NFPA®

2001

Standard on Clean Agent Fire Extinguishing Systems

2018

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listing. 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. These pre-engineered systems 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. All other requirements of the standard shall apply.
(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.

1.4.2.2 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

1.4.2.3* Where a total flooding system is used, a fixed enclosure shall be provided about the hazard that allows a specified agent concentration to be achieved and maintained for a specified period of time.

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

1.5 Safety.

1.5.1* Hazards to Personnel.

1.5.1.1* 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 U.S. Environmental Protection Agency (EPA) Significant New Alternatives Policy (SNAP) Program for total flooding agents.

Δ Table 1.4.1.2 Agents Addressed in NFPA 2001

Agent Designation	Chemical Name	Chemistry
FK-5-1-12	Dodecafluoro-2-methylpentan-3-one	$CF_3CF_2C(O)CF(CF_3)_2$
HCFC Blend A	Dichlorotrifluoroethane HCFC-123 (4.75%)	$CHCl_2CF_3$
	Chlorodifluoromethane HCFC-22 (82%)	$CHClF_2$
	Chlorotetrafluoroethane HCFC-124 (9.5%)	$CHClFCF_3$
	Isopropenyl-1-methylcyclohexene (3.75%)	
HCFC-124	Chlorotetrafluoroethane	$CHClFCF_3$
HFC-125	Pentafluoroethane	CHF_2CF_3
HFC-227ea	Heptafluoropropane	CF_3CHFCF_3
HFC-23	Trifluoromethane	CHF_3
HFC-236fa	Hexafluoropropane	$CF_3CH_2CF_3$
FIC-13I1	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
IG-55	Nitrogen (50%)	N_2
	Argon (50%)	Ar
HFC Blend B	Tetrafluoroethane (86%)	$CH_2 FCF_3$
	Pentafluoroethane (9%)	CHF_2CF_3
	Carbon dioxide (5%)	CO_2

Notes:
(1) Other agents could become available at later dates. They 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. Composition of HCFC Blend A is given in percent by weight.
(3) The full analogous ASHRAE nomenclature for FK-5-1-12 is FK-5-1-12mmy2.

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

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

U.S. Coast Guard, Title 46, Code of Federal Regulations, Part 72.

U.S. Coast Guard, Title 46, Code of Federal Regulations, Subchapter J, "Electrical Engineering."

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

2.3.12 Other Publications.

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

2.4 References for Extracts in Mandatory Sections.

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

Chapter 3 Definitions

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

3.2 NFPA Official Definitions.

3.2.1* Approved. Acceptable to the authority having jurisdiction.

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

3.2.3* 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 phrase "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.

N **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.

Δ **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 Design Concentration.

3.3.10.1* ***Adjusted Minimum Design Concentration (AMDC).*** The target minimum design concentration after the safety factor and the design factors have been taken into account.

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

3.3.11 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.

3.3.12 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.

3.3.13 Fill Density. Mass of agent per unit of container volume (the customary units are lb/ft^3 or kg/m^3).

3.3.14 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.

5.3.6.1 If not shut down or closed automatically, the volume of the self-contained recirculating undampered ventilation system ducts and components mounted below the ceiling height of the protected space shall be considered as part of the total hazard volume when determining the quantity of agent.

5.3.6.2 Ventilation systems necessary to ensure safety shall not be required to be shut down upon activation of the fire suppression system. An extended agent discharge shall be provided to maintain the design concentration for the required duration of protection.

5.3.7* The protected enclosure shall have the structural strength and integrity necessary to contain the agent discharge. If the developed pressures present a threat to the structural strength of the enclosure, venting shall be provided to prevent excessive pressures. Designers shall consult the system manufacturer's recommended procedures relative to enclosure venting. *[For pressure relief vent area or equivalent leakage area, see 5.1.2.2(28).]*

5.4 Design Concentration Requirements.

5.4.1 The flame extinguishing or inerting concentrations shall be used in determining the agent design concentration for a particular fuel. For combinations of fuels, the flame extinguishment or inerting value for the fuel requiring the greatest concentration shall be used unless tests are made on the actual mixture.

5.4.2 Flame Extinguishment.

5.4.2.1* The flame extinguishing concentration for Class B fuels shall be determined by the cup burner method described in Annex B.

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

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

5.4.2.2* The flame extinguishing concentration for Class A fuels shall be determined by test as part of a listing program. As a minimum, the listing program shall conform to ANSI/UL 2127 or ANSI/UL 2166 or equivalent.

