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Title: Draft BS EN 15004-1 Fixed firefighting systems - Gas extinguishing systems

Part 1: Design, installation and maintenance (ISO 14520-1:2015, modified)

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Introduction

This draft standard is based on European discussions in which the UK has taken an active part. Your comments on this draft are welcome and will assist in the preparation of the consequent British Standard. Comment is particularly welcome on national, legislative or similar deviations that may be necessary.

Even if this draft standard is not approved by the UK, if it receives the necessary support in Europe, the UK will be obliged to publish the official English Language text unchanged as a British Standard and to withdraw any conflicting standard.

UK Vote

Please indicate whether you consider the UK should submit a negative (with reasons) or positive vote on this draft.

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Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
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1	2	(3)	4	5	(6)	(7)
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/ Figure/ Table/Note	Type of comment	Comment (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	

English Version

**Fixed firefighting systems - Gas extinguishing systems -
Part 1: Design, installation and maintenance (ISO 14520-
1:2015, modified)**

Installations fixes de lutte contre l'incendie -
Installations d'extinction à gaz - Partie 1 : Calcul,
installation et maintenance (ISO 14520-1:2015,
modifiée)

Ortsfeste Brandbekämpfungsanlagen - Löschanlagen
mit gasförmigen Löschmitteln - Teil 1: Planung,
Installation und Instandhaltung (ISO 14520-1:2015,
modifiziert)

This draft European Standard is submitted to CEN members for enquiry. It has been drawn up by the Technical Committee CEN/TC 191.

If this draft becomes a European Standard, CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

This draft European Standard was established by CEN in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

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Recipients of this draft are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

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COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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European foreword

This document (prEN 15004-1:2016) has been prepared by Technical Committee CEN/TC 191 “Fixed firefighting systems”, the secretariat of which is held by BSI.

This document is currently submitted to the CEN Enquiry.

This document will supersede EN 15004-2:2008.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association

The text of the International Standard ISO 14520-1:2015 from Technical Committee ISO/TC 21 “Equipment for fire protection and firefighting” 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;*
- *Part 2: Physical properties and system design of gas extinguishing systems for FK-5-1-12 extinguishant;*
- *Part 3: Physical properties and system design of gas extinguishing systems for HCFC Blend A extinguishant;*
- *Part 4: Physical properties and system design of gas extinguishing systems for HFC 125 extinguishant;*
- *Part 5: Physical properties and system design of gas extinguishing systems for HFC 227ea extinguishant;*
- *Part 6: Physical properties and system design of gas extinguishing systems for HFC 23 extinguishant;*
- *Part 7: Physical properties and system design of gas extinguishing systems for IG-01 extinguishant;*
- *Part 8: Physical properties and system design of gas extinguishing systems for IG-100 extinguishant;*
- *Part 9: Physical properties and system design of gas extinguishing systems for IG-55 extinguishant;*
- *Part 10: Physical properties and system design of gas extinguishing systems for IG-541 extinguishant.*

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 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.

Introduction

Fire fighting systems covered in this part of EN 15004 are designed to provide a supply of gaseous extinguishing medium for the extinction of fire.

Several different methods of supplying extinguishant to, and applying it at, the required point of discharge for fire extinction have been developed in recent years, and there is a need for dissemination of information on established systems and methods. This part of EN 15004 has been prepared to meet this need.

The requirements of this part of EN 15004 are made in the light of the best technical data known to the working group at the time of writing but, since a wide field is covered, it has been impracticable to consider every possible factor or circumstance that might affect implementation of the recommendations.

It has been assumed in the preparation of this part of EN 15004 that the execution of its provisions is entrusted to people appropriately qualified and experienced in the specification, design, installation, testing, approval, inspection, operation and maintenance of systems and equipment, for whose guidance it has been prepared, and who can be expected to exercise a duty of care to avoid unnecessary release of extinguishant.

Attention is drawn to the Montreal Protocol on substances that deplete the ozone layer.

It is important that the fire protection of a building or plant be considered as a whole. Gaseous extinguishant systems form only a part, though an important part, of the available facilities, but it should not be assumed that their adoption necessarily removes the need to consider supplementary measures, such as the provision of portable fire extinguishers or other mobile appliances for first aid or emergency use, or to deal with special hazards.

Gaseous extinguishants have for many years been a recognized effective medium for the extinction of inflammable liquid fires and fires in the presence of electrical and ordinary Class A hazards, but it should not be forgotten, in the planning of comprehensive schemes, that there may be hazards for which these media are not suitable, or that in certain circumstances or situations there may be dangers in their use requiring special precautions.

Advice on these matters can be obtained from the appropriate manufacturer of the extinguishant or the extinguishing system. Information may also be sought from the appropriate fire authority, the health and safety authorities and insurers. In addition, reference should be made as necessary to other national standards and statutory regulations of the particular country.

It is essential that fire-fighting equipment be carefully maintained to ensure instant readiness when required. Routine maintenance is liable to be overlooked or given insufficient attention by the owner of the system. It is, however, neglected at peril to the lives of occupants of the premises and at the risk of crippling financial loss. The importance of maintenance cannot be too highly emphasized. Installation and maintenance should only be done by qualified personnel.

Inspection preferably by a third party, should include an evaluation that the extinguishing system continues to provide adequate protection for the risk (protected zones, as well as state of the art can change over time).

1 Scope

This part of EN 15004 specifies requirements and gives recommendations for the design, installation, testing, maintenance and safety of gaseous fire fighting systems in buildings, plants or other structures, and the characteristics of the various extinguishants and types of fire for which they are a suitable extinguishing medium.

It covers total flooding systems primarily related to buildings, plants and other specific applications, utilizing electrically non-conducting gaseous fire extinguishants that do not leave a residue after discharge and for which there are sufficient data currently available to enable validation of performance and safety characteristics by an appropriate independent authority. This part of EN 15004 is not applicable to explosion suppression.

This part of EN 15004 is not intended to indicate approval of the extinguishants listed therein by the appropriate authorities, as other extinguishants may be equally acceptable. CO₂ is not included as it is covered by other International Standards.

This part of EN 15004 is applicable to the extinguishants listed in Table 1. It is essential that it be used in conjunction with the separate parts of EN 15004 for specific extinguishants, as cited in Table 1.

Table 1 — Listed extinguishant

Extinguishant	Chemical	Formula	CAS No.	European Standard
FK-5-1-12	Dodecafluoro-2-methylpentan-3-one	CF ₃ CF ₂ C(O)CF(CF ₃) ₂	756-13-8	EN 15004-2
HCFC Blend A				EN 15004-3
HCFC-123	Dichlorotrifluoroethane	CHCl ₂ CF ₃	306-83-2	
HCFC-22	Chlorodifluoromethane	CHClF ₂	75-45-6	
HCFC-124	Chlorotetrafluoroethane	CFCIFCF ₃	2837-89-0	
	Isopropenyl-1-methylcyclohexene	C ₁₀ H ₁₆	5989-27-5	
HFC 125	Pentafluoroethane	CHF ₂ CF ₃	354-33-6	EN 15004-4
HFC 227ea	Heptafluoropropane	CF ₃ CHFCF ₃	2252-84-8	EN 15004-5
HFC 23	Trifluoromethane	CHF ₃	75-46-7	EN 15004-6
IG-01	Argon	Ar	74040-37-1	EN 15004-7
IG-100	Nitrogen	N ₂	7727-37-9	EN 15004-8
	Nitrogen (50 %)	N ₂	7727-37-9	
IG-55	Argon (50 %)	Ar	74040-37-1	EN 15004-9
	Nitrogen (52 %)	N ₂	7727-37-9	
IG-541	Argon (40 %)	Ar	74040-37-1	EN 15004-10
	Carbon dioxide (8 %)	CO ₂	124-38-9	

2 Normative references

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.

