if the exposure time could be limited to not more than 1.13 minutes. Similarly, exposure to an inert gas agent concentration up to 43 percent is permitted if the exposure time is limited to not more than 5 minutes, while exposure to a concentration up to 52 percent is permitted only if the exposure time is limited to not more than 3 minutes.

A.4.3.7.1 Inert gases used to operate pre-discharge alarms include inert gas clean agents, nitrogen, and carbon dioxide.

A.4.5.5 Electrostatic charging of ungrounded conductors could occur during the discharge of liquefied gases. These conductors could discharge to other objects, causing an electric arc of sufficient energy to initiate an explosion.

While an attractive feature of these agents is their suitability for use in environments containing energized electrical equipment without damaging that equipment, in some instances the electrical equipment could be the source of ignition. In such cases, the energized equipment should be de-energized prior to or during agent discharge.

See NFPA 77.

A.4.6 Many factors impact the environmental acceptability of a fire suppression agent. Uncontrolled fires pose significant impact by themselves. All extinguishing agents should be used in ways that eliminate or minimize the potential environmental impact (see Table A.4.6). General guidelines to be followed to minimize this impact include the following:

- (1) Not performing unnecessary discharge testing
- (2) Considering the ozone depletion and global warming impact of the agent under consideration and weighing those impacts against the fire safety concerns
- (3) Recycling all agents where possible
- (4) Consulting the most recent environmental regulations on each agent

The unnecessary emission of clean extinguishing agents with non-zero ODP, non-zero GWP, or both should be avoided. All phases of design, installation, testing, and maintenance of systems using these agents should be performed with the goal of no emission into the environment.

GWP is a measure of how much a given mass of greenhouse gas is estimated to contribute to global warming. It is a relative scale that compares the gas in question to the same mass of carbon dioxide whose GWP is by convention equal to 1.

It is important to understand that the impact of a gas on climate change is a function of both the GWP of the gas and the amount of the gas emitted.

The ODP of an agent provides a relative comparison of the ability to react with ozone at altitudes within the stratosphere. ODP values are reported relative to the same mass CFC-11, which has an ODP equal to 1. When the environmental profile of a compound is considered, both the ODP and the GWP values should be considered to ensure that the agent selected complies with all local and regional regulations balanced with end user specifications. Good independent resources for environmental properties in terms of GWP and ODP of clean agent alternatives are available from the Montreal Protocol and the Intergovernmental Panel on Climate Change (IPCC).

A.4.8.1 It is generally believed that, because of the highly stable nature of the compounds that are derived from the families that include halogenated hydrocarbons and inert gases, incompatibility will not be a problem. These materials tend to behave in a similar fashion, and, as far as is known, the reactions that could occur as the result of the mixing of these materials within the container is not thought to be a real consideration with regard to their application to a fire protection hazard.

It clearly is not the intent of 4.8.1 to deal with compatibility of the agents with components of the extinguishing hardware nor to deal with the subject of storability or storage life of individual agents or mixtures of those agents. Each of these concerns is addressed elsewhere in this standard.

A.5.1.1.2 An additional complement of charged cylinders (connected reserve) manifolded and piped to feed into the automatic system should be considered on all installations. The reserve supply is normally actuated by manual operation of the main/reserve switch on either electrically operated or pneumatically operated systems. A connected reserve is desirable for the following reasons:

- (1) It provides protection should a reflash occur.

Table A.4.6 Potential Environmental Impacts

Agent	GWP (IPCC 2013)	ODP
FIC-1311	≤1	0*
FK-5-1-12	<1	0
HCFC Blend A	1500	0.048
HFC Blend B	1400	0
HCFC-124	527	0.022
HFC-125	3170	0
HFC-227ea	3350	0
HFC-23	12,400	0
HFC-236fa	8060	0
IG-01	0	0
IG-100	0	0
IG-541	0	0
IG-55	0	0
HB-55	1	0.000

Note: GWP is reported over a 100-year integrated time horizon.

*Agent might have a non-zero ODP if released at altitudes high above ground level.

- (2) It provides reliability should the main bank malfunction.
- (3) It provides protection during impaired protection when main tanks are being replaced.
- (4) It provides protection of other hazards if selector valves are involved and multiple hazards are protected by the same set of cylinders.

