

**Gaseous fire-extinguishing systems — Physical properties and system design —
Part 9: HFC 227ea extinguishant**

**Systèmes d'extinction d'incendie utilisant des agents gazeux -- Propriétés physiques
et conception des systèmes -- Partie 9: Agent extincteur HFC 227ea**

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 21, *Equipment for fire protection and fire fighting*, Subcommittee SC 8, *Gaseous media and firefighting systems using gas*.

This fourth edition cancels and replaces the third edition (ISO 14520-9:2016), which has been technically revised. The main changes compared to the previous edition are as follows:

- a new subclause 6.4 on fill density and superpressurization levels has been added.

A list of all parts in the ISO 14520 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Gaseous fire-extinguishing systems — Physical properties and system design — Part 9: HFC 227ea extinguishant

1 Scope

This document contains specific requirements for gaseous fire-extinguishing systems, with respect to the HFC 227ea extinguishant. It includes details of physical properties, specifications, usage and safety aspects.

This document is applicable to systems operating at nominal pressures of 25 bar, 42 bar and 50 bar with nitrogen propellant. This does not preclude the use of other systems.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 14520-1:2015, *Gaseous fire-extinguishing systems — Physical properties and system design — Part 1: General requirements*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 14520-1 apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

4 Characteristics and uses

4.1 General

Extinguishant HFC 227ea shall comply with the specification shown in Table 1.

HFC 227ea is a colourless, almost odourless, electrically non-conductive gas, with a density approximately six times that of air.

The physical properties are shown in Table 2.

HFC 227ea extinguishes fires mainly by physical means, but also by some chemical means.

Table 1 — Specification for HFC 227ea

Property	Requirement
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Purity	99,6 % by mass, min.
Acidity	3×10^{-6} by mass, max.
Water content	10×10^{-6} by mass, max.
Non-volatile residue	0,01 % by mass, max.
Suspended matter or sediment	None visible

Table 2 — Physical properties of HFC 227ea

Property	Units	Value
Molecular mass	—	170
Boiling point at 1,013 bar (absolute)	°C	-16,4
Freezing point	°C	-127
Critical temperature	°C	101,7
Critical pressure	bar abs	29,26
Critical volume	cm ³ /mol	274
Critical density	kg/m ³	573
Vapour pressure 20 °C	bar abs	3,90
Liquid density 20 °C	kg/m ³	1 410
Saturated vapour density 20 °C	kg/m ³	31,035
Specific volume of superheated vapour at 1,013 bar and 20 °C	m ³ /kg	0,137 4
Chemical formula	CF ₃ CHF ₂ CF ₃	
Chemical name	Heptafluoropropane	

4.2 Use of HFC 227ea systems

HFC 227ea total flooding systems may be used for extinguishing fires of all classes within the limits specified in ISO 14520-1:2015, Clause 4.

The extinguishant requirements per volume of protected space are shown in Table 3 for various levels of concentration. These are based on methods shown in ISO 14520-1:2015, 7.6.

The extinguishing concentrations and design concentrations for *n*-heptane and surface class A hazards are shown in Table 4. Concentrations for other fuels are shown in Table 5 and inerting concentrations are shown in Table 6.

Table 3 — HFC 227ea total flooding quantity

Temperature <i>T</i> °C	Specific vapour volume <i>S</i> m ³ /kg	HCF 227ea mass requirements per unit volume of protected space, <i>m/V</i> (kg/m ³)									
		Design concentration (by volume)									
		6 %	7 %	8 %	9 %	10 %	11 %	12 %	13 %	14 %	15 %
-10	0,121 5	0,525 4	0,619 6	0,715 8	0,814 2	0,914 7	1,017 4	1,122 5	1,230 1	1,340 1	1,452 7
-5	0,124 1	0,514 2	0,606 4	0,700 5	0,796 7	0,895 1	0,995 7	1,098 5	1,203 8	1,311 4	1,421 6
0	0,126 8	0,503 4	0,593 6	0,685 8	0,780 0	0,876 3	0,974 8	1,075 5	1,178 5	1,283 9	1,391 8

