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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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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT), see the following URL: Foreword — Supplementary information.

The committee responsible for this document is ISO/TC 21, *Equipment for fire protection and fire fighting*, Subcommittee SC 8, *Gaseous media firefighting systems using gas*.

This third edition cancels and replaces the second edition (ISO 14520-15:2005), 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 contains 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.

This part of ISO 14520 covers 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, although design data for other pressures are not available at this time.

2 Normative reference

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 14520-1:2006, *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

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. The mixture specification for IG-541 (based on 8 % carbon dioxide with tolerance of ± 5 %) is as follows:

a) carbon dioxide percentage range 7,6 % to 8,4 %;

b) argon percentage range 37,2 % to 42,8 %;

c) nitrogen percentage range 48,8 % to 55,2 %.

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

Extinguishant IG-541 shall comply with the specification shown in Table 1.

The physical properties are shown in Table 2.

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

Table 1 — Component gas specification for IG-541

	Argon	Nitrogen	Carbon dioxide
Purity	99,997 % by volume, min.	99,99 % by volume, min.	99,5 % by volume, min.
Moisture	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.
NOTE Only principal contaminants are shown. Other measurements can include hydrocarbons, CO, NO, NO_2. Most are < 20 × 10–6.			

Table 2 — Physical properties of IG-541

Property	Units	Value
Molecular mass	—	34,0
Boiling point at 1,013 bar (absolute)	°C	–196
Freezing point	°C	–78,5
Critical temperature	°C	—
Critical pressure	bar abs	—
Critical volume	cm^3/mol	—
Critical density	kg/m^3	—
Vapour pressure 20 °C	bar abs	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	0,706
Components	N_2 52 % by volume Ar 40 % by volume CO_2 8 % by volume	
Chemical name	Nitrogen/argon/carbon dioxide	

4.2 Use of IG-541 systems

IG-541 total flooding systems can be used for extinguishing fires of all classes within the limits specified in ISO 14520-1:2006, 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 14520-1:2006, 7.6.

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

Table 3 — IG-541 total flooding quantity

Temperature T °C	**Specific vapour volume** S m³/kg	**IG-541 volume requirements per unit volume of protected space**, V/V (m³/m³) **Design concentration** (by volume)							
		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

NOTE This information refers only to the product IG-541, and does not represent any other products containing argon, nitrogen, or carbon dioxide as components.

Symbols:

V/V is the agent volume requirements (m³/m³); i.e. the quantity Q_R (m³) 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:

Table 3 *(continued)*

$$Q_R = m \cdot S_R$$

where

S_R is the specific reference volume (m³/kg); i.e. the specific vapour volume at the filling reference temperature for superheated IG-541 vapour at a pressure of 1,013 bar which can be approximated by the formula:

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

where

k_1 = 0,657 99;

k_2 = 0,002 39

T_R is the reference temperature (°C); 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 (m³); i.e. the enclosed volume minus the fixed structures impervious to extinguishant;

T is the temperature (°C); i.e. the design temperature of the protected area;

S is the specific volume (m³/kg); the specific volume of superheated IG-541 vapour at a pressure of 1,013 bar can be approximated by the formula:

$S = k_1 + k_2 \cdot T$

where

c is the concentration (%); 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)	33,8	43,9
Heptane (room test)	29,6	
Surface class A		
Wood crib	28,2	
PMMA	30,7	39,9
PP	30,6	
ABS	30,7	
Higher Hazard Class A	See Note 4	41,7
NOTE 1 The extinguishment values for the Class B and the Surface Class A fuels are determined by testing in accordance with ISO 14520-1:2006, 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 4 extinguishment values, the minimum design concentration for Surface Class A shall be that of Higher Hazard Class A. NOTE 4 Higher-Hazard Class A hazards are those having the characteristics described in the CAUTION statement of ISO 14520-1:2006, 7.5.1.3. 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. NOTE 5 See ISO 14520-1:2006, 7.5.1.3 for guidance on Class A fuels. NOTE 6 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 can be achieved and allowed when validated by test reports from internationally recognized laboratories.		

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
Diethlyl ether	34,9	45,4
Ethane	31,7	41,2
Ethanol	35,0	45,5
Ethly acetate	32,7	42,5
Ethylene	42,1	54,7
NOTE Extinguishing concentrations for all Class B fuels listed were derived in accordance with ISO 14520-1:2006, Annex B. Minimum design values have been increased to the minimum design concentration established for heptane in accordance with ISO 14520-1:2006, 7.5.1.		

Table 5 *(continued)*

Fuel	Extinguishment % by volume	Minimum design % by volume
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
NOTE Extinguishing concentrations for all Class B fuels listed were derived in accordance with ISO 14520-1:2006, Annex B. Minimum design values have been increased to the minimum design concentration established for heptane in accordance with ISO 14520-1:2006, 7.5.1.		

Table 6 — IG-541 inerting and design concentrations

Fuel	Inerting % by volume	Minimum design % by volume
Methane	43,0	47,3
Propane	49,0	53,9
NOTE Inerting concentrations were derived in accordance with the requirements of ISO 14520-1:2006, 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 reduction in oxygen; and

b) the combustion products of the fire.

For minimum safety requirements, see ISO 14520-1:2006, Clause 5.

Physiological information for IG-541 is shown 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
NOTE These values are based on the physiological effects on 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, 200 bar, and 300 bar respectively.

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

The relationships between pressure and temperature are shown in Figure 1.

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

Property	Unit	Value
Filling pressure at 15 °C	bar	150
Maximum container working pressure at 50 °C	bar	175
NOTE Reference should be made to Figure 1 for further data on pressure/temperature relationships.		

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

Property	Unit	Value
Filling pressure at 15 °C	bar	200
Maximum container working pressure at 50 °C	bar	235
NOTE Reference should be made to Figure 1 for further data on pressure/temperature relationships.		

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

Property	Unit	Value
Filling pressure at 15 °C	bar	300
Maximum container working pressure at 50 °C	bar	360
NOTE Reference should be made to Figure 3 for further data on pressure/temperature relationships.		

6.2 Superpressurization

Containers for IG-541 are not superpressurized.