If a full complement of charged cylinders cannot be obtained or if the empty cylinder cannot be recharged, delivered, and reinstalled within 24 hours, a third complement of fully charged, nonconnected spare cylinders should be considered and made available on the premises for emergency use. The need for spare cylinders could depend on whether the hazard is under the protection of automatic sprinklers.

A.5.1.2 The normal and accepted procedures for making these quality measurements are provided in international standards (e.g., ASTM, Air-conditioning Heating and Refrigeration Institute) or by the chemical manufacturer. Refer to the *Code of Practice for Use of Recycled Halogenated Clean Agents* for additional information.

A.5.1.2.3 The NFPA 2001 purity specifications and cardiac sensitization NOAEL help to address the safety of agents included in the standard. Historically, the unstated safety assumptions have been as follows:

- (1) The NOAEL for cardiac sensitization will be protective for all other end points of acute toxicity.
- (2) 99 percent purity precludes the presence of impurities that could impact the NOAEL for agent acute toxicity.

However, there are some impurities that, when present at less than 1 percent by weight in the liquid agent, could result in acute toxicity at agent concentrations below the NOAEL for cardiac sensitization. Hexafluoropropylene (HFP) thermodynamic and kinetic dimers are examples of such impurities. For these dimers, a 5-minute exposure to a concentration in air greater than 10 ppm by volume for the HFP thermodynamic dimer or greater than 300 ppm by volume for the HFP kinetic dimer could cause toxicological effects. [Maranian, 2020] For FK-5-1-12 at a use concentration of 10 percent by volume in air, these levels would translate to 95 ppm (0.0095 percent) by weight in the liquid agent for the thermodynamic dimer and 2850 ppm (0.2850 percent) by weight in the liquid agent for the kinetic dimer.

Reference: Maranian, B., Memo to the NFPA 2001 Technical Committee, "Re: Section 5.1.1.2 Second Draft Public Comment #23," US Environmental Protection Agency, October 6, 2020.

A.5.1.3.2 Storage containers should not be exposed to a fire in a manner likely to impair system performance.

A.5.1.4.1 Containers used for agent storage should be fit for the purpose. Materials of construction of the container, closures, gaskets, and other components should be compatible with the agent and designed for the anticipated pressures. Each container is equipped with a pressure relief device to protect against excessive pressure conditions.

The variations in vapor pressure with temperature for the various clean agents are shown in Figure A.5.1.4.1(a) through A.5.1.4.1(n).

For halocarbon clean agents, the pressure in the container is significantly affected by fill density and temperature. At elevated temperatures, the rate of increase in pressure is very sensitive to fill density. If the maximum fill density is exceeded, the pressure will increase rapidly with temperature increase and present a hazard to personnel and property. Therefore, it is important that the maximum fill density limit specified for each liquefied clean agent not be exceeded. Adherence to the limits for fill density and pressurization levels specified in Table A.5.1.4.1 should prevent excessively high pressures from occurring if the agent container is exposed to elevated temperatures. Adherence to the limits will also minimize the possibility of an inadvertent discharge of agent through the pressure relief device. The manufacturer should be consulted for superpressurization levels other than those shown in Table A.5.1.4.1.

Annex F discusses the effects of temperature changes on superpressurized vaporizing-liquid agents.

With the exception of inert gas-type systems, all the other clean agents are classified as liquefied compressed gases at 70°F (21°C). For these agents, the pressure in the container is significantly affected by fill density and temperature. At elevated temperatures, the rate of increase in pressure is very sensitive to fill density. If the maximum fill density is exceeded, the pressure will increase rapidly with temperature increase and present a hazard to personnel and property. Therefore, it is important that the maximum fill density limit specified for each liquefied clean agent not be exceeded. Adherence to the limits for fill density and pressurization levels specified in Table A.5.1.4.1 should prevent excessively high pressures from occurring if the agent container is exposed to elevated temperatures. Adherence to the limits will also minimize the possibility of an inadvertent discharge of agent through the pressure relief

device. The manufacturer should be consulted for superpressurization levels other than those shown in Table A.5.1.4.1.