5	0,129 4	0,493 2	0,581 6	0,671 9	0,764 2	0,858 6	0,955 0	1,053 7	1,154 6	1,257 9	1,363 6
10	0,132 0	0,483 4	0,570 0	0,658 5	0,749 0	0,841 4	0,936 0	1,032 7	1,131 6	1,232 8	1,336 4
15	0,134 7	0,474 0	0,558 9	0,645 7	0,734 4	0,825 1	0,917 8	1,012 6	1,109 6	1,208 9	1,310 5
20	0,137 3	0,465 0	0,548 3	0,633 5	0,720 5	0,809 4	0,900 4	0,993 4	1,088 6	1,185 9	1,285 6
25	0,139 9	0,456 4	0,538 2	0,621 7	0,707 1	0,794 4	0,883 7	0,975 0	1,068 4	1,164 0	1,261 8
30	0,142 5	0,448 1	0,528 4	0,610 4	0,694 3	0,780 0	0,867 6	0,957 3	1,049 0	1,142 8	1,238 8
35	0,145 0	0,440 1	0,519 0	0,599 6	0,681 9	0,766 1	0,852 2	0,940 2	1,030 3	1,122 4	1,216 8
40	0,147 6	0,432 4	0,509 9	0,589 1	0,670 1	0,752 8	0,837 4	0,923 9	1,012 4	1,102 9	1,195 6
45	0,150 2	0,425 0	0,501 2	0,579 0	0,658 6	0,739 9	0,823 0	0,908 0	0,995 0	1,084 0	1,175 1
50	0,152 7	0,418 0	0,492 9	0,569 4	0,647 6	0,727 6	0,809 3	0,892 9	0,978 4	1,066 0	1,155 5
55	0,155 3	0,411 1	0,484 7	0,560 0	0,636 9	0,715 6	0,796 0	0,878 2	0,962 3	1,048 4	1,136 5
60	0,157 8	0,404 5	0,477 0	0,551 0	0,626 7	0,704 1	0,783 2	0,864 1	0,946 9	1,031 6	1,118 3
65	0,160 4	0,398 0	0,469 4	0,542 3	0,616 7	0,692 9	0,770 7	0,850 4	0,931 8	1,015 2	1,100 5
70	0,162 9	0,391 9	0,462 1	0,533 8	0,607 2	0,682 1	0,758 8	0,837 1	0,917 3	0,999 4	1,083 4
75	0,165 4	0,385 9	0,455 0	0,525 7	0,597 9	0,671 7	0,747 1	0,824 3	0,903 3	0,984 1	1,066 8
80	0,167 9	0,380 1	0,448 2	0,517 8	0,589 0	0,661 7	0,736 0	0,812 0	0,889 8	0,969 4	1,050 9
85	0,170 4	0,374 5	0,441 6	0,510 2	0,580 3	0,651 9	0,725 1	0,800 0	0,876 7	0,955 1	1,035 4
90	0,173 0	0,369 0	0,435 1	0,502 7	0,571 7	0,642 3	0,714 5	0,788 3	0,863 8	0,941 1	1,020 2
95	0,175 5	0,363 8	0,429 0	0,495 6	0,563 6	0,633 2	0,704 4	0,777 1	0,851 6	0,927 7	1,005 7
100	0,178 0	0,358 7	0,422 9	0,488 6	0,555 7	0,624 3	0,694 5	0,766 2	0,839 6	0,914 7	0,991 6

NOTE This information refers only to the product HFC-227ea and does not represent any other products containing 1,1,1,2,3,3,3-heptafluoropropane as a component.

Symbols:

m/V is the agent mass requirements (kg/m^3), i.e. mass, m , in kilograms of agent required per cubic metre of protected volume, V , to produce the indicated concentration at the temperature specified;

V is the net volume of hazard (m^3), i.e. the enclosed volume minus the fixed structures impervious to extinguishant

$$m = \left(\frac{c}{100 - c} \right) \frac{V}{S}$$

T is the temperature ($^{\circ}\text{C}$), i.e. the design temperature in the hazard area;

S is the specific volume (m^3/kg), the specific volume of superheated HFC 227ea vapour at a pressure of 1,013 bar may be approximated by the formula

$$S = k_1 + k_2 T$$

where

$$k_1 = 0,126 9;$$

$$k_2 = 0,000 513.$$

c is the concentration (%), i.e. the volumetric concentration of HFC 227ea in air at the temperature indicated and a pressure of 1,013 bar absolute.

