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Gaseous fire-extinguishing systems — Physical properties and system design — Part 8: HFC 125 extinguishant

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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 14520-8:2016), 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.

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Gaseous fire-extinguishing systems — Physical properties and system design — Part 8: HFC 125 extinguishant

1 Scope

This document contains specific requirements for gaseous fire-extinguishing systems, with respect to the HFC 125 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 and 42 bar, superpressurized with nitrogen. 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 125 shall comply with the specification shown in Table 1.

HFC 125 is a colourless, almost odourless, electrically non-conductive gas, with a density approximately four times that of air.

The physical properties are shown in Table 2.

HFC 125 extinguishes fires mainly by physical means, but also by some chemical means.

Table 1 — Specification for HFC 125

Property	Requirement

Purity	99,6 % by mass, min.
Acidity	3 × 10^{-4} % by mass (3 parts per million), max.
Water content	10 × 10^{-4} % by mass (10 parts per million), max.
Non-volatile residue	0,01 % by mass, max.
Suspended matter or sediment	None visible

Table 2 — Physical properties of HFC 125

Property	Units	Value
Molecular mass	—	120,02
Boiling point at 1,013 bar (absolute)	°C	−48,09
Freezing point	°C	−101
Critical temperature	°C	66,02
Critical pressure	bar abs	36,18
Critical volume	cm^3/mol	210
Critical density	kg/m^3	573,6
Vapour pressure 20 °C	bar abs	12,05
Liquid density 20 °C	kg/m^3	1 218,0
Saturated vapour density 20 °C	kg/m^3	77,97
Specific volume of superheated vapour at 1,013 bar and 20 °C	m^3/kg	0,197 2
Chemical formula	CF_3CHF_2	
Chemical name	Pentafluoroethane	

4.2 Use of HFC 125 systems

HFC 125 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

Table 3 — HFC 125 total flooding quantity

Temperature T °C	Specific vapour volume S	HFC 125 mass requirements per unit volume of protected space, m/V (kg/m^3) Design concentration (by volume)									
	m^3/kg	7 %	8 %	9 %	10 %	11 %	12 %	13 %	14 %	15 %	16 %
−45	0,149 7	0,502 8	0,580 9	0,660 7	0,742 2	0,825 6	0,910 9	0,998 2	1,087 4	1,178 8	1,272 4
−40	0,153 4	0,490 7	0,566 9	0,644 7	0,724 3	0,805 7	0,888 9	0,974 1	1,061 2	1,150 4	1,241 7
−35	0,157 2	0,478 8	0,553 2	0,629 1	0,706 8	0,786 2	0,867 5	0,950 5	1,035 6	1,122 6	1,211 7