A.5.1.4.2 Although it is not a requirement of 5.1.4.2, all new and existing halocarbon agent storage containers should be affixed with a label advising the user that the product in question can be returned for recovery and recycling to a qualified recycler when the halocarbon agent is no longer needed. The qualified recycler can be a halocarbon agent manufacturer, a fire equipment manufacturer, a fire equipment distributor or installer, or an independent commercial venture. It is not the intent to set down specific requirements but to indicate the factors that need to be taken into consideration with regard to recycling and reclamation of the halocarbon agent products, once facilities are available. As more information becomes available, more definitive requirements can be set forth in this section regarding quality, efficiency, recovery, and qualifications and certifications of facilities recycling halocarbon agents. Currently, no such facilities exist that would apply to the halocarbon agents covered by this document.

Inert gas agents need not be collected or recycled.

A.5.1.4.5 For refillable halocarbon agent containers, an LLI can be considered, where available from the system manufacturer. The LLI provides the means to safely determine the quantity of halocarbon agent in accordance with the requirements of 11.3.1 without lifting or moving the container.

A.5.1.4.6(2) Inert gas agents are single-phase gases in storage and at all times during discharge.

A.5.1.4.7 The use of environmental controls should be considered when the storage location for clean agent system containers is subject to conditions outside of the storage temperature limits stated in the listed manual for the clean agent system.

A.5.2.1 Piping should be installed in accordance with good commercial practice. Care should be taken to avoid possible restrictions due to foreign matter, faulty fabrication, or improper installation.

The piping system should be securely supported with due allowance for agent thrust forces and thermal expansion and contraction and should not be subjected to mechanical, chemical, vibration, or other damage. ASME B31.1, *Power Piping Code*, should be consulted for guidance on this matter. Where explosions are likely, the piping should be attached to supports that are least likely to be displaced.

A.5.2.1.1 Paragraph 5.2.1.1 requires that "the thickness of the piping shall be calculated in accordance with ASME B31.1." To comply with this requirement, the guidelines found in the *FSSA Pipe Design Guide for Use with Special Hazard Fire Suppression Systems* should be followed. The *FSSA Pipe Design Guide 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. ASME B31.1 allows the pressure to exceed the maximum design pressure, provided it is for short operating periods. Clean agent piping systems are not subjected to continuous pressurization. When discharge times are less than 60 minutes in duration, NFPA 2001 allows the yield stress factors (SE) published in ASME B31.1 to be increased by 20 percent when calculating the pipe thickness.

Table A.5.1.4.1 Storage Container Characteristics

Extinguishing Agent	Maximum Fill Density (lb/ft ³)	Minimum Container Design Level Working Pressure (Gauge) (psi)	Total Gauge Pressure Level at 70°F (psi)
FK-5-1-12	90	500	360
HCFC Blend A	56.2	500	360
HCFC-124	71	240	195
HFC-125	58	320	166.4 ^a
HFC-227ea	72	500	360
HFC-23	54	1800	608.9 ^a
FIC-131I	104.7	500	360
IG-01	N/A	2120	2370
IG-100 (300)	N/A	3600	4061
IG-100 (240)	N/A	2879	3236
IG-100 (180)	N/A	2161	2404
IG-541	N/A	2015	2175
IG-541 (200)	N/A	2746	2900
IG-55 (2222)	N/A	2057	2222 ^b
IG-55 (2962)	N/A	2743	2962 ^c
IG-55 (4443)	N/A	4114	4443 ^d
HFC Blend B	58	400	195 ^e
HB-55	81.5	500	360
HB-55	81.0	500	500

For SI units, 1 lb/ft³ = 16.018 kg/m³; 1 psi = 6895 Pa; °C = (°F – 32)/1.8.

Notes:

(1) The maximum fill density requirement is not applicable for IG-541. Cylinders for IG-541 are DOT 3A or 3AA and are stamped 2015 or greater.