EN 2, *Classification of fires*

EN 54 (all parts), *Fire detection and fire alarm systems*

EN 12094 (all parts), *Fixed firefighting systems – Components for gas extinguishing systems*

EN 15004-2, *Fixed firefighting systems - Gas extinguishing systems - Part 2: Physical properties and system design of gas extinguishing systems for FK-5-1-12 extinguishant (ISO 14520-5:2006, modified)*

EN 15004-3, *Fixed firefighting systems - Gas extinguishing systems - Part 3: Physical properties and system design of gas extinguishing systems for HCFC Blend A extinguishant (ISO 14520-6:2006, modified)*

EN 15004-4, *Fixed firefighting systems - Gas extinguishing systems - Part 4: Physical properties and system design of gas extinguishing systems for HFC 125 extinguishant (ISO 14520-8:2006, modified)*

EN 15004-5, *Fixed firefighting systems - Gas extinguishing systems - Part 5: Physical properties and system design of gas extinguishing systems for HFC 227ea extinguishant (ISO 14520-9:2006, modified)*

EN 15004-6, *Fixed firefighting systems - Gas extinguishing systems - Part 6: Physical properties and system design of gas extinguishing systems for HFC 23 extinguishant (ISO 14520-10:2005, modified)*

EN 15004-7, *Fixed firefighting systems - Gas extinguishing systems - Part 7: Physical properties and system design of gas extinguishing systems for IG-01 extinguishant (ISO 14520-12:2005, modified)*

EN 15004-8, *Fixed firefighting systems - Gas extinguishing systems - Part 8: Physical properties and system design of gas extinguishing systems for IG-100 extinguishant (ISO 14520-13:2005, modified)*

EN 15004-9, *Fixed firefighting systems - Gas extinguishing systems - Part 9: Physical properties and system design of gas extinguishing systems for IG-55 extinguishant (ISO 14520-14:2005, modified)*

EN 15004-10, *Fixed firefighting systems - Gas extinguishing systems - Part 10: Physical properties and system design of gas extinguishing systems for IG-541 extinguishant (ISO 14520-15:2005, modified)*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1

approved

acceptable to a relevant authority

Note 1 to entry: See 3.2.

Note 2 to entry: In determining the acceptability of installations or procedures, equipment, or materials, the authority can base acceptance on compliance with the appropriate International Standards.

3.2

authority

organization, office, or individual responsible for approving equipment, installations, or procedures

3.3**automatic/manual switch**

means of converting the system from automatic to manual actuation

Note 1 to entry: This can be in the form of a manual switch on the control panel or other units, or a personnel door interlock. In all cases, this changes the actuation mode of the system from automatic and manual to manual only or vice versa.

3.4**competent person**

designated person, suitably trained, qualified by knowledge and practical experience and with the necessary instructions to enable the required tests and examinations to be carried out

3.5**disable device**

manual shut-off valve installed into the discharge piping downstream of the agent containers; or another type of device that mechanically prevents agent container actuation

Note 1 to entry: The actuation of this device provides an indication of system isolation.

Note 2 to entry: The intent is to prevent the discharge of agent into the hazard area when the disable device is activated.

3.6**extinguishant**

electrically non-conducting gaseous fire extinguishing agent that, upon evaporation, does not leave a residue

Note 1 to entry: See Table 1.

Note 2 to entry: The terms “extinguishant” and “agent” are used interchangeably throughout in this part of EN 15004.

3.7**clearance**

air gap between equipment, including piping and nozzles and unenclosed or uninsulated live electrical components at other than ground potential

3.8**concentration****3.8.1****design concentration**

concentration of extinguishant, including a safety factor, required for system design purposes

3.8.2**maximum concentration**

concentration achieved from the actual extinguishant quantity at the maximum ambient temperature in the protected area

3.8.3**extinguishing concentration**

minimum concentration of extinguishant required to extinguish a fire involving a particular fuel under defined experimental conditions excluding any safety factor

3.9

engineered system

system in which the supply of extinguishant stored centrally is discharged through a system of pipes and nozzles in which the size of each section of pipe and nozzle orifice has been calculated in accordance with relevant parts of EN 15004

3.10

fill density

mass of extinguishant per unit volume of container

3.11

flooded quantity

mass or volume of extinguishant required to achieve the design concentration within the protected volume

3.12

net volume

volume enclosed by the building elements around the protected enclosure, minus the volume of any permanent impermeable building elements within the enclosure

3.13

hold time

period of time during which a concentration of extinguishant greater than the fire extinguishing concentration surrounds the hazard

3.14

inspection

visual check to give reasonable assurance that the extinguishing system is fully charged and operable

Note 1 to entry: This is done by seeing that the system is in place, that it has not been activated or tampered with, and that there is no obvious physical damage or condition to prevent operation.

3.15

installer

legal person that is responsible for the design and installation and is able to ensure that the quality assurance is exercised

3.16

lock-off device

manual shut-off valve installed in the discharge piping downstream of the agent containers or another type of device that mechanically prevents agent container actuation

Note 1 to entry: The actuation of this device provides an indication of system isolation.

Note 2 to entry: The intent is to prevent the discharge of agent into the hazard area when the lock-off device is activated.

3.17

lowest observed adverse effect level

LOAEL

lowest concentration at which an adverse toxicological or physiological effect has been observed

3.18**maintenance**

combination of all technical, administrative and managerial actions during the life cycle of an item intended to retain it in, or restore it to, a state in which it can perform the required function

3.19**maximum working pressure**

equilibrium pressure within a container at the maximum working temperature

Note 1 to entry: For liquefied gases, this is at the maximum fill density and can include superpressurization.

Note 2 to entry: The equilibrium pressure for a container in transit can differ from that in storage within a building.

3.20**no observed adverse effect level****NOAEL**

highest concentration at which no adverse toxicological or physiological effect has been observed

3.21**non-liquefied gas**

gas or gas mixture (normally an inert gas), which, under service pressure and permissible service temperature conditions, is always present in the gaseous form

3.22**normally occupied area**

area intended for occupancy

3.23**normally unoccupied area**

area not normally occupied by people but which may be entered occasionally for brief periods

3.24**pre-engineered systems**

system consisting of a supply of extinguishant of specified capacity coupled to pipework with a balanced nozzle arrangement up to a maximum permitted design

Note 1 to entry: No deviation is permitted from the limits specified by the manufacturer or authority.

3.25**regulated system**

non-liquefied gas systems which produce a flow of gas at controlled reduced where the pressure downstream of a pressure regulation device is limited to some maximum pressure under both flow and no flow conditions during the discharge period

3.26**safety factor**

multiplier of the agent extinguishing concentration to determine the agent minimum design concentration

3.27**sea level equivalent of oxygen**

oxygen concentration (volume percent) at sea level for which the partial pressure of oxygen matches the ambient partial pressure of oxygen at a given altitude

3.28

selector valve

valve installed in the discharge piping downstream of the agent containers, to direct the agent to the appropriate hazard enclosure

Note 1 to entry: It is used where one or more agent containers are arranged in order to selectively discharge agent to any of several separate hazard enclosures.

3.29

superpressurization

addition of a gas to the extinguishant container, where necessary, to achieve the required pressure for proper system operation

3.30

total flooding system

system arranged to discharge extinguishant into an enclosed space to achieve the appropriate design concentration

3.31

unoccupiable area

area that cannot be occupied due to dimensional or other physical constraints

EXAMPLE Shallow voids and cabinets.

4 Use and limitations

4.1 General

Throughout all the parts of EN 15004, the word “shall” indicates a mandatory requirement; the word “should” indicates a recommendation or that which is advised but not required.