−30	0,160 8	0,468 1	0,540 8	0,615 1	0,691 0	0,768 6	0,848 0	0,929 3	1,012 4	1,097 5	1,184 6
−25	0,164 5	0,457 6	0,528 6	0,601 2	0,675 4	0,751 3	0,829 0	0,908 4	0,989 6	1,072 8	1,157 9
−20	0,168 2	0,447 5	0,517 0	0,588 0	0,660 6	0,734 8	0,810 7	0,888 4	0,967 8	1,049 2	1,132 4
−15	0,171 9	0,437 9	0,505 9	0,575 3	0,646 4	0,719 0	0,793 3	0,869 3	0,947 0	1,026 6	1,108 1
−10	0,175 5	0,428 9	0,495 5	0,563 5	0,633 1	0,704 2	0,777 0	0,851 4	0,927 6	1,005 5	1,085 3
−5	0,179 1	0,420 3	0,485 5	0,552 2	0,620 4	0,690 1	0,761 4	0,834 3	0,908 9	0,985 3	1,063 5
0	0,182 8	0,411 8	0,475 7	0,541 0	0,607 8	0,676 1	0,746 0	0,817 4	0,890 5	0,965 4	1,042 0
5	0,186 4	0,403 8	0,466 5	0,530 6	0,596 1	0,663 1	0,731 6	0,801 6	0,873 3	0,946 7	1,021 9
10	0,190 0	0,396 2	0,457 7	0,520 5	0,584 8	0,650 5	0,717 7	0,786 4	0,856 8	0,928 8	1,002 5
15	0,193 5	0,389 0	0,449 4	0,511 1	0,574 2	0,638 7	0,704 7	0,772 2	0,841 3	0,912 0	0,984 4
20	0,197 1	0,381 9	0,441 2	0,501 8	0,563 7	0,627 1	0,691 9	0,758 1	0,825 9	0,895 3	0,966 4
25	0,200 7	0,375 0	0,433 3	0,492 8	0,553 6	0,615 8	0,679 4	0,744 5	0,811 1	0,879 3	0,949 1
30	0,204 2	0,368 6	0,425 8	0,484 3	0,544 1	0,605 3	0,667 8	0,731 8	0,797 2	0,864 2	0,932 8
35	0,207 8	0,362 2	0,418 5	0,475 9	0,534 7	0,594 8	0,656 2	0,719 1	0,783 4	0,849 2	0,916 6
40	0,211 3	0,356 2	0,411 5	0,468 1	0,525 8	0,584 9	0,645 4	0,707 2	0,770 4	0,835 2	0,901 4
45	0,214 9	0,350 3	0,404 6	0,460 2	0,517 0	0,575 1	0,634 5	0,695 3	0,757 5	0,821 2	0,886 3
50	0,218 4	0,344 6	0,398 2	0,452 8	0,508 8	0,565 9	0,624 4	0,684 2	0,745 4	0,808 0	0,872 1
55	0,221 9	0,339 2	0,391 9	0,445 7	0,500 7	0,557 0	0,614 5	0,673 4	0,733 6	0,795 3	0,858 4
60	0,225 4	0,333 9	0,385 8	0,438 8	0,493 0	0,548 3	0,605 0	0,662 9	0,722 2	0,782 9	0,845 1
65	0,228 9	0,328 8	0,379 9	0,432 1	0,485 4	0,540 0	0,595 7	0,652 8	0,711 2	0,771 0	0,832 1
70	0,232 4	0,323 9	0,374 2	0,425 6	0,478 1	0,531 8	0,586 8	0,643 0	0,700 5	0,759 3	0,819 6
75	0,235 8	0,319 2	0,368 8	0,419 4	0,471 2	0,524 2	0,578 3	0,633 7	0,690 4	0,748 4	0,807 8
80	0,239 3	0,314 5	0,363 4	0,413 3	0,464 3	0,516 5	0,569 8	0,624 4	0,680 3	0,737 4	0,796 0
85	0,242 8	0,310 0	0,358 1	0,407 3	0,457 6	0,509 0	0,561 6	0,615 4	0,670 5	0,726 8	0,784 5
90	0,246 3	0,305 6	0,353 1	0,401 5	0,451 1	0,501 8	0,553 6	0,606 7	0,660 9	0,716 5	0,773 4
95	0,249 8	0,301 3	0,348 1	0,395 9	0,444 8	0,494 8	0,545 9	0,598 2	0,651 7	0,706 4	0,762 5

NOTE This information refers only to the product HFC-125 and does not represent any other products containing pentafluoroethane 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 (°C); i.e. the design temperature in the hazard area;

S is the specific volume (m^3/kg); the specific volume of superheated HFC 125 vapour at a pressure of 1,013 bar may be approximated by the formula:

$S = k_1 + k_2 T$

where

k_1 = 0,182 5;

k_2 = 0,000 7.

c is the concentration (%), i.e. the volumetric concentration of HFC 125 in air at the temperature indicated and a pressure of 1,013 bar.

Table 4 — HFC 125 reference extinguishing and design concentrations

Fuel	**Extinguishment** % by volume	**Minimum design** % by volume
Class B		
Heptane (cup burner)	9,3	12,1
Heptane (room test)	9,3	
Surface Class A		
Wood Crib	6,7	11,2
PMMA	8,6	
PP	8,6	
ABS	8,6	
Higher Hazard Class A	See NOTE 4	11,5

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.

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.

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.

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.

NOTE 5 See ISO 14520-1:2015, 7.5.1.3 for guidance on Class A fuels.

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 125 extinguishing and design concentrations for other fuels

Fuel	**Extinguishment** % by volume	**Minimum design** % by volume
Acetone	9,3	12,1
Ethanol	11,3	14,7
Ethyl acetate	9,3	12,1
Methanol	12,3	15,9
Kerosene	9,3	12,1
Propane	9,7	12,6
Toluene	9,3	12,1

NOTE 1 Extinguishing concentrations for all Class B fuels listed were derived in accordance with ISO 14520-1:2015, Annex B.

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.

5 Safety of personnel

Any hazard to personnel created by the discharge of HFC 125 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 125 is shown in Table 6.

Table 6 — Toxicological information for HFC 125

Property	Value % by volume
ALC	>70
No observed adverse effect level (NOAEL)	7,5
Lowest observed adverse effect level (LOAEL)	10
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 shown in Table 7 for 25 bar system and Table 8 for 42 bar system.

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 for various levels of fill density.