(2) Total pressure level at 70°F (21°C) is calculated from the following filling conditions:

IG-100 (300): 4351 psi (30.0 MPa) and 95°F (35°C)

IG-100 (240): 3460 psi (23.9 MPa) and 95°F (35°C)

IG-100 (180): 2560 psi (17.7 MPa) and 95°F (35°C)

IG-55 (2222): 2175 psi (15 MPa) and 59°F (15°C)

IG-55 (2962): 2901 psi (20 MPa) and 59°F (15°C)

IG-55 (4443): 4352 psi (30 MPa) and 59°F (15°C)

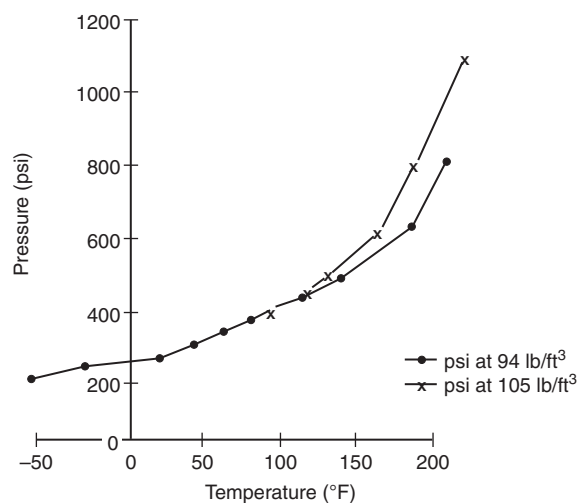
^a Vapor pressure for HFC-23 and HFC-125.

^b Cylinders for IG-55 are stamped 2060.

^c Cylinders for IG-55 are DOT 3A or 3AA stamped 2750 or greater.

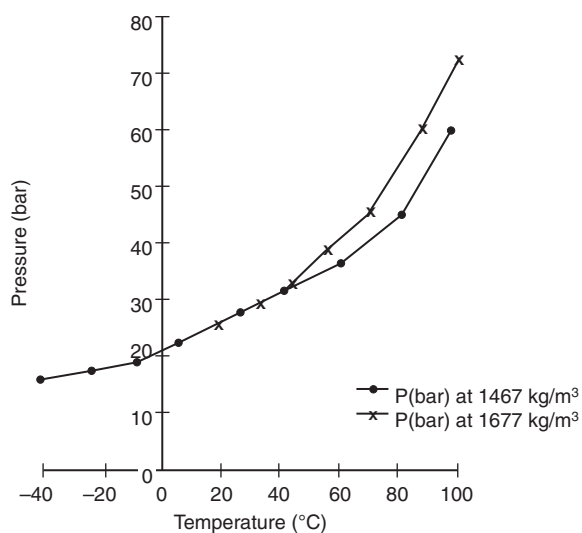
^d Cylinders for IG-55 are DOT 3A or 3AA stamped 4120 or greater.

^e Vapor pressure of agent.



Note: CF3I pressure versus temperature at 94 lb/ft³ and 105 lb/ft³

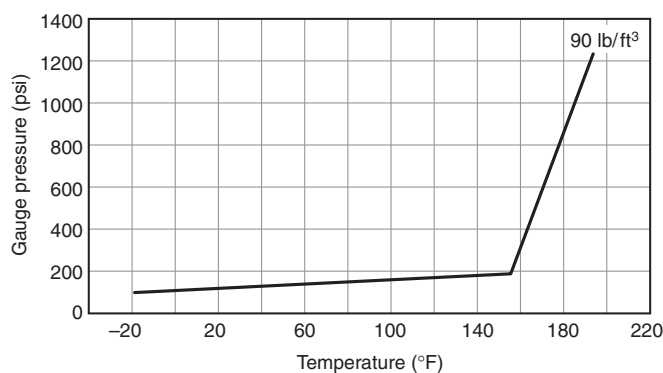
(1) U.S.