The design, installation, service and maintenance of gaseous fire-extinguishing systems shall be performed by those competent in fire extinguishing system technology. Maintenance and installation shall only be done by qualified personnel and companies.

The hazards against which these systems offer protection, and any limitations on their use, shall be contained in the system supplier’s design manual.

Total flooding fire-extinguishing systems are used primarily for protection against hazards that are in enclosures or equipment that, in itself, includes an enclosure to contain the extinguishant. The following are typical of such hazards, but the list is not exhaustive:

- a) electrical and electronic hazards;
- b) telecommunications facilities;
- c) inflammable and combustible liquids and gases;
- d) other high-value assets.

For the purposes of this document, the term “bar” shall be taken as “gauge”, unless otherwise indicated. Concentrations or quantities expressed in percentages (%) shall be taken as by volume, unless otherwise indicated.

4.2 Extinguishants

Any agent that is to be recognized by this part of EN 15004 or proposed for inclusion in this part of EN 15004 shall first be evaluated in a manner equivalent to the process used by the US. Environmental Protection Agency's (EPA) SNAP Programme or other internationally recognized extinguishing agent approval institutions.

The extinguishants referred to in this part of EN 15004 are electrically non-conductive media.

The extinguishants and specialized system parameters are each covered individually in the parts of EN 15004 for specific extinguishants. These parts shall be used in conjunction with this part of EN 15004.

Unless relevant testing has been carried out to the satisfaction of the authority, the extinguishants referred to in the specific parts of EN 15004 shall not be used on fires involving the following:

- a) chemicals containing their own supply of oxygen, such as cellulose nitrate;
- b) mixtures containing oxidizing materials, such as sodium chlorate or sodium nitrate;
- c) chemicals capable of undergoing autothermal decomposition, such as some organic peroxides;
- d) reactive metals (such as sodium, potassium, magnesium, titanium and zirconium), reactive hydrides, or metal amides, some of which may react violently with some gaseous extinguishants;
- e) environments where significant surface areas exist at temperatures greater than the breakdown temperature of the extinguishing agent and are heated by means other than the fire.

4.2.1 Environmental properties

Global warming potential (GWP) and ozone depletion potential (ODP) values applicable to the gaseous extinguishing agents are detailed in EN 15004-2 to EN 15004-10.

NOTE GWP is a measure of how much a given mass of gas is estimated to contribute to global warming. The scale is a relative comparison on a mass basis where a clean agent is compared to carbon dioxide, which has a GWP equal to 1. ODP provides a relative comparison of the ability to react with ozone at altitudes within the stratosphere. ODP values are reported relative to the same mass of CFC-11, which has an ODP equal to 1. The intergovernmental panel on climate change (IPCC) and the Parties to the Montreal Protocol provide up to date environmental information on clean agent alternatives. Users of this part of EN 15004 are encouraged to review the information provided by those organizations to understand the significance of the environmental properties of the agents in this part of EN 15004.

The list of compounds and their global warming potentials can be found at the IPCC site at: http://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch2s2-10-2.html. The list of compounds and their ozone depletion potentials can be found at the Montreal Protocol site at: http://montreal-protocol.org/new_site/en/Treaties/treaties_decisions-hb.php?art_id=59,60,61,62,63.

4.3 Electrostatic discharge

Care shall be taken when discharging extinguishant into potentially explosive atmospheres. Electrostatic charging of conductors not bonded to earth may occur during the discharge of extinguishant. These conductors may discharge to other objects with sufficient energy to initiate an explosion. Where the system is used for inerting, pipework shall be adequately bonded and earthed.

4.4 Compatibility with other extinguishants

Mixing of extinguishants in the same container shall be permitted only if the system is approved for use with such a mixture.

Systems using the simultaneous discharge of different extinguishants to protect the same enclosed space shall not be permitted.

4.5 Temperature limitations

All devices shall be designed for the service they will encounter and shall not readily be rendered inoperative or susceptible to accidental operation. Devices normally shall be designed to function properly from -20°C to $+50^{\circ}\text{C}$, or marked to indicate temperature limitations, or in accordance with manufacturers' specifications which shall be marked on the name-plate, or (where there is no name-plate) in the manufacturer's instruction manual.

5 Safety

5.1 Hazard to personnel

Any hazard to personnel created by the discharge of gaseous extinguishants shall be considered in the design of the system, in particular with reference to the hazards associated with particular extinguishants in the supplementary parts of EN 15004. Unnecessary exposure to all gaseous extinguishants shall be avoided.

Adherence to EN 15004 does not remove the user's statutory responsibility to comply with the appropriate safety regulations.

The decomposition products generated by the clean agent breaking down in the presence of very high degrees of heat can be hazardous. All of the present halocarbon agents contain fluorine. In the presence of available hydrogen (from water vapour, or the combustion process itself), the main decomposition product is hydrogen fluoride (HF).

These decomposition products have a sharp, acrid odour, even in minute concentrations of only a few parts per million. This characteristic provides a built-in warning system for the agent, but at the same time creates a noxious, irritating atmosphere for those who shall enter the hazard following a fire.

The amount of agent that can be expected to decompose in extinguishing a fire depends to a large extent on the size of the fire, the particular clean agent, the concentration of the agent, and the length of time the agent is in contact with the flame or heated surface. If there is a very rapid build-up of concentration to the critical value, then the fire will be extinguished quickly and the decomposition will be limited to the minimum possible with that agent. Should that agent's specific composition be such that it could generate large quantities of decomposition products, and the time to achieve the critical value is lengthy, then the quantity of decomposition products can be quite great. The actual concentration of the decomposition products then depends on the volume of the room in which the fire was burning and on the degree of mixing and ventilation.

Clearly, longer exposure of the agent to high temperatures would produce greater concentrations of these gases. The type and sensitivity of detection, coupled with the rate of discharge, should be selected to minimize the exposure time of the agent to the elevated temperature if the concentration of the breakdown products is to be minimized.

Non-liquefied agents do not decompose measurably in extinguishing a fire. As such, toxic or corrosive decomposition products are not found. However, breakdown products of the fire itself can still be substantial and could make the area untenable for human occupancy.

5.2 Safety precautions

5.2.1 General

As acceptable alternatives to the requirements of 5.2 and 5.3, either the requirements of Annex G for safe personnel exposure guidelines or those requirements specified by appropriate national standards may be followed.

The safety precautions required by this part of EN 15004 do not address toxicological or physiological effects associated with the products of combustion caused by fire. The maximum exposure time assumed by the safety precautions in this part of EN 15004 is 5 min. Exposure times longer than 5 min may involve physiological or toxicological effects not addressed by this part of EN 15004.

Non-electrical disable devices shall be approved in accordance with EN 12094-6.

Time delay devices shall be approved in accordance with EN 12094-1 or EN 12094-2.

5.2.2 For normally occupied areas

The minimum safety precautions taken shall be in accordance with Table 2.

Table 2 — Minimum safety precautions

Maximum concentration	Time delay device	Automatic/manual switch	Lock-off device
Up to and including the NOAEL	Required	Not required	Not required
Above the NOAEL and up to the LOAEL	Required	Required	Not required
LOAEL and above	Required	Required	Required
NOTE The intent of this table is to avoid unnecessary exposure of occupants to the discharged extinguishant. Factors such as the time for egress and the risk to the occupants, by the fire, should be considered when determining the system discharge time delay. Where national standards require other precautions, these should be implemented.			

