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Second edition
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Gaseous fire-extinguishing systems — Physical properties and system design —

Part 15: IG-541 extinguishant

Systèmes d'extinction d'incendie utilisant des agents gazeux — Propriétés physiques et conception des systèmes —

Partie 15: Agent extincteur IG-541

Reference number
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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Foreword

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The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 14520-15 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 second edition cancels and replaces the first edition (ISO 14520-15:2000), which has been technically revised.

ISO 14520 consists of the following parts, under the general title *Gaseous fire-extinguishing systems — Physical properties and system design*:

— *Part 1: General requirements*

— *Part 2: CF_3I extinguishant*

— *Part 5: FK-5-1-12 extinguishant*

— *Part 6: HCFC Blend A extinguishant*

— *Part 8: HFC 125 extinguishant*

— *Part 9: HFC 227ea extinguishant*

— *Part 10: HFC 23 extinguishant*

— *Part 11: HFC 236fa extinguishant*

— *Part 12: IG-01 extinguishant*

— *Part 13: IG-100 extinguishant*

— *Part 14: IG-55 extinguishant*

— *Part 15: IG-541 extinguishant*

Parts 3, 4 and 7, which dealt with FC-2-1-8, FC-3-1-10 and HCFC 124 extinguishants, respectively, have been withdrawn, as these types are no longer manufactured.

Gaseous fire-extinguishing systems — Physical properties and system design —

Part 15: IG-541 extinguishant

1 Scope

This part of ISO 14520 gives specific requirements for gaseous fire-extinguishing systems, with respect to the IG-541 extinguishant. It includes details of physical properties, specification, usage and safety aspects and is applicable to systems operating at nominal pressures of 150 bar, 200 bar and 300 bar, at 15 °C. This does not preclude the use of other systems; however, design data for other pressures were not available at time of publication.

2 Normative references

The following referenced documents are indispensable for the application 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:— [1)], *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.

4 Characteristics and uses

4.1 General

Extinguishant IG-541 shall comply with the specification according to Table 1.

IG-541 is a colourless, odourless, electrically non-conductive gas with a density approximately the same as that of air. It is an inert gas mixture consisting nominally of 52 % nitrogen, 40 % argon and 8 % carbon dioxide, with the following mixture specification (based on 8 % carbon dioxide with tolerance of ± 5 %).

a) Carbon dioxide: range of 7,6 % to 8,4 %.

b) Argon: range of 37,2 % to 42,8 %.

c) Nitrogen: range of 48,8 % to 55,2 %.

NOTE Individual container or batch analysis is based on carbon dioxide measurement only.

1) To be published. (Revision of ISO 14520-1:2000)

The physical properties are given in Table 2.

IG-541 extinguishes fires mainly by a reduction of the oxygen concentration in the atmosphere of the hazard enclosure.

Table 1 — Specification for IG-541

Property	Requirement		
	Argon	Nitrogen	Carbon dioxide
Purity	99,997 % by volume, min.	99,99 % by volume, min.	99,5 % by volume, min.
Water content	4×10^{-6} by mass, max.	5×10^{-6} by mass, max.	10×10^{-6} by mass, max.
Oxygen	3×10^{-6} by mass, max.	3×10^{-6} by mass, max.	10×10^{-6} by mass, max.
Only principal contaminants are shown. Other measurements may include hydrocarbons, CO, NO, NO_2. Most are $< 20 \times 10^{-6}$.			

Table 2 — Physical properties of IG-541

Property	Unit	Value
Molecular mass	—	34,0
Boiling point at 1,013 bar (absolute) [a]	°C	−196
Freezing point	°C	−78,5
Critical temperature	°C	—
Critical pressure	bar abs [a]	—
Critical volume	cm^3/mol	—
Critical density	kg/m^3	—
Vapour pressure 20 °C	bar abs [a]	152
Liquid density 20 °C	kg/m^3	—
Saturated vapour density 20 °C	kg/m^3	—
Specific volume of superheated vapour at 1,013 bar and 20 °C	m^3/kg	0,697
Chemical formulas	N_2	52 % by volume
	Ar	40 % by volume
	CO_2	8 % by volume
Chemical names	Nitrogen	
	Argon	
	Cabon dioxide	

[a] 1 bar = 0,1 MPa = 10^5 Pa; 1 MPa = 1 N/mm^2.

4.2 Use of IG-541 systems

IG-541 total flooding systems may be used for extinguishing fires of all classes within the limits specified in ISO 14520-1:— [2], 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 given in ISO 14520-1— [2], 7.6.