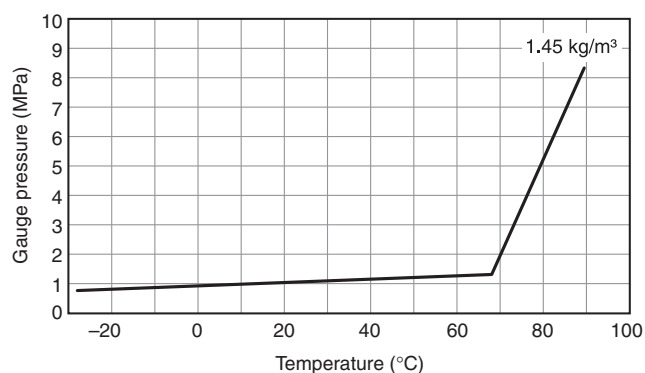
Note: CF3I pressure versus temperature at 1467 kg/m³ and 1677 kg/m³

(2) SI

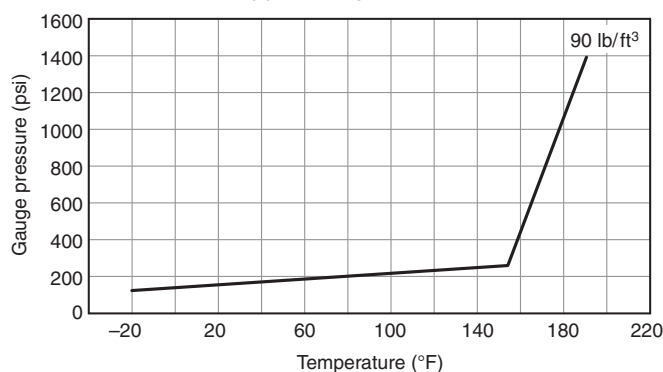
FIGURE A.5.1.4.1(a) Isometric Diagram of FIC-13I1.