Table 4 — HFC 227ea reference extinguishing and design concentrations

Fuel	Extinguishment % by volume	Minimum design % by volume
Class B		

Heptane (cup burner)	6,7	9,0
Heptane (room test)	6,9	
Surface Class A		
Wood Crib	4,9	7,9
PMMA	6,1	
PP	6,1	
ABS	6,1	
Higher Hazard Class A	See NOTE 4	8,5
<p>NOTE 1 The extinguishment values for the Class B and the Surface Class A fuels are determined by testing in accordance with ISO 14520-1:2015, Annexes B and C.</p> <p>NOTE 2 The minimum design concentration for the Class B fuel is the higher value of the heptane cup burner or room test heptane extinguishment concentration multiplied by 1,3.</p> <p>NOTE 3 The minimum design concentration for Surface Class A fuel is the highest value of the wood crib, PMMA, PP or ABS extinguishment concentrations multiplied by 1,3. In the absence of any of the four extinguishment values, the minimum design concentration for Surface Class A is that of Higher Hazard Class A.</p> <p>NOTE 4 The minimum design concentration for Higher Hazard Class A fuels is the higher of the Surface Class A or 95 % of the Class B minimum design concentration.</p> <p>NOTE 5 See ISO 14520-1:2015, 7.5.1.3 for guidance on Class A fuels.</p>		

In Table 4, the extinguishing and design concentrations for room-scale test fires are for information purposes only. Lower and higher extinguishing concentrations than those shown for room-scale test fires may be achieved and allowed when validated by test reports from internationally recognized laboratories.

Table 5 — HFC 227ea extinguishing and design concentrations for other fuels

Fuel	Extinguishment % by volume	Minimum design % by volume
Acetone	6,7	8,7
Ethanol	8,4	10,9
Ethyl acetate	6,7	8,7
Ethylene glycol	7,8	10,1
Kerosene	6,1	7,9
Methanol	9,5	12,4
Propane	7,4	9,6
Toluene	4,9	6,4
<p>NOTE 1 Extinguishing concentrations for all Class B fuels listed were derived in accordance with ISO 14520-1:2015, Annex B.</p> <p>NOTE 2 Minimum design values have been increased to the minimum design concentration established for heptane in accordance with ISO 14520-1:2015, 7.5.1.</p>		

Table 6 — HFC 227ea inerting and design concentrations

Fuel	Inertion % by volume	Minimum design % by volume
Isobutane	11,3	12,4
1-Chloro-1,1-difluoroethane (HCFC 141b)	6,7	8,7

1,1-Difluoroethane (HFC 152a)	8,6	9,5
Difluoromethane (HFC 32)	6,7	8,7
Ethylene oxide	13,6	15,0
Methane	8,0	8,8
Pentane	11,6	12,8
Propane	11,6	12,8
NOTE Inerting concentrations were derived in accordance with the requirements of ISO 14520-1:2015, Annex D and 7.5.2.		

5 Safety of personnel

Any hazard to personnel created by the discharge of HFC 227ea shall be considered in the design of the system.

Potential hazards can arise from the following:

- a) the extinguishant itself;
- b) the combustion products of the fire;
- c) breakdown products of the extinguishant resulting from exposure to fire.

For minimum safety requirements, see ISO 14520-1:2015, Clause 5.

Toxicological information for HFC 227ea is shown in Table 7.

Table 7 — Toxicological information for HFC 227ea

Property	Value
ALC	>80 at 20 % O ₂
No observed adverse effect level (NOAEL)	9,0
Lowest observed adverse effect level (LOAEL)	10,5
NOTE ALC is the approximate lethal concentration for a rat population during a 4-h exposure.	

6 System design

6.1 Fill density

The fill density of the container shall not exceed the values given in Table 8, Table 9, and Table 10 for 25 bar, 42 bar or 50 bar systems.

Exceeding the maximum fill density may result in the container becoming "liquid full", with the effect that an extremely high rise in pressure occurs with small increases in temperature, which could adversely affect the integrity of the container assembly.