5.4.2.3 The minimum design concentration for a Class B fuel hazard shall be the extinguishing concentration, as determined in 5.4.2.1, times a safety factor of 1.3.

5.4.2.4* 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 5.4.2.2, times a safety factor of 1.2
(2) Equal to the minimum extinguishing concentration for heptane as determined from 5.4.2.1

5.4.2.5 The minimum design concentration for a Class C hazard shall be the extinguishing concentration, as determined in 5.4.2.2, times a safety factor of 1.35.

5.4.2.5.1 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 testing, as necessary, and a hazard analysis.

5.4.2.6* The minimum design concentration for a smoldering combustion hazard (deep-seated fire hazard) shall be determined by an application-specific test.

5.4.3* Inerting.

5.4.3.1 The inerting concentration shall be determined by test.

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

5.4.3.3 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.

5.5 Total Flooding Quantity.

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

[5.5.1]

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

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 [°F (°C)] of the protected volume [ft^3/lb (m^3/kg)]

5.5.1.1 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:

[5.5.1.1]

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

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)]

5.5.1.2 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 5.1.2.4 and 5.2.4.

5.5.2* The quantity of inert gas agent required to achieve the design concentration shall be calculated using Equation 5.5.2, 5.5.2.1a, or 5.5.2.1b:

5.5.3.1.2 The hazard with the greatest design factor tee count shall be used in Table 5.5.3.1 to determine the design factor.

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

5.5.3.2* 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 5.8.2)*
(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

5.5.3.3* Design Factor for Enclosure Pressure. The design quantity of the clean agent shall be adjusted 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 70°F (760 mm Hg at 0°C)]. *(See Table 5.5.3.3.)*

5.6* Duration of Protection. A minimum concentration of 85 percent of the adjusted 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 time period sufficient to allow for response by trained personnel.

5.6.1* It is important that the adjusted minimum design concentration of agent not only shall be achieved but also shall be maintained for the specified period of time to allow effective emergency action by trained personnel.

5.7 Distribution System.

5.7.1 Rate of Application.

5.7.1.1* Discharge Time.

5.7.1.1.1* For halocarbon agents, the discharge time required to achieve 95 percent of the minimum design concentration for flame extinguishment based on a 20 percent safety factor shall not exceed 10 seconds or as otherwise required by the authority having jurisdiction.

5.7.1.1.2* For inert gas agents, the discharge time required to achieve 95 percent of the minimum design concentration for flame extinguishment 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.

5.7.1.1.3* The discharge time period is 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 based on a 20 percent safety factor for flame extinguishment.

5.7.1.1.4 Flow calculations performed in accordance with Section 5.2 or in accordance with the listed pre-engineered systems instruction manuals shall be used to demonstrate compliance with 5.7.1.1.

5.7.1.1.5 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.

5.7.2* Extended Discharge. When an extended discharge is necessary to maintain the design concentration for the specified period of time, additional agent quantities can be applied at a reduced rate. The initial discharge shall be completed within the limits specified in 5.7.1.1. The performance of the extended discharge system shall be confirmed by test.

5.8 Nozzle Choice and Location.

5.8.1 Nozzles shall be of the type listed for the intended purpose and shall be placed within the protected enclosure in compliance with listed limitations with regard to spacing, floor coverage, and alignment.

5.8.2 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.

Δ Table 5.5.3.3 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

Chapter 6 Local Application Systems

6.1 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.

6.1.1 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.

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

6.1.3* Safety Requirements. The safety requirements of Section 1.5 shall apply. During agent discharge, locally high concentrations of the agent will be developed; therefore the

Δ Table A.4.2.2.2(b) Piping Systems Fittings for Use in Inert Gas Systems Downstream of the Pressure Reducer

Maximum Pressure Downstream of the Pressure Reducer at 70°F (21°C) (up to and including)		Minimum Acceptable Fittings	Maximum Pipe Size (NPS)
psi	kPa		
1,000	6,895	Class 300 threaded malleable iron	3 in.
		Class 2,000 threaded/ welded forged steel	All
		Class 600 flanged joint	All
1,350	9,308	Class 300 threaded malleable iron	2 in.
		Class 2,000 threaded/ welded forged steel	All
		Class 600 flanged joint	All
1,500	10,343	Class 300 threaded malleable iron	2 in.
		Class 2,000 threaded/ welded forged steel	All
		Class 900 flanged joint	All
2,000	13,790	Class 300 threaded malleable iron	1 in.
		Class 2,000 threaded/ welded forged steel	All
		Class 900 flanged joint	All