When using inert gas agents, the NOAEL and LOAEL are the agent concentrations that result in low-limit partial pressures of oxygen of 12,1 kPa (91,0 mm Hg) and 10,2 kPa (76,6 mm Hg), respectively. These agent concentrations depend on the barometric pressure at the altitude at which the hazard is located. The relationship of altitude to average atmospheric pressure is as follows:

$$P_{\text{ATM}} = 101,325(1 - 0,0000225577h)^{5,25588} \quad (1)$$

where

h is the altitude, m;

P is the atmospheric pressure, Pa.

The maximum inert gas agent concentration, C_{MAX} , that reduces the oxygen partial pressure to the low-limit value, can be calculated using Formula (2):

$$C_{\text{MAX}} = 476,2(0,21P_{\text{ATM}} - P_{\text{O}_2, \text{LOW-LIMIT}}) / P_{\text{ATM}} \quad (2)$$

where

C_{MAX} is the maximum allowable agent concentration, vol. %;

P_{ATM} is the local atmospheric pressure, Pa;

$P_{\text{O}_2, \text{LOW-LIMIT}}$ is the minimum allowed oxygen concentration in the agent-air mixture, Pa.

The effect of applying these formulae on C_{MAX} as a function of altitude is shown in Table 3.

Table 3 — Maximum inert gas agent concentration at the NOAEL and LOAEL limits as a function of altitude

			NOAEL	LOAEL
$P_{O_2, \text{LOW-LIMIT}}$, kPa →			12,1	10,2
h	P	$P_{O_2, \text{ATM}}$	C_{MAX}	C_{MAX}
m	Pa	kPa	vol. %	vol. %
0	101,325	21,28	43,1	52,1
250	98,358	20,66	41,4	50,6
500	95,461	20,05	39,6	49,1
750	92,634	19,45	37,8	47,6
1 000	89,875	18,87	35,9	46,0
1 250	87,182	18,31	33,9	44,3
1 500	84,556	17,76	31,9	42,6
1 750	81,994	17,22	29,7	40,8
2 000	79,495	16,69	27,5	38,9
2 250	77,058	16,18	25,2	37,0
2 500	74,683	15,68	22,8	35,0
2 750	72,366	15,20	20,4	32,9
3 000	70,109	14,72	17,8	30,7

5.2.3 For normally unoccupied areas

The maximum concentration shall not exceed the LOAEL for the extinguishant used unless a lock-off device is fitted.

It is recommended that systems where the NOAEL is expected to be exceeded be placed in non-automatic mode whilst the room is occupied.

WARNING — Any change to the enclosure volume, or addition or removal of fixed contents that was not covered in the original design will affect the concentration of extinguishant. In such instances, the system shall be recalculated to ensure that the required design concentration is achieved and the maximum concentration is consistent with Table 2.

5.2.4 For unoccupiable areas

The maximum concentration may exceed the LOAEL for the extinguishant used, without the need for a lock-off device to be fitted.

5.3 Occupiable areas

In areas that are protected by total flooding systems and that are capable of being occupied, the following shall be provided.

- a) Time delay devices:

- 1) For applications where a discharge delay does not significantly increase the threat to life or property, from fire, extinguishing systems shall incorporate a pre-discharge alarm with a time delay sufficient to allow personnel evacuation prior to discharge.
 - 2) Time delay devices shall be used only for personnel evacuation or to prepare the hazard area for discharge.
- b) Automatic/manual switch and lock-off devices where required in accordance with 5.2.
- NOTE Although lock-off devices are not always required, they are essential in some situations, particularly for some specific maintenance functions.
- c) Exit routes, which shall be kept clear at all times, and emergency lighting and adequate direction signs to minimize travel distances.
 - d) Outward-swinging self-closing doors that can be opened from the inside, including when locked from the outside.
 - e) Continuous visual and audible alarms at entrances and designated exits inside the protected area and continuous visual alarms outside the protected area, which operate until the protected area has been made safe.
 - f) Appropriate warning and instructions signs.
 - g) Where required, pre-discharge alarms within such areas, which are distinctive from all other alarm signals, and which, upon detection of the fire, will operate immediately on commencement of time delay.
 - h) Means for prompt natural or forced-draft ventilation of such areas after any discharge of extinguishant. Forced-draft ventilation will often be necessary. Care shall be taken to completely dissipate hazardous atmospheres and not just move them to other locations, as most extinguishants are heavier than air.
 - i) Instructions and drills of all personnel within or in the vicinity of protected areas, including maintenance or construction personnel who may be brought into the area, to ensure their correct actions when the system operates.

In addition to the above requirements, the following are recommended:

- 1) Self-contained breathing apparatus should be supplied and personnel trained in its use.
- 2) Personnel should not enter the enclosure until it has been verified as being safe to do so.

5.4 Electrical hazards

Where exposed electrical conductors are present, clearances no smaller than those given in Table 4 shall be provided, where practicable, between the electrical conductors and all parts of the system that may be approached during maintenance. Where these clearance distances cannot be achieved, warning notices shall be provided and a safe system of maintenance work shall be adopted.

The system should be so arranged that all normal operations can be carried out with safety to the operator.

Table 4 — Safety clearances to enable operation, inspection, cleaning, repairs, painting and normal maintenance work to be carried out

Maximum rated voltage	Minimum clearance from any point on or about the permanent equipment where a person may be required to stand ^a	
	To the nearest unscreened live conductor in air (section clearance)	To the nearest part not at earth potential of an insulator ^b supporting a live conductor (ground clearance)
kV	m	m
15	2,6	2,5
33	2,75	
44	2,90	
66	3,10	
88	3,20	
110	3,35	
132	3,50	
165	3,80	
220	4,30	
275	4,60	
^a Measured from position of the feet.		
^b The term insulator includes all forms of insulating supports, such as pedestal and suspension insulators, bushings, cable sealing ends and the insulating supports of certain types of circuit breaker.		

5.5 Electrical earthing

Systems within electrical substations or switchrooms shall be efficiently bonded and earthed to prevent the metalwork becoming electrically charged.

5.6 Electrostatic discharge

The system shall be adequately bonded and earthed to minimize the risk of electrostatic discharge.

6 System design

6.1 General

This clause sets out the requirements for the design of the extinguishing system.

All ancillary systems and components shall comply with the relevant national or International Standards.

6.2 Extinguishant supply

6.2.1 Quantity

6.2.1.1 The amount of extinguishant in the system shall be at least sufficient for the largest single hazard or group of hazards that are to be protected against simultaneously.

6.2.1.2 Where required, the reserve quantity shall be as many multiples of the main supply as the authority considers necessary.

6.2.1.3 Where uninterrupted protection is required, both the main and reserve supply shall be permanently connected to the distribution piping and arranged for easy changeover.

6.2.2 Quality

The extinguishant shall comply with the relevant part of EN 15004.

6.2.3 Container arrangement

6.2.3.1 Arrangements shall be made for container and valve assemblies and accessories to be accessible for inspection, testing and other maintenance when required.

6.2.3.2 Containers shall be adequately mounted and suitably supported according to the systems installation manual so as to provide for convenient individual servicing of the container and its contents.

6.2.3.3 Containers shall be located as near as is practical to the enclosure they protect, preferably outside the enclosure. Containers can be located within the enclosure only if sited so as to minimize the risk of exposure to fire and explosion.

6.2.3.4 Storage containers shall not be located where they will be subjected to severe weather conditions or to potential damage due to mechanical, chemical, or other causes. Where potentially damaging exposure or unauthorized interference are likely, suitable enclosures or guards shall be provided.

NOTE Direct sunlight has the potential to increase the container temperature above that of the surrounding atmospheric temperature.

6.2.4 Storage containers

6.2.4.1 General

Containers shall be designed to hold the specific extinguishant. Containers shall not be charged to a fill density greater than specified in the part of EN 15004 relating to the specific extinguishant.