Table 7 — 25 bar storage container characteristics for HFC 125

Property	Unit	Value
Maximum fill density	kg/m^3	929
Maximum container working pressure at 50 °C	bar	40
Super pressurization at 22 °C	bar	25
NOTE Figure 1 shows further data on pressure/temperature relationships.		

Table 8 — 42 bar storage container characteristics for HFC 125

Property	Unit	Value
Maximum fill density	kg/m³	929
Maximum container working pressure at 50 °C	bar	73
Super pressurization at 22 °C	bar	42
NOTE Figure 2 shows further data on pressure/temperature relationships.		

6.2 Superpressurization

Containers shall be superpressurized with nitrogen with a moisture content of not more than 60×10^{-4} % by mass (60 parts per million) to an equilibrium pressure of 25 bar or 42 bar $^{+5}_{0}$ % at a temperature of 20 °C (see Clause 1 for an exception).

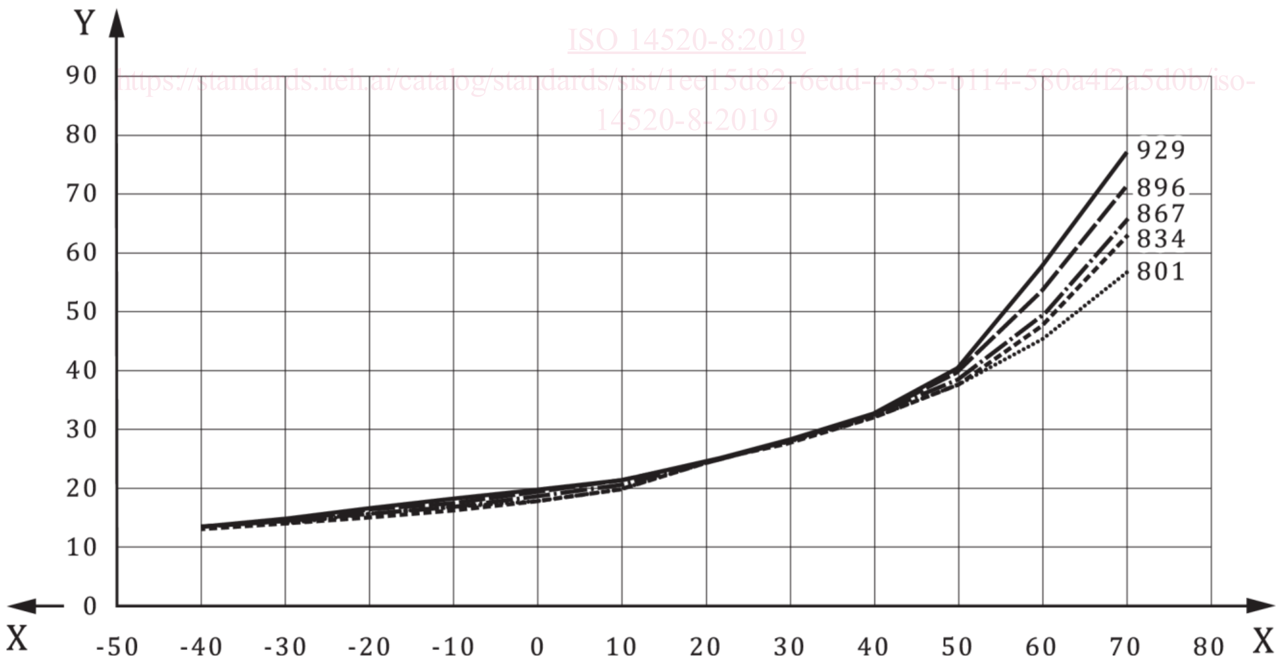
6.3 Extinguishant quantity

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



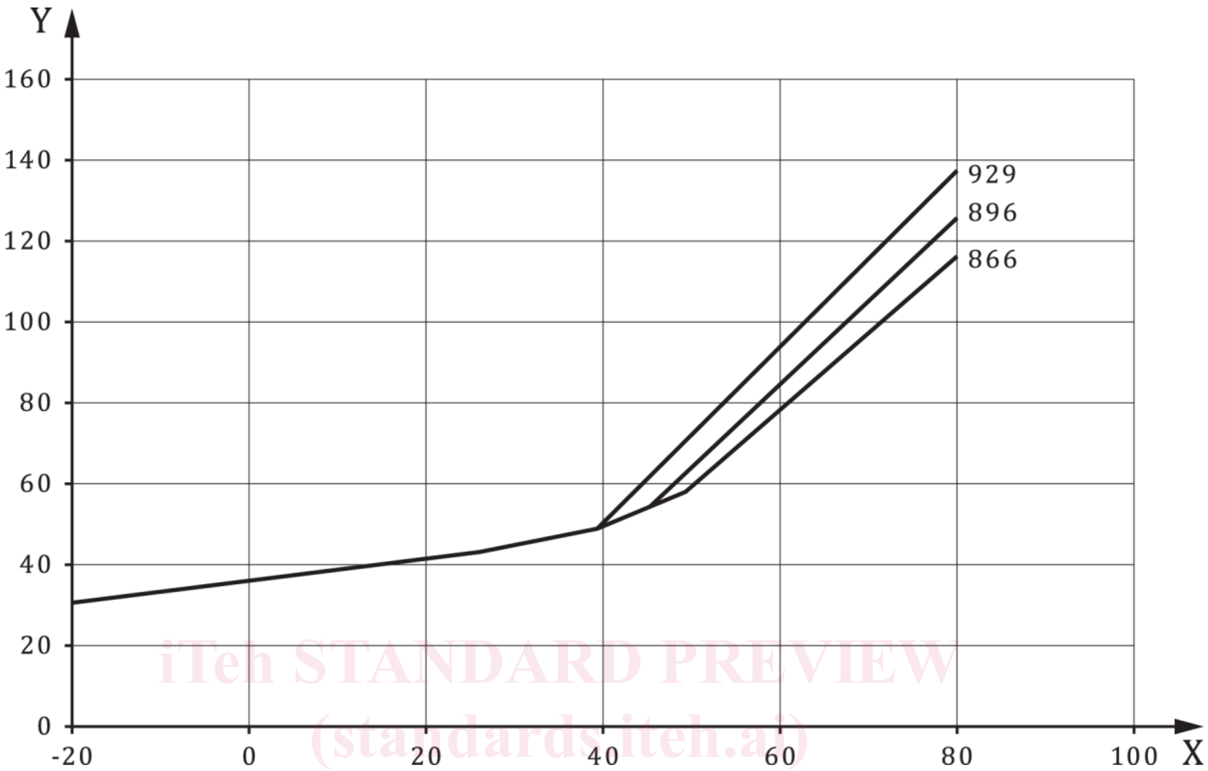
Key

X temperature, °C

Y pressure, bar

Figure 1 — Temperature/pressure graph for HFC 125 pressurized with nitrogen to 25 bar at 22 °C

Values of density in kilograms per cubic metre



Key

X temperature, °C

Y pressure, bar

Figure 2 — Temperature/pressure graph for HFC 125 pressurized with nitrogen at 42 bar and 22 °C

6.4 Other fill density and superpressurization levels

Fill density and superpressurization levels at values other than stated in 6.1 and 6.2 are permitted provided that the manufacturer makes available to the user and authorities data, similar to that shown in subclauses 6.1, 6.2 and 6.3 to include:

a) maximum fill density;