The relationships between pressure and temperature are shown in Figure 1 and Figure 2 for various levels of fill density.

Table 8 — 25 bar storage container characteristics for HFC 227ea

Property	Unit	Value
Maximum fill density	kg/m ³	1 150
Maximum container working pressure at 50 °C	bar	34
Superpressurization at 21 °C	bar	25
NOTE Figure 1 shows further data on pressure/temperature relationships.		

Table 9 — 42 bar storage container characteristics for HFC 227ea

Property	Unit	Value
Maximum fill density	kg/m ³	1 150
Maximum container working pressure at 50 °C	bar	62
Superpressurization at 21 °C	bar	42
NOTE Figure 2 shows further data on pressure/temperature relationships.		

Table 10 — 50 bar storage container characteristics for HFC 227ea

Property	Unit	Value
Maximum fill density	kg/m ³	1 050
Maximum container working pressure at 50 °C	bar	59
Superpressurization at 21 °C	bar	50
NOTE Figure 3 shows further data on pressure/temperature relationships.		

6.2 Superpressurization

Containers shall be pressurized with nitrogen with a moisture content of not more than 60×10^{-6} by mass to an equilibrium pressure of 25 bar⁺⁵₀ %, 42 bar⁺⁵₀ % or 50 bar⁺⁵₀ % for the respective system, at a temperature of 21 °C.

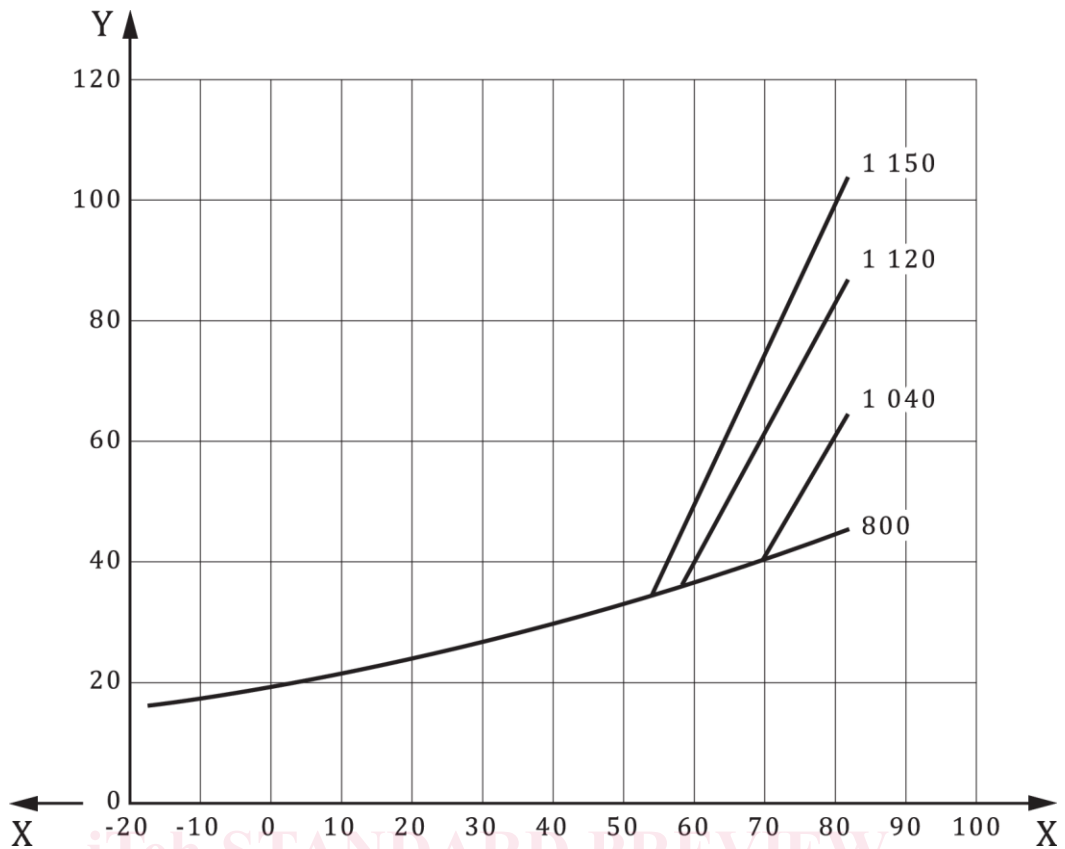
6.3 Extinguishant quantity

The quantity of extinguishant shall be the minimum required to achieve the design concentration within the hazard volume at the minimum expected temperature, determined using Table 3 and the method specified in ISO 14520-1:2015, 7.6.

