

Fixed firefighting systems — Gas extinguishing systems —

**Part 10: Physical properties and system
design of gas extinguishing systems for
IG-541 extinguishant**

ICS 13.220.20

National foreword

This British Standard is the UK implementation of EN 15004-10:2008. It supersedes BS ISO 14520-15:2005 which is withdrawn.

The UK participation in its preparation was entrusted by Technical Committee FSH/18, Fixed firefighting systems, to Subcommittee FSH/18/6, Gaseous extinguishing media and systems.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Foreword

This document (EN 15004-10:2008) has been prepared by Technical Committee CEN/TC 191 "Fixed firefighting systems", the secretariat of which is held by BSI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by December 2008, and conflicting national standards shall be withdrawn at the latest by December 2008.

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

The text of the International Standard ISO 14520-15:2005 from Technical Committee ISO/TC 21 "Equipment for fire protection and fire fighting" of the International Organization for Standardization (ISO) has been taken over as a European Standard by Technical Committee CEN/TC 191 "Fixed firefighting systems", the secretariat of which is held by BSI, with common modifications which are indicated by a straight line in the margin of the text.

This European Standard will consist of the following parts, under the general title *Fixed firefighting systems – Gas extinguishing systems*:

- *Part 1: Design, installation and maintenance (ISO 14520-1, modified)*
- *Part 2: Physical properties and system design of gas extinguishing systems for FK-5-1-12 extinguishant (ISO 14520-5, modified)*
- *Part 3: Physical properties and system design of gas extinguishing systems for HCFC Blend A extinguishant (ISO 14520-6, modified)*
- *Part 4: Physical properties and system design of gas extinguishing systems for HFC 125 extinguishant (ISO 14520-8, modified)*
- *Part 5: Physical properties and system design of gas extinguishing systems for HFC 227ea extinguishant (ISO 14520-9, modified)*
- *Part 6: Physical properties and system design of gas extinguishing systems for HFC 23 extinguishant (ISO 14520-10, modified)*
- *Part 7: Physical properties and system design of gas extinguishing systems for IG-01 extinguishant (ISO 14520-12, modified)*
- *Part 8: Physical properties and system design of gas extinguishing systems for IG-100 extinguishant (ISO 14520-13, modified)*
- *Part 9: Physical properties and system design of gas extinguishing systems for IG-55 extinguishant (ISO 14520-14, modified)*
- *Part 10: Physical properties and system design of gas extinguishing systems for IG-541 extinguishant (ISO 14520-15, modified)*

The International Standards ISO 14520-2 and ISO 14520-11, which dealt with CF₃I and HFC 236fa extinguishants, respectively, have not been implemented by CEN, as CF₃I extinguishant is only valid for local

application and HFC 236fa extinguishant is only applicable for portable fire extinguishers and local application, respectively, which is not covered by the scope.

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Foreword of ISO 14520-15:2005

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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.

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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 media fire extinguishing systems — Physical properties and system design*:

- *Part 1: General requirements*
- *Part 2: CF₃I 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.

1 Scope

This document 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 pressure 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.

EN 15004-1:2008, *Fixed firefighting systems – Gas extinguishing systems - Design, installation and maintenance (ISO 14520-1, modified)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 15004-1:2008 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.

The physical properties are given in Table 2.

IG-541 extinguishes fires 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, NO₂. 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	
	Carbon dioxide	

^a 1 bar = 0,1 MPa = 10⁵ Pa; 1 MPa = 1 N/mm².

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 EN 15004-1:2008, 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 EN 15004-1:2008, 7.6.

The extinguishing concentrations and design concentrations for *n*-heptane and Surface Class A hazards are given in Table 4.