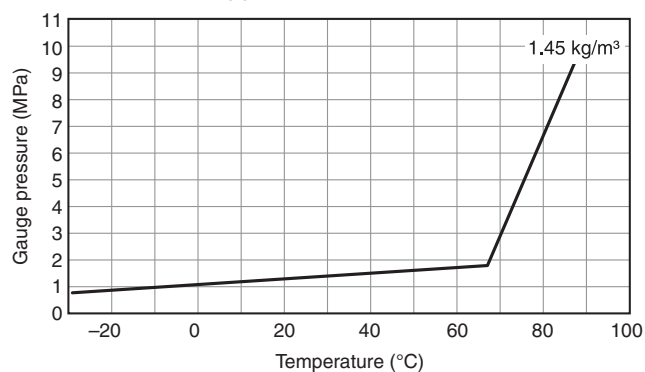
(1) For 150 psi containers



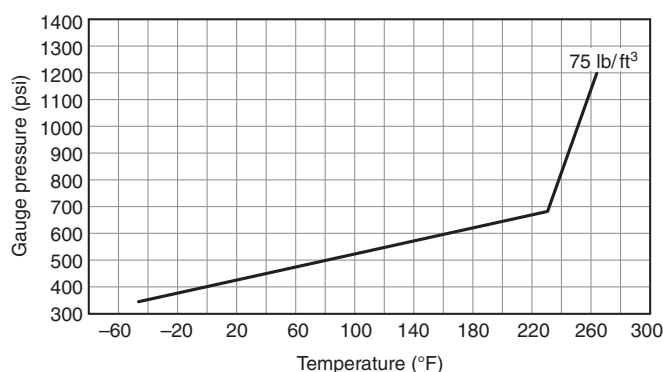
(2) For 1.0 MPa containers



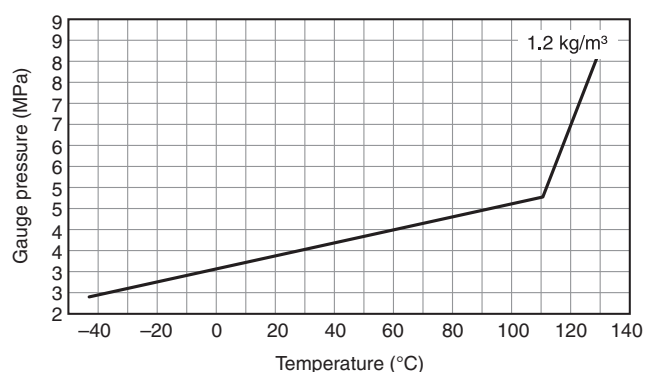
(3) For 195 psi containers



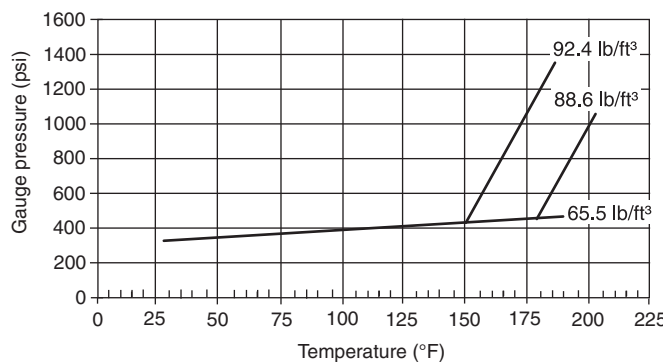
(4) For 1.3 MPa containers



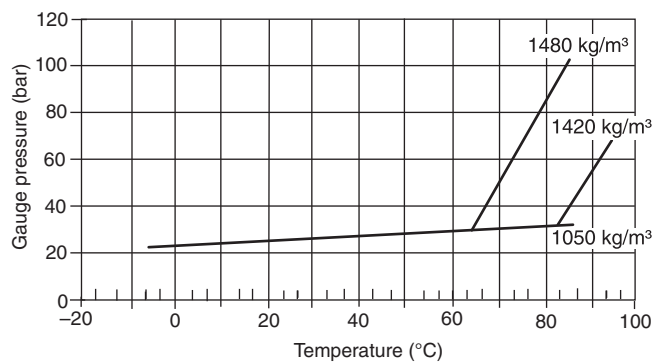
(5) For 500 psi containers



(6) For 3.4 MPa containers

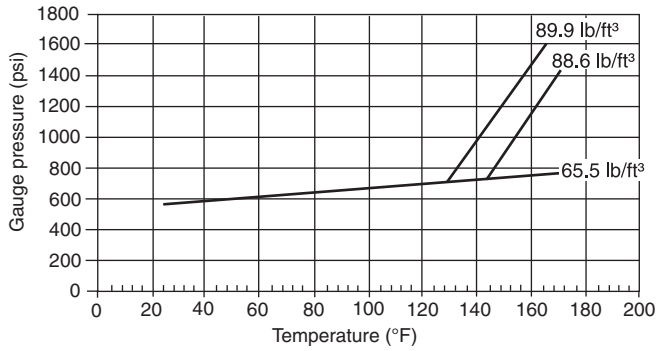


(7) To 360 psi at 70°F

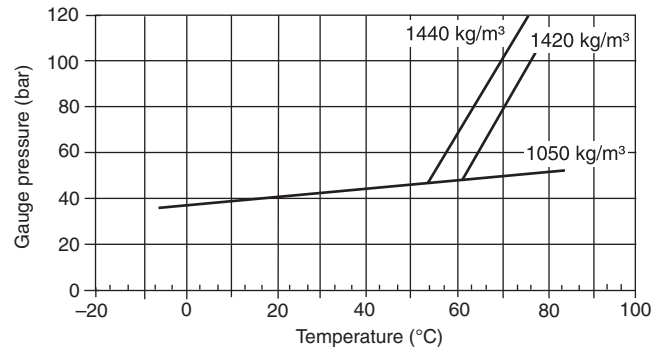


(8) To 25 bar at 20°C

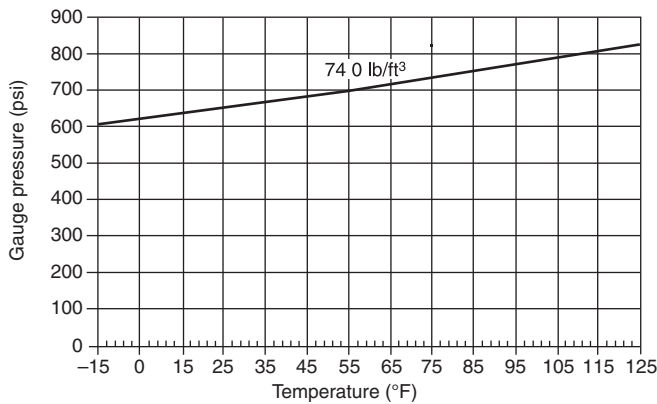
FIGURE A.5.1.4.1(b) Isometric Diagram of FK-5-1-12.