The design concentrations shall be that specified for relevant hazards shown in Table 4. This includes at least a 1,3 safety factor on the extinguishing concentration.

Consideration should be given to increasing this for particular hazards, and seeking advice from the relevant authority.

Values of density in kilograms per cubic metre



Key

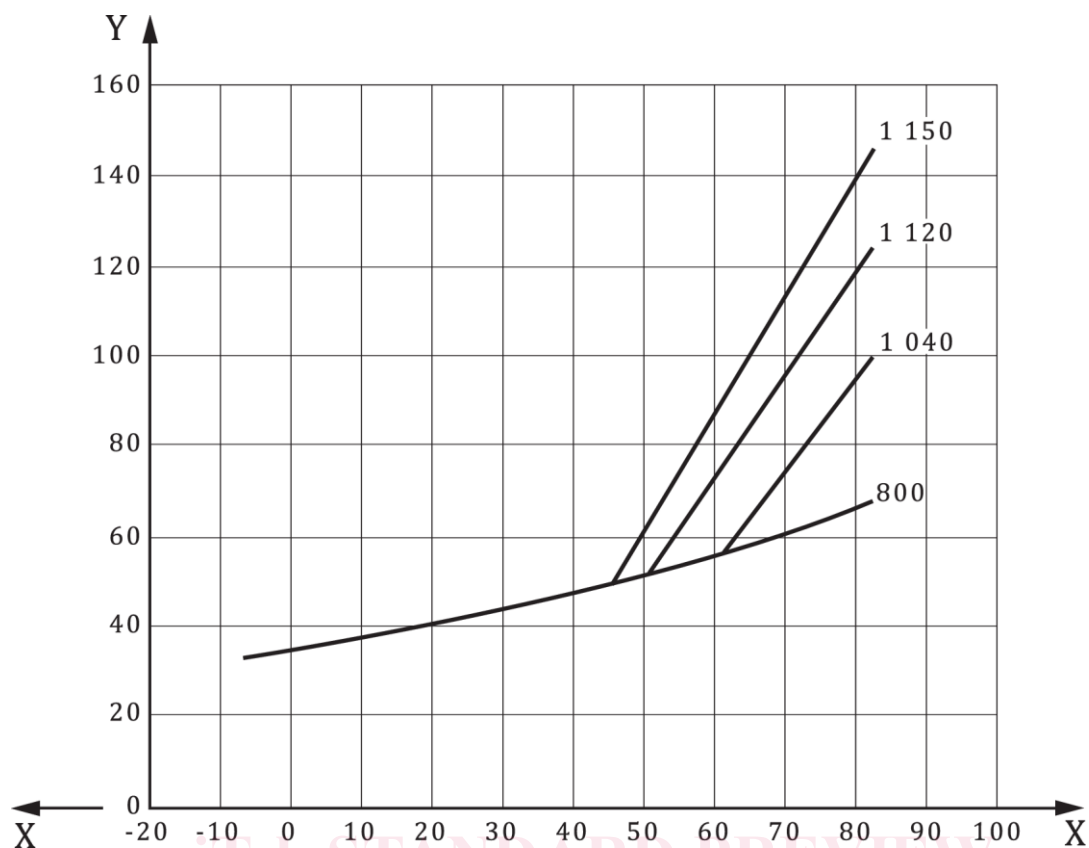
X temperature, °C

Y pressure, bar

Figure 1 — Temperature/pressure graph for HFC 227ea superpressurized with nitrogen to 25 bar at 21 °C

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Values of density in kilograms per cubic metre



Key
 X temperature, °C
 Y pressure, bar

Figure 2 — Temperature/pressure graph for HFC 227ea pressurized with nitrogen to 42 bar at 21 °C

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Values of density in kilograms per cubic metre