Δ Table A.5.4.2.1 Minimum Flame Extinguishing Concentration (Fuel: n-heptane)

	MEC (vol %)	
Agent	2004 Test Method	2008 Test Method**
FIC-13I1	3.2*	
FK-5-1-12	4.5	
HCFC Blend A	9.9	
HCFC-124	6.6	
HFC-125	8.7	
HFC-227ea	6.6†	6.62
HFC-23	12.9	
HFC-236fa	6.3	
HFC Blend B	11.3	
IG-01	42	
IG-100	31*	32.2
IG-541	31	
IG-55	35	

*Not derived from standardized cup burner method.
†A value of cup burner extinguishing concentration of 6.7 percent for HCF-227ea for commercial heptane fuel.
**A working group appointed by the then NFPA 2001 technical committee revised Annex B to include a refinement of the method reported in the 2004 and earlier editions.

(b) When tested as described in A.5.4.2.2(2)(a) through A.5.4.2.2(5)(b), an extinguishing system unit should extinguish all fires within 30 seconds after the end of system discharge. When tested as described in A.5.4.2.2(2)(a) through A.5.4.2.2(3)(c) and A.5.4.2.2(6)(a) through A.5.4.2.2(6)(f), an extinguishing system should prevent reignition of the wood crib after a 10 minute soak period.

(c) The tests described in A.5.4.2.2(2)(a) through A.5.4.2.2(6)(f) should be carried out. Consider the intended use and limitations of the extinguishing system, with specific reference to the following:

- i. The area coverage for each type of nozzle
- ii. The operating temperature range of the system
- iii. Location of the nozzles in the protected area
- iv. Either maximum length and size of piping and number of fittings to each nozzle or minimum nozzle pressure
- v. Maximum discharge time
- vi. Maximum fill density

(2) The test enclosure construction is as follows:

(a) The enclosure for the test should be constructed of either indoor or outdoor grade minimum ⅜ in. (9.5 mm) thick plywood or equivalent material.

(b) An enclosure(s) is to be constructed having the maximum area coverage for the extinguishing system unit or nozzle being tested and the minimum and maximum protected area height limitations.

The test enclosure(s) for the maximum height, flammable liquid, and wood crib fire extinguishment tests need not have the maximum coverage area, but should be at least 13.1 ft (4.0 m) wide by 13.1 ft (4.0 m) long and 3351 ft^3 (100 m^3) in volume.

(3) The extinguishing system is as follows:

(a) A pre-engineered type of extinguishing system unit is to be assembled using its maximum piping limitations with respect to number of fittings and length of pipe to the discharge nozzles and nozzle configuration(s), as specified in the manufacturer's design and installation instructions.

(b) An engineered-type extinguishing system unit is to be assembled using a piping arrangement that results in the minimum nozzle design pressure at 70°F (21°C).

(c) Except for the flammable liquid fire test using the 2.5 ft^2 (0.23 m^2) square pan and the wood crib extinguishment test, the cylinders are to be conditioned to the minimum operating temperature specified in the manufacturer's installation instructions.

(4) The extinguishing concentration is as follows:

(a) The extinguishing agent concentration for each Class A test is to be 83.34 percent of the intended end use design concentration specified in the manufacturer's design and installation instructions at the ambient temperature of approximately 70°F (21°C) within the enclosure.

(b) The extinguishing agent concentration for each Class B test is to be 76.9 percent of the intended end-use design concentration specified in the

iii. Agent concentration (±5 percent) (Inert gas concentration can be calculated based on oxygen concentration.)

(b) The following events are timed and recorded:

i. Time at which heptane is ignited
ii. Time of heptane pan burnout
iii. Time of plastic sheet ignition
iv. Time of beginning of agent discharge
v. Time of end of agent discharge
vi. Time all visible flame is extinguished

The minimum extinguishing concentration is determined by all of the following conditions:

(1) All visible flame is extinguished within 600 seconds of agent discharge.
(2) The fuel weight loss between 10 seconds and 600 seconds after the end of discharge does not exceed 0.5 oz (15 g).
(3) There is no ignition of the fuel at the end of the 600 second soak time and subsequent test compartment ventilation.