The containers used in these systems shall be designed to meet the requirements of relevant national standards.

Where required, the container and valve assembly should be fitted with a pressure relief device complying with the appropriate national standard.

Container valves shall be approved in accordance with EN 12094-4.

6.2.4.2 Contents indication

Means shall be provided to indicate that each container is correctly charged.

If pressure gauges, switches or mechanical weighing devices are used these shall be according to EN 12094-10 or EN 12094-11.

6.2.4.3 Marking

Each halocarbon container shall have a permanent name-plate or other permanent marking specifying the extinguishant, tare and gross mass, and the superpressurization level (where applicable) of the

container. Each inert gas container shall have a permanent marking specifying the extinguishant, pressurization level of the container and nominal volume.

6.2.4.4 Manifolded containers

When two or more containers are connected to the same manifold, automatic means (such as check valves) shall be provided to prevent extinguishant loss from the manifold if the system is operated when any containers are removed for maintenance.

Check valves shall be approved in accordance with EN 12094-13.

Containers connected to a common manifold in a system shall be

- a) of the same nominal form and capacity,
- b) filled with the same nominal mass of extinguishant, and
- c) pressurized to the same nominal working pressure.

Different sized storage containers connected to a common manifold may be used for non-liquefied gas containers, provided they are all pressurized to the same nominal working pressure.

6.2.4.5 Operating temperatures

Unless otherwise approved, in-service container operating temperatures for total flooding systems shall not exceed 50 °C nor be less than -20 °C (see also 7.3.1).

External heating or cooling should be used to keep the temperature of the storage container within the specified range unless the system is designed for proper operation with operating temperatures outside this range.

6.3 Distribution

6.3.1 General

6.3.1.1 Pipework and fittings shall comply with the appropriate national standards, shall be non-combustible and able to withstand the expected pressures and temperatures without damage.

6.3.1.2 Before final assembly, pipe and fittings shall be inspected visually to ensure they are clean and free of burrs and rust, and that no foreign matter is inside and the full bore is clear. After assembly, the system shall be thoroughly blown through with dry air or other compressed gas.

A dirt trap consisting of a tee with a capped nipple, at least 50 mm long, shall be installed at the end of each pipe run. Drain traps protected against interference by unauthorized personnel should be fitted at the lowest points in the pipework system if there is any possibility of a build-up of water.

6.3.1.3 In systems where valve arrangements introduce sections of closed piping, such sections shall be equipped with the following:

- a) indication of extinguishant trapped in piping;
- b) means for safe manual venting (see 6.3.1.4);
- c) automatic relief of over pressures.

Over-pressure relief devices shall be designed to operate at the lesser of a pressure no greater than 63 % of the test pressure of the pipework or 95 % of the maximum working pressure, or as required by the appropriate national standard.

6.3.1.4 Pressure relief devices, which can include the selector valve, shall be fitted so that the discharge, in the event of operation, will not injure or endanger personnel and, if necessary, so that the discharge is piped to an area where it will not become a hazard to personnel.

6.3.1.5 In systems using pressure-operated container valves, automatic means shall be provided to vent any container leakage that could build up pressure in the pilot system and cause unwanted opening of the container valve. The means of pressure venting shall not prevent operation of the container valve.

6.3.1.6 All closed-section pipework and pipework upstream of pressure-reducing devices shall be hydrostatically tested to a minimum of $1,5 \times$ the maximum working pressure **or the maximum pressure obtained with a regulated system** for 2 min during which there shall be no leakage. On completion of the test, the pipework shall be purged to remove moisture.

6.3.1.7 Adequate protection shall be given to pipes, fittings or support brackets and steelwork that are likely to be affected by corrosion. Special corrosion-resistant materials or coatings shall be used in highly corrosive atmospheres.

6.3.2 Piping

6.3.2.1 Piping shall be of non-combustible material having physical and chemical characteristics, such that its integrity under stress can be predicted with reliability. The thickness of the pipe wall shall be calculated in accordance with the relevant national standard. The pressure for this calculation shall be the developed pressure at a maximum storage temperature of not less than 50 °C. If higher operating temperatures are approved for a given system, the design pressure shall be adjusted to the developed pressure at maximum temperature.

In performing these calculations, all joint factors and threading, grooving or welding allowances shall be taken into account.

Where a static pressure-reducing device is used in a non-liquefied gas system, the maximum working pressure in the distribution pipework downstream of the device shall be used in the calculation of the downstream pipe wall thickness.

6.3.2.2 Cast iron and non-metallic pipes shall not be used except where approved for the rated operating pressure.

6.3.2.3 Flexible tubing or hoses (including connections) shall be of approved materials and shall be suitable for service at the anticipated extinguishant pressure and maximum and minimum temperatures.

Hoses and flexible connectors shall be approved in accordance with EN 12094-8.

6.3.3 Fittings

6.3.3.1 Fittings shall have a minimum rated working pressure equal to or greater than the maximum pressure in the container at 50 °C, or the temperature specified in the national standard, when filled to the maximum permissible fill density for the extinguishant being used. For systems that use a pressure-reducing device in the distribution piping, the fittings downstream of the device shall have a minimum rated working pressure equal to or greater than the maximum anticipated pressure in the downstream piping.

Cast iron fittings shall not be used.

6.3.3.2 Welding and brazing alloys shall have a melting point above 500 °C.

6.3.3.3 Welding shall be performed in accordance with relevant national standards.

6.3.3.4 Where copper, stainless steel or other suitable tubing is joined with compression fittings, the manufacturer's pressure/temperature ratings of the fitting shall not be exceeded and care shall be taken to ensure the integrity of the assembly.

6.3.4 Pipe and valve supports

Pipe and valve supports shall be of a non-combustible material, shall be suitable for the expected temperature and shall be able to withstand the dynamic and static forces involved. Due allowance shall be made for the stresses induced in the pipe work by temperature variations. Adequate environmental protection shall be given to supports and associated steelwork. The distance between pipe supports shall be as specified in Table 5.

Adequate support shall be provided for nozzles and their reactive forces such that in no case shall the distance from the last support be greater than as follows:

a) ≤ 25 mm pipe $\varnothing$: ≤ 100 mm;

b) > 25 mm pipe $\varnothing$: ≤ 250 mm.

Movement of pipework, caused by temperature fluctuations arising from environment or the discharge of extinguishant, may be considerable particularly over long lengths and should be taken into account when deciding support fixing methods.

Table 5 — Maximum pipework spans

Nominal diameter of pipe DN	Maximum pipework span m
6	0,5
10	1,0
15	1,5
20	1,8
25	2,1
32	2,4
40	2,7
50	3,4
65	3,5
80	3,7
100	4,3
125	4,8
150	5,2
200	5,8

6.3.5 Valves

6.3.5.1 All valves, gaskets, O-rings, sealants and other valve components shall be constructed of materials that are compatible with the extinguishant and shall be suitable for the envisaged pressures and temperatures.

6.3.5.2 Valves shall be protected against mechanical, chemical or other damage.

6.3.5.3 Special corrosion-resistant materials or coatings shall be used in severely corrosive atmospheres.

6.3.5.4 Selector valves shall be in accordance with EN 12094-5.

6.3.6 Nozzles

6.3.6.1 Nozzle choice and location

Nozzles, including nozzles directly attached to containers, shall be approved and shall be located with the geometry of the enclosure taken into consideration.

The type number and placement of nozzles shall be such that

- a) the design concentration is achieved in all parts of the enclosure (see EN 12094-7),
- b) the discharge does not unduly splash inflammable liquids or create dust clouds that might extend the fire, create an explosion or otherwise adversely affect the occupants, and
- c) the velocity of discharge does not adversely affect the enclosure or its contents.