Table 3 — IG-541 total flooding quantity

Temperature <i>T</i> °C	Specific vapour volume <i>S</i> m ³ /kg	IG-541 volume requirements per unit volume of protected space, <i>V/V</i> (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)							
		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 = 0,65799; *k*₂ = 0,002239; *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)	31,7	48,1
Heptane (room test)	37,0	
Surface Class A		
Wood crib	28,2	39,9
PMMA	30,7	
PP	30,6	
ABS	30,7	
Higher Hazard Class A	a	45,7
<p>The extinguishment values for the Class B and the Surface Class A fuels are determined by testing in accordance with EN 15004-1:2008, Annexes B and C.</p> <p>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>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.</p> <p>See EN 15004-1:2008, 7.5.1.3, for guidance on Class A fuels.</p> <p>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.</p>		
<p>^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.</p>		

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 EN 15004-1:2008, Clause 5.

Physiological information for IG-541 is given in Table 5.

Table 5 — 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 6, 7 and 8 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.

Table 6 — 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 .		

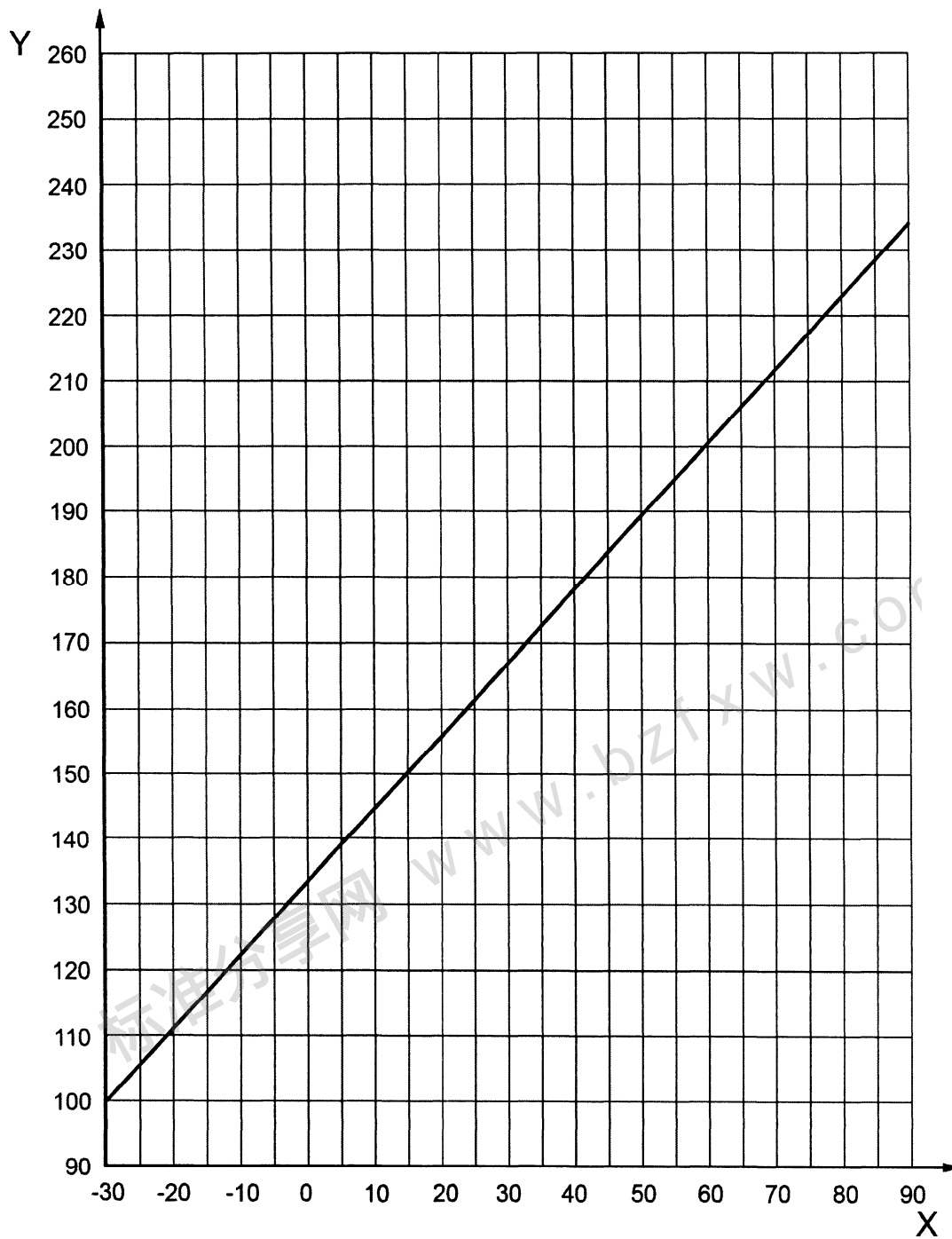
Table 7 — Storage container characteristics for IG-541 — 200 bar