b) container pressure at a stated fill temperature;

c) container pressure at the maximum storage temperature;

d) container pressure values at maximum fill density for temperatures between the minimum and maximum storage temperatures, in graphical form similar to that shown in 6.3.

7 Environmental properties

For information purposes, environmental properties of HFC 125 extinguishant are provided:

— GWP (100 years) 3 500;

— ODP 0[1].

NOTE 1 See ISO 14520-1:2015, 4.2.1 for a discussion of GWP values and their relation to the impact of a gas on climate change/global warming.

NOTE 2 Environmental properties derived from the following:

— IPCC, Report AR4 Climate Change 2007: The Physical Science Basis, Chapter 2 “Changes in Atmospheric Constituents and in Radiative Forcing,” Table 2.14. “Lifetimes, radiative efficiencies and direct (except for CH4) GWPs relative to CO2. For ozone-depleting substances and their replacements, data are taken from IPCC/TEAP (2005) unless otherwise indicated,” pp. 212-213.

— ENVIRONMENTAL PROTECTION AGENCY, 40 CFR Part 82 [EPA-HQ-OAR-2015-0663; FRL-9952-18-OAR], RIN 2060-AS80 Protection of Stratospheric Ozone: New Listings of Substitutes; Changes of Listing Status; and Reinterpretation of Unacceptability for Closed Cell Foam Products under the Significant New Alternatives Policy Program; and Revision of Clean Air Act Section 608 Venting Prohibition for Propane, Table 22: “GWP, ODP, and VOC Status of 2-BTP Compared to Other Total Flooding and Streaming Agents,” 9/26/2016.

[1] Extinguishant HFC 125 has zero ODP because it contains no chlorine, bromine, or iodine, the primary kinetically active species for ozone depletion.