Deep-seated fires involving Class A fuels can require substantially higher design concentrations and extended holding times than the design concentrations and holding times required for surface-type fires involving Class A fuels. Wood crib and polymeric sheet Class A fire tests may not adequately indicate extinguishing concentrations suitable for the protection of certain plastic fuel hazards (e.g., electrical- and electronic-type hazards involving grouped power or data cables such as computer and control room underfloor voids and telecommunication facilities).

The values in Table A.5.4.2.2(b) are representative of the minimum extinguishing concentrations and design concentrations for various agents. The concentrations required can vary by equipment manufacturer. Equipment manufacturers should be contacted for the concentration required for their specific system.

A.5.4.2.4 Hazards containing both Class A and Class B fuels should be evaluated on the basis of the fuel requiring the highest design concentration.

A.5.4.2.6 Two types of fires can occur in solid fuels: (1) one in which volatile gases resulting from heating or decomposition of the fuel surface are the source of combustion and (2) one in which oxidation occurs at the surface of or in the mass of fuel. The first type of fire is commonly referred to as “flaming” combustion, while the second type is often called “smoldering” or “glowing” combustion. The two types of fires frequently occur concurrently, although one type of burning can precede the other. For example, a wood fire can start as flaming combustion and become smoldering as burning progresses. Conversely, spontaneous ignition in a pile of oily rags can begin as a smoldering fire and break into flames at some later point. Flaming combustion, because it occurs in the vapor phase, can be extinguished with relatively low levels of clean agents. In the absence of smoldering combustion, it will stay out.

Unlike flaming combustion, smoldering combustion is not subject to immediate extinguishment. Characteristic of this type of combustion is the slow rate of heat losses from the reaction zone. Thus, the fuel remains hot enough to react with oxygen, even though the rate of reaction, which is controlled by diffusion processes, is extremely slow. Smoldering fires can continue to burn for many weeks, for example, in bales of cotton and jute and heaps of sawdust. A smoldering fire ceases to burn only when either all the available oxygen or fuel has been consumed or the fuel surface is at too low a temperature to react. Smoldering fires usually are extinguished by reducing the fuel temperature, either directly by application of a heat-absorbing medium, such as water, or by blanketing with an inert gas. The inert gas slows the reaction rate to the point where heat generated by oxidation is less than heat losses to surroundings. This causes the temperature to fall below the level necessary for spontaneous ignition after removal of the inert atmosphere.

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

Δ Table A.5.4.2.2(b) Class A Flame Extinguishing and Minimum Design Concentrations Tested to UL 2166 and UL 2127

Agent	Class A MEC	Class A Minimum Design Concentration	Class C Minimum Design Concentration
FK-5-1-12	3.3	4.5	4.5
HFC-125	6.7	8.7	9.0
HFC-227ea	5.2	6.7	7.0
HFC-23	15.0	18.0	20.3
IG-541	28.5	34.2	38.5
IG-55	31.6	37.9	42.7
IG-100	31.0	37.2	41.9

Note: Concentrations reported are at 70°F (21°C). Class A design values are the greater of (1) the Class A extinguishing concentration, determined in accordance with 5.4.2.2, times a safety factor of 1.2; or (2) the minimum extinguishing concentration for heptane as determined from 5.4.2.1.

Table A.5.4.2.2(a) Plastic Fuel Properties

			25 kW/m² Exposure in Cone Calorimeter — ASTM E1354					
			Ignition Time		180-Second Average Heat Release Rate		Effective Heat of Combustion	
Fuel	Color	Density (g/cm²)	sec	Tolerance	kW/m²	Tolerance	MJ/kg	Tolerance
PMMA	Black	1.19	77	±30%	286	25%	23.3	±15%
PP	Natural (white)	0.905	91	±30%	225	25%	39.8	±15%
ABS	Natural (cream)	1.04	115	±30%	484	25%	29.1	±15%

C.2.6.1.2 Inspect all dampers with smoke to ensure they are closing properly. Record problems and notify individuals responsible for the enclosure of the problems.

C.2.6.1.3 Inspect doors and hatches to ensure correct closure. Record problems and notify individuals responsible for the enclosure of the problems.

C.2.6.1.4 Inspect the wall perimeter (above and below the false floor) and the floor slab for major leaks. Note location and size of major leaks. Track down major air flow currents.

C.2.6.2 Bias Pressure Measurement.