The extinguishing concentrations and design concentrations for *n*-heptane and Surface Class A hazards are given in Table 4, concentrations for other fuels in Table 5 and inerting concentrations in Table 6.

2) To be published. (Revision of ISO 14520-1:2000)

Table 3 — IG-541 total flooding quantity

Temperature T	**Specific vapour volume** S	**IG-541 volume requirements per unit volume of protected space**, V/V (m^3/m^3) This information refers only to IG-541, and may not represent any other products containing argon, nitrogen or carbon dioxide as components.							
		Design concentration (by volume)							
°C	m^3/kg	34 %	38 %	42 %	46 %	50 %	54 %	58 %	62 %
–40	0,5624	0,521	0,600	0,684	0,773	0,870	0,975	1,089	1,214
–35	0,5743	0,511	0,587	0,669	0,757	0,852	0,954	1,066	1,189
–30	0,5863	0,500	0,575	0,656	0,742	0,834	0,935	1,044	1,165
–25	0,5982	0,490	0,564	0,643	0,727	0,818	0,916	1,023	1,142
–20	0,6102	0,481	0,553	0,630	0,713	0,802	0,898	1,003	1,119
–15	0,6221	0,471	0,542	0,618	0,699	0,786	0,881	0,984	1,098
–10	0,6341	0,463	0,532	0,606	0,686	0,772	0,864	0,966	1,077
–5	0,6460	0,454	0,522	0,595	0,673	0,757	0,848	0,948	1,057
0	0,6580	0,446	0,513	0,584	0,661	0,744	0,833	0,931	1,038
5	0,6699	0,438	0,504	0,574	0,649	0,730	0,818	0,914	1,019
10	0,6819	0,430	0,495	0,564	0,638	0,717	0,804	0,898	1,001
15	0,6938	0,423	0,486	0,554	0,627	0,705	0,790	0,882	0,984
20	0,7058	0,416	0,478	0,545	0,616	0,693	0,777	0,868	0,968
25	0,7177	0,409	0,470	0,536	0,606	0,682	0,764	0,853	0,951
30	0,7297	0,402	0,462	0,527	0,596	0,670	0,751	0,839	0,936
35	0,7416	0,395	0,455	0,518	0,586	0,660	0,739	0,826	0,921
40	0,7536	0,389	0,448	0,510	0,577	0,649	0,727	0,812	0,906
45	0,7655	0,383	0,441	0,502	0,568	0,639	0,716	0,800	0,892
50	0,7775	0,377	0,434	0,494	0,559	0,629	0,705	0,787	0,878
55	0,7894	0,371	0,427	0,487	0,551	0,620	0,694	0,776	0,865
60	0,8014	0,366	0,421	0,480	0,543	0,610	0,684	0,764	0,852
65	0,8133	0,361	0,415	0,473	0,535	0,601	0,674	0,753	0,840
70	0,8253	0,355	0,409	0,466	0,527	0,593	0,664	0,742	0,827
75	0,8372	0,350	0,403	0,459	0,519	0,584	0,655	0,731	0,816
80	0,8492	0,345	0,397	0,453	0,512	0,576	0,645	0,721	0,804
85	0,8611	0,341	0,392	0,446	0,505	0,568	0,636	0,711	0,793
90	0,8731	0,336	0,386	0,440	0,498	0,560	0,628	0,701	0,782
95	0,8850	0,331	0,381	0,434	0,491	0,553	0,619	0,692	0,772
100	0,8970	0,327	0,376	0,429	0,485	0,545	0,611	0,683	0,761

V/V is the agent volume requirement (in cubic metres per cubic metre); i.e. the quantity Q (in cubic metres) of agent required at a reference temperature of 20 °C and a pressure of 1,013 bar per cubic metre of protected volume to produce the indicated concentration at the temperature specified:

$$Q_R = m \cdot S_R$$

where

S_R is the specific reference volume (in cubic metres per kilogram); i.e. the specific vapour volume at the filling reference temperature for superheated IG-541 vapour at a pressure of 1,013 bar which may be approximated by the formula:

$$S_R = k_1 + k_2 \cdot T_R$$

where k_1 = 0,657 99; k_2 = 0,002 239; T_R is the reference temperature (in degrees Celsius), i.e. filling temperature (20 °C in the table);

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

V is the net volume of hazard (in cubic metres); i.e. the enclosed volume minus the fixed structures impervious to extinguishant;

T is the temperature (in degrees Celsius); i.e. the design temperature in the hazard area;

S is the specific volume (in cubic metres per kilogram); the specific volume of superheated IG-541 vapour at a pressure of 1,013 bar may be approximated by

$$S = k_1 + k_2 \cdot T$$

c is the concentration (in percent); i.e. the volumetric concentration of IG-541 in air at the temperature indicated, and a pressure of 1,013 bar absolute.