Where clogging by foreign materials is possible, the discharge nozzles shall be provided with frangible discs or blow-out caps. These devices shall provide an unobstructed opening upon system operation and shall be designed and arranged so they will not injure personnel.

Nozzles shall be suitable for the intended use and shall be approved for discharge characteristics, in accordance to EN 12094-7, or shall be approved under the procedure described in national, european or international nozzle standards.

Nozzles shall be of adequate strength for use with the expected working pressures, they shall be able to resist nominal mechanical abuse and shall be constructed to withstand expected temperatures without deformation.

Nozzle discharge orifice inserts shall be of corrosion-resistant material.

6.3.6.2 Nozzles in ceiling tiles

In order to minimize the possibility of lifting or displacement of lightweight ceiling tiles, precautions shall be taken to securely anchor tiles for a minimum distance of 1,5 m from each discharge nozzle.

NOTE The discharge velocities created by the design of nozzles can be a factor in the displacement of ceiling tiles.

6.3.6.3 Marking

Discharge nozzles shall be permanently marked to identify the manufacturer and size of the orifice.

6.3.6.4 Filters

The inlet of any nozzle assembly or pressure-reducing assembly, which contains an orifice of area less than 7 mm², shall be provided with an internal filter capable of preventing obstruction of the orifice.

Only filters as approved together with the nozzle shall be used.

6.3.7 Pressure reducing orifice assembly

Pressure reducing orifice assemblies shall be permanently marked to identify the size of the orifice. This marking shall be readily visible after the assembly is installed.

6.4 Detection, actuation and control systems

6.4.1 General

Detection, actuation and control systems may be either automatic or manual. Where they are automatic, provision shall also be made for manual operation.

Detection, actuation, alarm and control systems shall be installed, tested and maintained in accordance with appropriate national standards.

Unless otherwise specified in a national standard, 24 h minimum standby sources of energy shall be used to provide for operation of the detection, signalling, control and actuation requirements of the system.

6.4.2 Automatic detection

Automatic detection shall be by any method or device acceptable to the authority and shall be capable of early detection and indication of heat, flame, smoke, combustible vapours or any abnormal condition in the hazard that is likely to produce fire.

Fire detection components shall be approved in accordance with the relevant part of EN 54 or EN 12094, whichever applies.

NOTE Detectors installed at the maximum approved spacing for fire alarm use can result in excessive delay in extinguishant release, especially where more than one detection device is required to be in alarm before automatic actuation results.

6.4.3 Operating devices

6.4.3.1 Automatic operation

Automatic systems shall be controlled by automatic fire detection and actuation systems suitable for the system and hazard and shall also be provided with a means of manual operation.

Electrically operated fire detection systems shall comply with the appropriate national standard. The electric power supply shall be independent of the supply for the hazard area and shall include an emergency secondary power supply with automatic changeover in case the primary supply fails.

When two or more detectors are used, such as those for detecting smoke or flame, it is preferable for the system to operate only after signals from two detectors have been received.

6.4.3.2 Manual operation

Provision shall be made for manual operation of the fire fighting system by means of a control situated outside the protected space or adjacent to the main exit from the space.

In addition to any means of automatic operation, the system shall be provided with the following:

- a) One or more means, remote from the containers, of manual operation.
- b) A manual device for providing direct mechanical actuation of the system or an electrical manual release system in which the control equipment monitors for abnormal conditions in the power supply and provides a signal when the power source is inadequate.

Manual operation shall cause simultaneous operation of the appropriate automatically operated valves for extinguishant release and distribution.

NOTE 1 National standards may not require a manual release or may require the release to operate via the pre-discharge alarms and time delay.

The manual operation device shall incorporate a double action or other safety device to restrict accidental operation. The device shall be provided with a means of preventing operation during maintenance of the system.

NOTE 2 The choice of the means of operation will depend upon the nature of the hazard to be protected. Automatic fire detection and alarm equipment will normally be provided on a manual system to indicate the presence of a fire.

Manual operating devices shall be approved in accordance with EN 12094-3.

6.4.4 Control equipment

6.4.4.1 Electric control equipment

Electric control equipment shall be used to supervise the detecting circuits, manual and automatic releasing circuits, signalling circuits, electrical actuating devices and associated wiring and, when required, cause actuation. The control equipment shall be capable of operation with the number and type of actuating devices utilized.

Electrical automatic control and delay devices shall be approved in accordance with EN 12094-1.

6.4.4.2 Pneumatic control equipment

Where pneumatic control equipment is used, the lines shall be protected against crimping and mechanical damage. Where installations could be exposed to conditions that could lead to loss of integrity of the pneumatic lines, special precautions shall be taken to ensure that no loss of integrity occurs.

Non-electrical automatic control and delay devices shall be approved in accordance with EN 12094-2.

6.4.5 Operating alarms and indicators

6.4.5.1 Alarms or indicators, or both, shall be used to indicate the operation of the system, hazards to personnel or failure of any supervised device. The type (audible, visual or olfactory), number and location of the devices shall be such that their purpose is satisfactorily accomplished. The extent and type of alarms or indicator equipment, or both, shall be approved.

Pneumatic alarm devices shall be approved in accordance with EN 12094-12.

6.4.5.2 Audible and visual pre-discharge alarms shall be provided within the protected area to give positive warning of impending discharge. The operation of the warning devices shall be continued after extinguishant discharge, until positive action has been taken to acknowledge the alarm and proceed with appropriate action.

6.4.5.3 Alarms indicating failure of supervised devices or equipment shall give prompt and positive indication of any failure and shall be distinct from alarms indicating operation or hazardous conditions.

6.4.6 Stop device

Stop devices, where provided, shall be located within the protected area and shall be located near the means of egress for the area. The stop device shall be a type that requires constant manual force to inhibit system operation. Operation of the hold function shall result in both audible and distinct visual indication of system impairment. Operation of the stop device when the system is in the quiescent state

shall result in a fault indication at the control unit. The stop device shall be clearly recognizable for the purpose intended.

Stop devices shall be approved in accordance with EN 12094-3.

7 Extinguishant system design

7.1 General

This clause sets out the requirements for the specifications, system flow calculations and extinguishant concentrations. It shall be read in conjunction with the appropriate part of EN 15004 for the specific agent.

7.2 Specifications, plans and approvals

7.2.1 Specifications

Specifications for gaseous fire-extinguishing systems shall be prepared under the supervision of a person fully experienced in the design of gaseous extinguishing systems and, where appropriate, with the advice of the authority. The specifications shall include all pertinent items necessary for the proper design of the system, such as the designation of the authority, variances from the standard to be permitted by the authority, design criteria, system sequence of operations, the type and extent of the acceptance testing to be performed after installation of the system and owner training requirements. Extinguishant specifications are included in the various parts of EN 15004 for the specific agent.

7.2.2 Working documents

Layout and system proposal documents shall be submitted for approval to the authority before installation or modification begins. The type of documentation required is specified in Annex A.

7.3 System flow calculations

7.3.1 General

System flow calculations shall be carried out at a nominal extinguishant storage temperature of 20 °C, shall have been validated by an accredited approval authority by appropriate tests, such as those described in this part of EN 15004, and shall be properly identified. The system design shall be within the manufacturer's specified limitations (see also Annex H).

NOTE 1 Variations from the nominal 20 °C storage temperature affect flow conditions used in calculations.

NOTE 2 Pre-engineered systems do not require a flow calculation when used within approved limitations.