C.2.6.2.1 Bias pressures are the background pressures that exist in the enclosure when the fan is stopped and sealed. Bias pressure must be measured or estimated for two different conditions. The first condition (which can always be measured) is the bias pressure present during the actual enclosure integrity test (P_{bt}). The second condition (which may need to be estimated) is the bias pressure expected after discharge, during the hold time (P_{bh}). To measure bias pressure, seal the fan opening with the door fan properly installed but without the fan operating. Observe the room pressure gauge for at least 30 seconds. Look for minor fluctuations in pressure. Determine the flow direction with smoke or other indicating method.

C.2.6.2.2 With the room set up as it would be under hold time conditions, measure the bias pressure P_{bh} across a section of envelope containing the largest quantity of leaks expected to leak clean agent. If the subfloor is pressurized during the hold time, measure the differential between the subfloor and outside the envelope. If the room cannot be set up as would be under discharge conditions, P_{bh} will need to be estimated.

C.2.6.2.3 With the room set up for the room integrity test, measure the bias pressure P_{bt}. If P_{bt} has an absolute value greater than 25 percent of the column pressure calculated in C.2.7.1.4, it must be permanently reduced. Large bias pressures decrease the level of certainty inherent in this procedure. The most common causes of excessive bias pressure are leaky dampers, ducts, and failure to shut down air-handling equipment serving the enclosure.

C.2.6.2.4 Record the position of all doorways, whether open or shut, when the bias pressure P_{bh} is measured.

C.2.7 Door Fan Measurement.

C.2.7.1 Total Enclosure Leakage Method.

C.2.7.1.1 This method determines the leakage of the entire enclosure envelope. It is determined by measuring the enclosure leakage under both positive and negative pressures and averaging the absolute values of the readings. This approach is used to minimize the influence of bias pressures on the leakage calculation.

C.2.7.1.2 The procedures for determining the leakage of the entire enclosure envelope are as follows:

(1) Prop open all doorways around the enclosure and post personnel to ensure they stay open.
(2) Ensure that adequate return path area is provided to allow an unrestricted return air flow path back to the door fan from enclosure leaks.
(3) Remove 1 percent of the floor tiles (for false floors) if an equivalent area is not already open.
(4) If agent is designed to discharge above the false ceiling, remove 1 percent of the ceiling tiles.
(5) Remeasure the bias pressure at the time of the door fan test (P_{bt}) between the room (not below the false floor) and the return path space.
(6) Make every effort to reduce P_{bt} by shutting down air-handling equipment even though it can operate during discharge. P_{bt} must be within a range of ±5 Pa.
(7) Record P_{bt} and determine its direction using smoke or other means.
(8) Record the position of each doorway, open/shut.
(9) If the bias pressure fluctuates due to wind, use a wind-damping system incorporating four averaging tubes on each side of the building or electronic averaging to eliminate its effects. CAN/CGSB-149.10-M86 can be used.
(10) If a subfloor pressurization air handler cannot be shut down for the test and leaks exist in the subfloor, those leaks cannot be accurately measured. Every attempt should be made to reduce subfloor leaks to insignificance. During the test, as many floor tiles as possible should be lifted to reduce the amount of subfloor pressurization. Note that under such conditions the suspended ceiling leakage neutralization method will be difficult to conduct due to massive air turbulence in the room.
CAUTION: The removal of raised floor tiles creates a serious safety hazard. Appropriate precautions should be taken.
(11) If relief dampers are present, they should be blocked shut so they do not open during the door fan test. (At the completion of the test, the dampers must be unblocked.)

C.2.7.1.3 Agent-Air Mixture Density. Calculate the density of the agent-air mixture (ρ_{mi}) using the following equation:

$$\rho_{mi} = \rho_e \frac{C_i}{100} + \left[\rho_a \frac{(100 - C_i)}{100} \right] \quad \text{[C.2.7.1.3]}$$

ρ_e values are shown in Table C.2.7.1.3.

Table C.2.7.1.3 Agent Vapor Densities at 70°F (21°C) and 14.7 psi (1.013 bar) atmospheric pressure (ρ_e)

	Vapor Densities	
Agent	**lb/ft³**	**kg/m³**
FK-5-1-12	0.865	13.86
HCFC Blend A	0.240	3.85
HCFC 124	0.363	5.81
HFC-125	0.313	5.02
HFC-227ea	0.453	7.26
HFC-23	0.183	2.92
HFC-236fa	0.407	6.52
FIC-13I1	0.500	8.01
HFC Blend B	0.263	4.22
IG-01	0.104	1.66
IG-100	0.072	1.16
IG-541	0.088	1.41
IG-55	0.088	1.41