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 8 — 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 .		

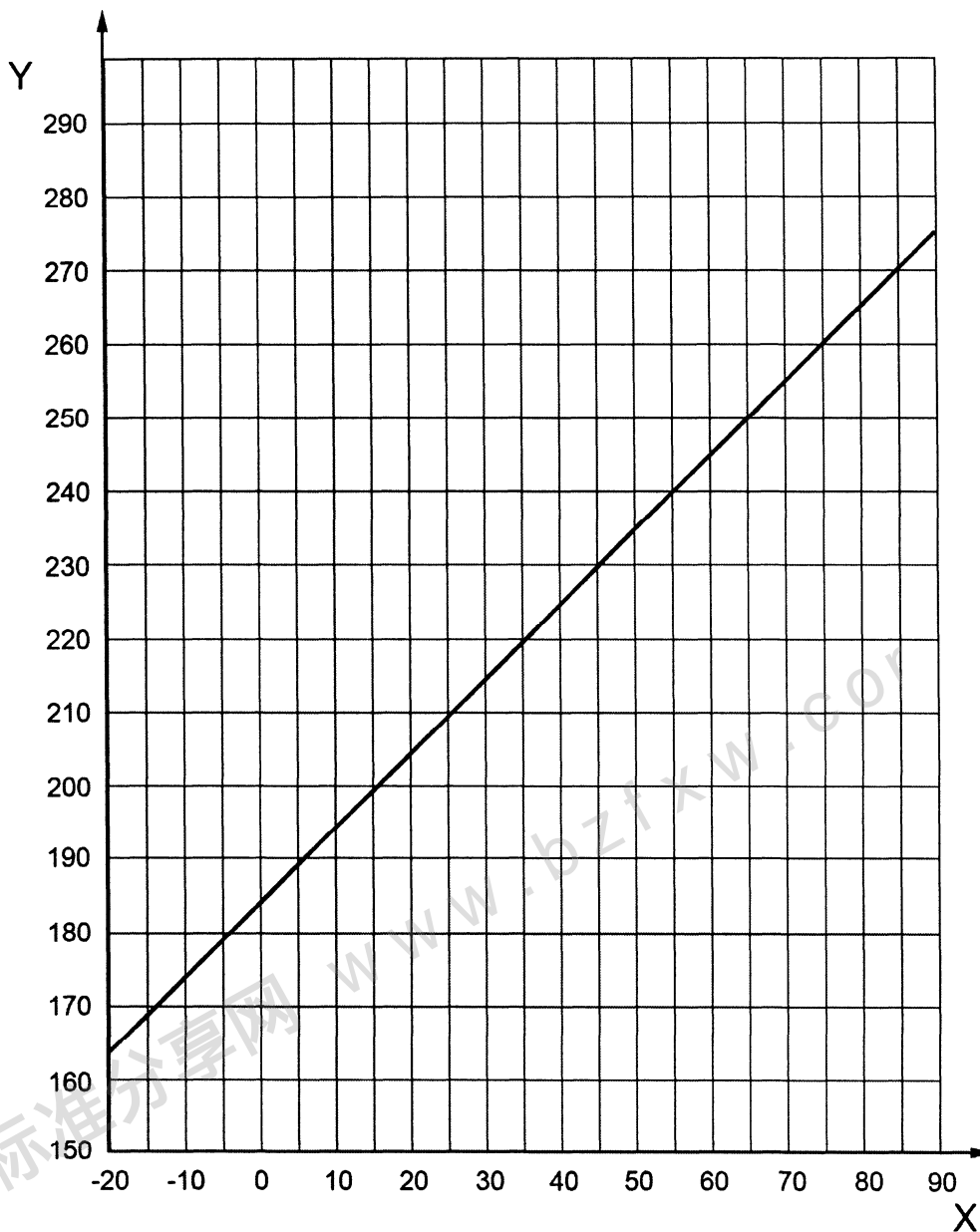
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Key