Table 4 — IG-541 reference extinguishing and design concentrations

Fuel	Extinguishment % by volume	Minimum design % by volume
Class B		
Heptane (cup burner) Heptane (room test)	31,7 29,6	41,2
Surface Class A		
Wood crib PMMA PP ABS	28,2 30,7 30,6 30,7	39,9
Higher Hazard Class A	[a]	39,9

The extinguishment values for the Class B and the Surface Class A fuels are determined by testing in accordance with ISO 14520-1:—[3)], Annexes B and C.

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.

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 4 extinguishment values, the minimum design concentration for Surface Class A shall be that of Higher Hazard Class A.

See ISO 14520-1:— [3)], 7.5.1.3, for guidance on Class A fuels.

The extinguishing and design concentrations for room-scale test fires are for informational 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.

[a] The minimum design concentration for Higher Hazard Class A fuels shall be the higher of the surface Class A or 95 % of the Class B minimum design concentration.

3) To be published. (Revision of ISO 14520-1:2000)

Table 5 — IG 541 extinguishing and design concentrations for other fuels

Fuel	Extinguishment % by volume	Minimum design % by volume
Acetone	31,7	41,2
Acetonitrile	31,7	41,2
Avgas 100	31,7	41,2
Avtur (Jet A)	36,2	47,1
1-Butanol	37,2	48,4
Cyclopentanone	42,1	54,7
Diesel No. 2	35,8	46,5
Diethyl ether	34,9	45,4
Ethane	31,7	41,2
Ethanol	35,0	45,5
Ethyl acetate	32,7	42,5
Ethylene	42,1	54,7
Hexane	31,7	41,2
Isopropanol	31,7	41,2
Methanol	44,2	57,5
Methyl ethyl ketone	35,8	46,5
Methyl isobutyl ketone	32,3	42,0
Octane	35,8	46,5
Pentane	37,2	48,4
Petroleum ether	35,0	45,5
Propane	32,3	42,0
Regular gasoline	35,8	46,5
Toluene	31,7	41,2
Vinyl acetate	34,4	44,7
Vacuum pump oil	32,0	41,6
Extinguishing concentrations for all Class B fuels listed were derived in accordance with ISO 14520-1:— [4], Annex B. Minimum design values have been increased to the minimum design concentration established for heptane in accordance with ISO 14520-1:— [4], 7.5.1.		

4) To be published. (Revision of ISO 14520-1:2000)

Table 6 — IG-541 inerting and design concentrations

Fuel	Inertion % by volume	Minimum design % by volume
Methane	43,0	47,3
Propane	49,0	53,9
Inerting concentrations derived in accordance with ISO 14520-1:— [3], Annex D and 7.5.2.		

5 Safety of personnel

Any hazard to personnel created by the discharge of IG-541 shall be considered in the design of the system.

Potential hazards can arise from the following:

a) the extinguishant itself, by oxygen reduction;

b) the combustion products of the fire.

For minimum safety requirements, see ISO 14250-1:— [5], Clause 5.

Physiological information for IG-541 is given in Table 7.

Table 7 — Physiological information for IG-541

Property	Value % by volume
No observed adverse effect level (NOAEL)	43
Lowest observed adverse effect level (LOAEL)	52
These values are based on physiological effects in human subjects of hypoxic atmospheres. These values are the functional equivalents of NOAEL and LOAEL values, and correspond to 12 % minimum oxygen for the no-effect level and 10 % minimum oxygen for the low-effect level.	

6 System design

6.1 Fill pressure

The fill pressure of the container shall not exceed the values given in Tables 8, 9 and 10 for systems operating at 150 bar at 15 °C, 200 bar at 15 °C and 300 bar 15 °C, respectively.

Other pressures may be used and the minimum design pressure specified accordingly.

The relationships between pressure and temperature are shown in Figures 1, 2 and 3.