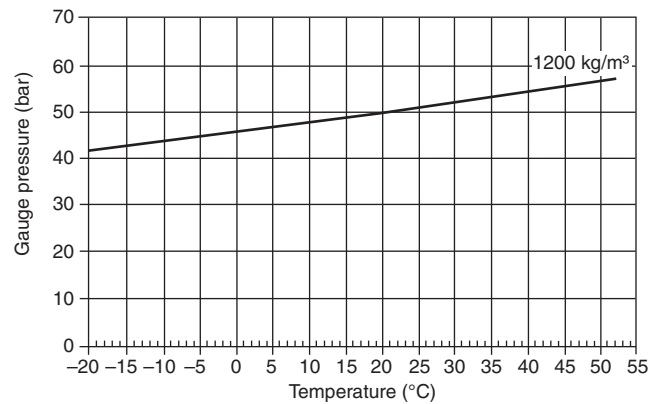
(9) To 610 psi at 70°F



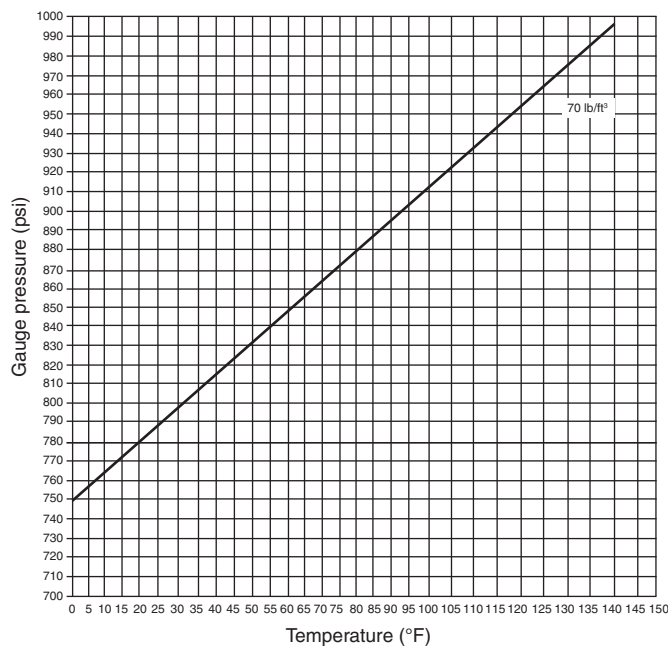
(10) To 42 bar at 20°C



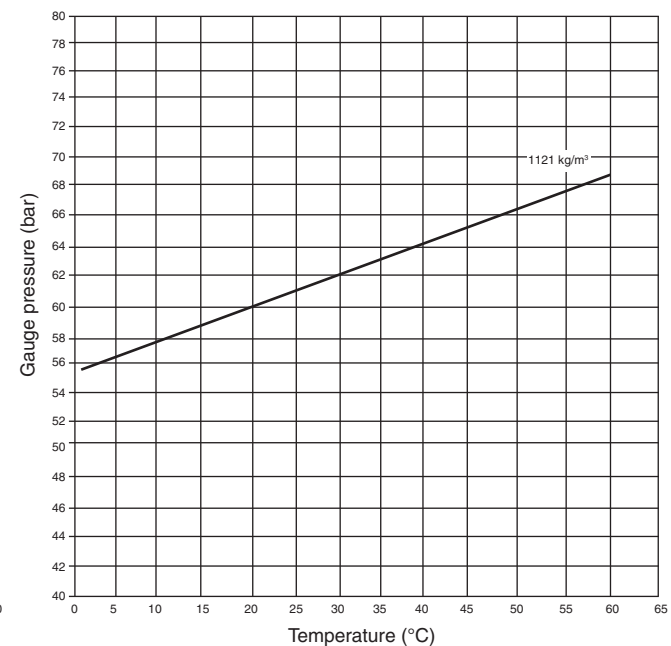
(11) To 725 psi at 68°F



(12) To 50 bar at 20°C



(13) To 870 psi at 70°F



(14) To 60 bar at 21°C

▲ FIGURE A.5.1.4.1(b) Continued