- X temperature, °C
- Y pressure, bar

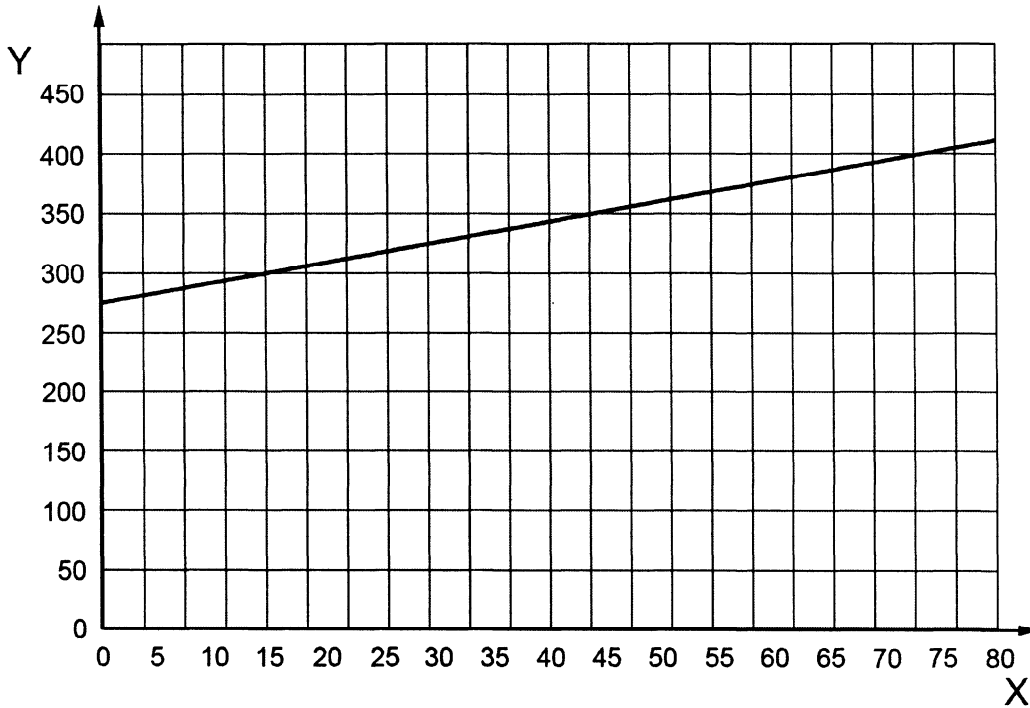
Figure 1 — Temperature/pressure graph for IG-541 pressurized to 150 bar at 15 °C



Key

- X temperature, °C
- Y pressure, bar

Figure 2 — Temperature/pressure graph for IG-541 pressurized to 200 bar at 15 °C



Key
X temperature, °C
Y pressure, bar

Figure 3 — Temperature/pressure graph for IG-541 pressurized to 300 bar at 15 °C

6.2 Superpressurization

Containers for IG-541 are not superpressurized.

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 according to EN 15004-1:2008, 7.6.

The design concentrations shall be those specified for relevant hazards in Table 4, including a 1,3 safety factor on the extinguishing concentration.

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

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