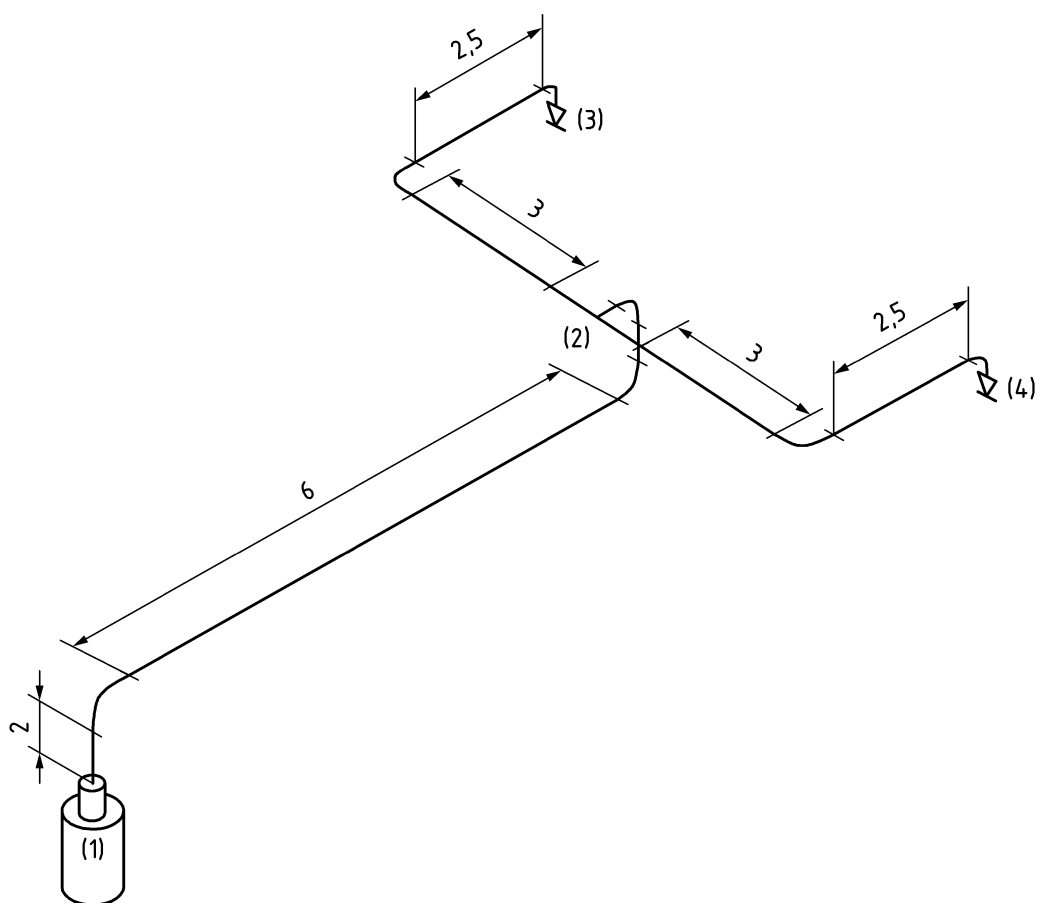
7.3.2 Balanced and unbalanced system

7.3.2.1 A balanced system shall be one in which of the following:

- a) actual or equivalent pipe lengths from the container to each nozzle are all within 10 % of each other;
- b) the discharge rate of each nozzle is the same (see Figure 1).

7.3.2.2 Any system that does not meet these criteria shall be considered to be an unbalanced system (see Figure 2)

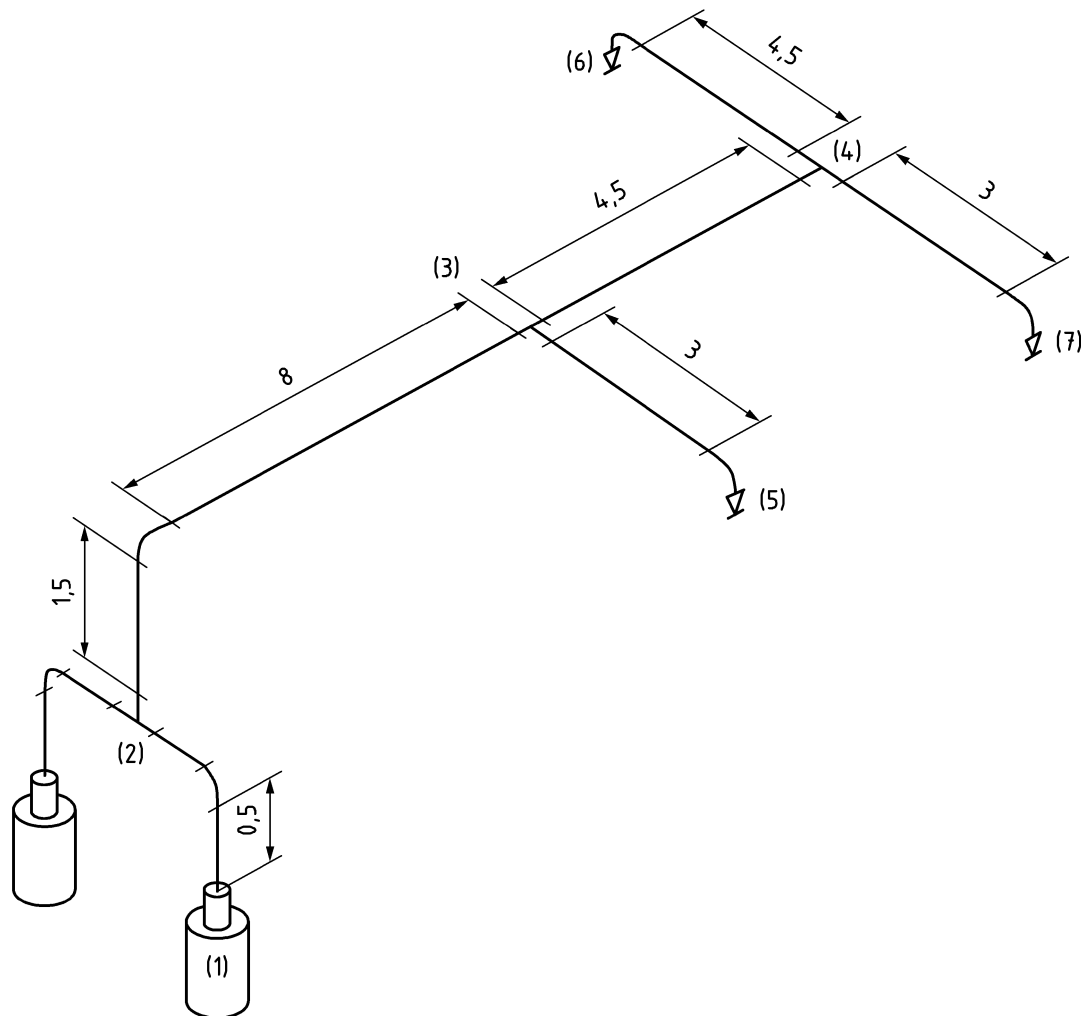
Dimensions in metres



NOTE Figures in bold in parentheses denote design nodes for calculations.

Figure 1 — Typical balanced system

Dimensions in metres



NOTE Figures in bold in parentheses denote design nodes for calculations.

Figure 2 — Typical unbalanced system

7.3.3 Friction losses

Allowance shall be made for the friction losses in pipes and in container valves, dip tubes, flexible connectors, selector valves, time delay devices and other equipment (e.g. pressure-reducing devices) within the flow line.

NOTE The flow of a liquefied gas has been demonstrated to be a two-phase phenomenon, the fluid consisting of a mixture of liquid and vapour the proportions of which are dependent on pressure and temperature. The pressure drop is non linear, with an increasing rate of pressure loss as the line pressure reduced by pipe friction.