5) To be published. (Revision of ISO 14520-1:2000)

Table 8 — Storage container characteristics for IG-541 — 150 bar

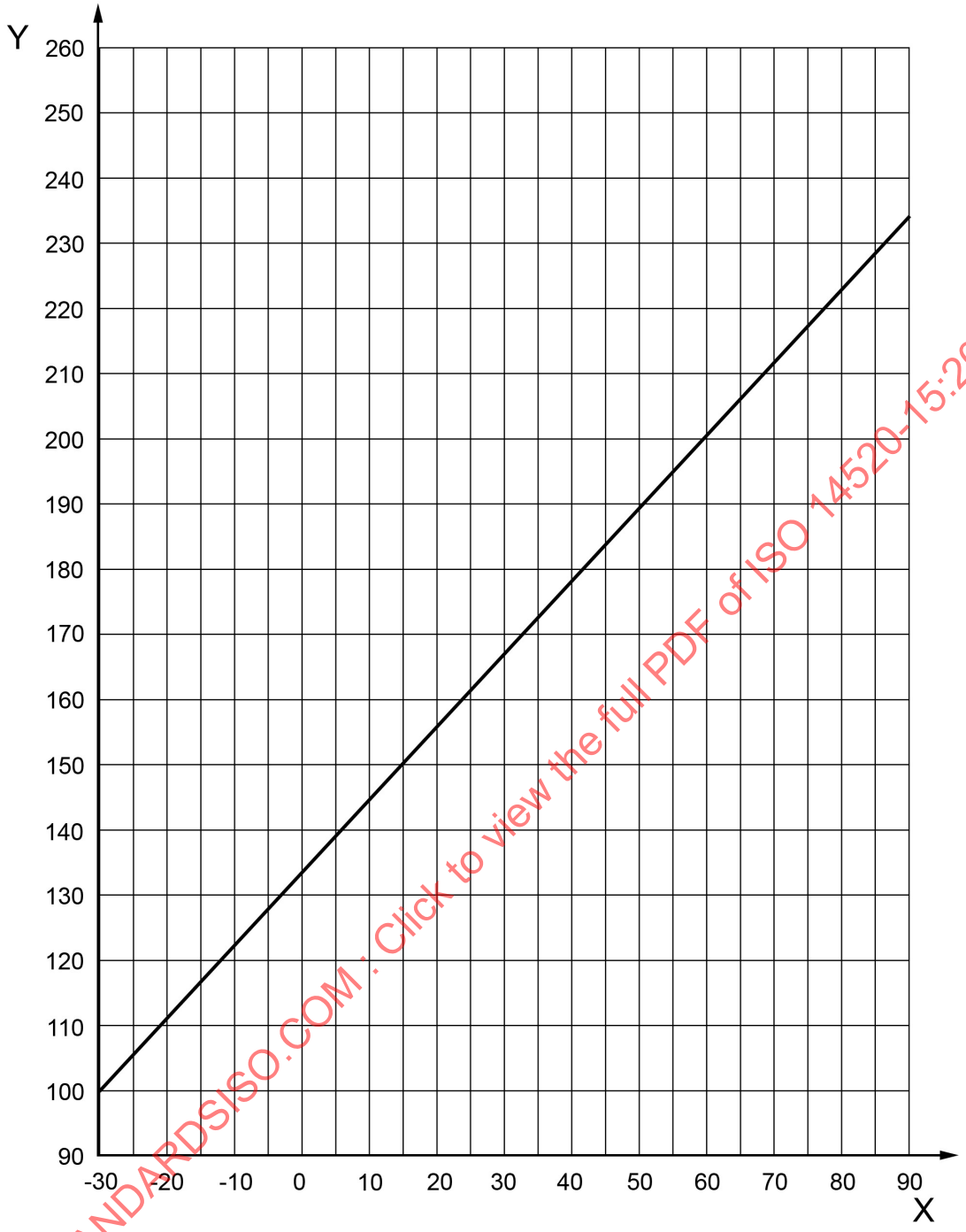
Property	Unit	Value
Filling pressure at 15 °C	bar [a]	150
Maximum container working pressure at 50 °C	bar [a]	175
Reference should be made to Figure 1 for further data on pressure/temperature relationships.		
[a] 1 bar = 0,1 MPa = 10^5 Pa; 1 MPa = 1 N/mm^2.		

Table 9 — Storage container characteristics for IG-541 — 200 bar

Property	Unit	Value
Filling pressure at 15 °C	bar [a]	200
Maximum container working pressure at 50 °C	bar [a]	235
Reference should be made to Figure 2 for further data on pressure/temperature relationships.		
[a] 1 bar = 0,1 MPa = 10^5 Pa; 1 MPa = 1 N/mm^2.		

Table 10 — Storage container characteristics for IG-541 — 300 bar

Property	Unit	Value
Filling pressure at 15 °C	bar [a]	300
Maximum container working pressure at 50 °C	bar [a]	360
Reference should be made to Figure 3 for further data on pressure/temperature relationships.		
[a] 1 bar = 0,1 MPa = 10^5 Pa; 1 MPa = 1 N/mm^2.		



Key

X temperature, °C

Y pressure, bar

Figure 1 — Temperature/pressure graph for IG-541 pressurized to 150 bar at 15 °C