7.3.4 Pressure drop

The pressure drop shall be calculated using two-phase flow equations for liquefied gases and single-phase flow equations for non-liquefied gases.

NOTE These equations use friction factors and constants dependent on pressure and density obtained empirically. As the formulae cannot be solved directly, a computer program is usually used to assist with the large number of iterative calculations in which pipe and nozzle sizes and, if appropriate, size of pressure reducing devices are selected within prescribed pressure losses.

7.3.5 Valves and fittings

Valves, fittings and check valves shall be rated for resistance coefficient or equivalent length in terms of pipe, or tubing sizes with which they will be used. The equivalent length of the container valves shall be listed and shall include syphon tube (where fitted), valve, discharge head, flexible connector and check valve.

7.3.6 Piping length

The piping length and nozzle and fitting orientation shall be in accordance with the manufacturer's approved manual to ensure proper system performance.

7.3.7 Drawings

If the final installation varies from the prepared drawings and calculations, new as-installed drawings and calculations shall be prepared.

7.3.8 Liquefied gases — Specific requirements

7.3.8.1 Allowance shall be made for changes in elevation as specified in the relevant section of this part of EN 15004 relating to the specific extinguishant.

7.3.8.2 The minimum discharge rate for liquefied extinguishants shall be sufficient to maintain the velocity required for turbulent flow to prevent separation.

NOTE If turbulent flow is not maintained, separation of the liquid and gaseous phases will occur, which can lead to unpredictable flow characteristics.

7.4 Enclosures

7.4.1 The protected enclosure shall have sufficient structural strength and integrity to contain the extinguishant discharge. Venting shall be provided to prevent excessive over- or underpressurization of the enclosure.

7.4.2 To prevent loss of extinguishant through openings to adjacent hazards or work areas, openings shall be permanently sealed or equipped with automatic closures. Where reasonable confinement of extinguishants is not practicable, protection shall be extended to include the adjacent connected hazards or work areas.

7.4.3 Forced-air ventilating systems shall be shut down or closed automatically where their continued operation would adversely affect the performance of the fire-extinguishing system or result in propagation of the fire. Ventilation systems necessary to ensure safety are not required to be shut down upon system activation. An extended extinguishant discharge shall be provided to maintain the design concentration for the required duration of protection. The volumes of both ventilated air and the ventilation system ductwork shall be considered as part of the total hazard volume when determining extinguishant quantities.

All services within the protected enclosure (e.g. fuel and power supplies, heating appliances, paint spraying) that are likely to impair the performance of the extinguishing system should be shut down prior to, or simultaneously with, the discharge of the extinguishant.

7.5 Extinguishant concentration requirements

7.5.1 Flame extinguishment

7.5.1.1 For fire classifications, see EN 2.

7.5.1.2 The minimum Class B design concentration for each extinguishant shall be a demonstrated extinguishing concentration for each Class B fuel plus a safety factor of 1,3. The extinguishing concentration used shall be that demonstrated by the cup burner test, carried out in accordance with the method set out in Annex B, that has been verified with the heptane pan tests detailed in C.6.2. For hazards involving multiple fuels, the value for the fuel requiring the greatest design concentration shall be used. The extinguishing concentration shall be taken as the cup burner value or the heptane pan test value (see Annex C), whichever is greater.

7.5.1.3 The extinguishing concentration for Class A surface fires shall be the greater of the values determined by the wood crib and polymeric sheet fire tests described in Annex C. The minimum design concentration for Class A fires shall be the extinguishing concentration increased by a safety factor of 1,3. For non-cellulosic Class A fuels, higher design concentrations may be required.

CAUTION — It is recognized that the wood crib and polymeric sheet Class A fire tests may not adequately indicate extinguishing concentrations suitable for the protection of certain plastic fuel hazards (e.g. electrical and electronic type hazards involving grouped power or data cables such as computer and control room under-floor voids, telecommunication facilities, etc.). An extinguishing concentration not less than that determined in accordance with 7.5.1.3, or not less than 95 % of that determined from the heptane fire tests described in B.7 and C.6.2, whichever is the greater, should be used under certain conditions. These Higher Hazard Class A conditions may include the following:

- a) cable bundles greater than 100 mm in diameter;
- b) cable trays with a fill density greater than 20 % of the tray cross-section;
- c) horizontal or vertical stacks of cable trays (closer than 250 mm);
- d) equipment energized during the extinguishment period where the collective power consumption exceeds 5 kW.

If polymeric sheet fire test data are not available, an extinguishing concentration 95 % of that determined from the heptane fire test shall be used.

The safety factor of 1,3 relates to the increase of 30 % from the extinguishing concentration to the design concentration, which results in additional quantity of agent. Circumstances which may not be adequately covered by this factor (although in some cases they are covered by other requirements in this part of EN 15004) and which may need allowance for additional extinguishant (i.e. more than 30 %) are included but not limited to the following.

- a) Where leakage occurs from a non-tight enclosure. This is covered in this part of EN 15004 by the requirement for a room integrity test and sealing of the enclosure to achieve a defined hold time.
- b) Where leakage occurs due to doors being opened during or immediately after discharge. This should be covered by operational protocols for individual risks.
- c) Where it is important to minimize the quantities of toxic or corrosive products of combustion from the fire.
- d) Where it is important to minimize the toxic or corrosive breakdown products from the extinguishant itself.
- e) Where excessive leakage occurs from an enclosure due to expansion of the extinguishant.

- f) Where hot surfaces, heated by fire or other means, may cause degradation of the extinguishing agent and hence reduce the efficiency of the agent.
- g) Where metal surfaces, heated by the fire, may act as an ignition source if not adequately cooled during agent discharge and hold time.

In practice, application of this part of EN 15004 is likely to result in higher safety factors, e.g. by the application of gross volumes rather than net volumes and design of systems for minimum anticipated temperatures, rather than those that apply in real conditions.

WARNING — Under certain conditions, it may be dangerous to extinguish a burning gas jet. As a first measure, shut off the gas supply.

7.5.2 Inerting

Inerting concentrations shall be used where conditions for subsequent reflash or explosion could exist. These conditions exist when both:

- a) the quantity of fuel permitted in the enclosure is sufficient to develop a concentration equal to or greater than one-half of the lower inflammable limit throughout the enclosure, and
- b) the volatility of the fuel before the fire is sufficient to reach the lower inflammable limit in air (maximum ambient temperature or fuel temperature exceeds the closed cup flash point temperature) or the system response is not rapid enough to detect and extinguish the fire before the volatility of the fuel is increased to a dangerous level as a result of the fire.

The minimum design concentrations used to inert atmospheres involving inflammable liquids and gases shall be determined by the test specified in Annex D, plus a safety factor of 10 %.

7.6 Total flooding quantity

7.6.1 General

The amount of extinguishant required to achieve the design concentration shall be calculated from Formulae (3) or (4) as appropriate, or from the data in Table 3 of EN 15004-2, EN 15004-4, EN 15004-5, EN 15004-6, EN 15004-7, EN 15004-8 and EN 15004-10 and EN 15004-3, Table 4.

In addition to these calculated concentration requirements, additional quantities of extinguishant may be required by national standards to compensate for any special conditions that would adversely affect the extinguishing efficiency (see 7.5.1), or if required by the physical characteristics of the extinguishant (see 7.9.1.2).

7.6.2 Liquefied gases

$$Q = \left(\frac{C}{100 - C} \right) \frac{V}{v} \quad (3)$$

7.6.3 Non-liquefied gas

$$Q = \frac{V}{v} \ln \left(\frac{C}{100 - C} \right) \quad (4)$$

where

- Q is the total flooding quantity, in kilograms;
- C is the design concentration in percent by volume;