

Australian Standard[®]

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

**Part 1: General requirements
(ISO 14520-1:2006, MOD)**



This Australian Standard® was prepared by Committee FP-011, Special Hazard Fire Protection Systems. It was approved on behalf of the Council of Standards Australia on 9 September 2009.

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- Australian Industry Group
 - Australian Museum
 - Commerce Queensland
 - CSIRO Manufacturing and Materials Technology
 - Department of Defence (Australia)
 - Engineers Australia
 - Fire Protection Association Australia
 - Institute of Security Executives
 - National Fire Industry Association
 - Society of Fire Protection Engineers Australasian Chapter
-

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Standards Australia wishes to acknowledge the participation of the expert individuals that contributed to the development of this Standard through their representation on the Committee and through the public comment period.

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Australian Standard[®]

Gaseous fire-extinguishing systems— Physical properties and system design

Part 1: General requirements (ISO 14520-1:2006, MOD)

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PREFACE

This Standard was prepared by the Standards Australia Committee FP-011, Special Hazard Fire Protection Systems, to supersede, in part, AS 4214—2002, *Gaseous fire extinguishing systems*.

This Standard is an adoption with Australian modifications and has been reproduced from ISO 14520-1:2006, *Gaseous media fire-extinguishing systems—Physical properties and system design*, Part 1: *General requirements* (including Technical Corrigendum 1), and has been varied as indicated to take account of Australian conditions. The modifications are specified in Appendix ZZ. Additional requirements for marking and marine environment are specified in Annexes ZA, ZB. A procedure for a discharge test is given in Annex ZC. The variations are also indicated by bar lines set in the margin against the clause, table, figure or part thereof affected.

The objective of this Standard is to provide designers and installers with minimum requirements for the design, installation, testing and commissioning of gaseous fire extinguishing systems for structures, building and plant.

As this Standard is reproduced from an International Standard, the following applies:

- (a) Its number appears on the cover and title page while the international standard number appears only on the cover.
- (b) In the source text ‘this International Standard’ should read ‘this Australian Standard’.
- (c) A full point substitutes for a comma when referring to a decimal marker.

The full suite of AS ISO 14520 Standards consists of the following parts:

AS

14520	Gaseous fire extinguishing systems—Physical properties
14520.1	Part 1: General requirements
14520.2	Part 2: CF ₃ I extinguishant
14520.5	Part 5: FK-5-1-12 extinguishant
14520.6	Part 6: HCFC Blend A extinguishant
14520.8	Part 8: HFC 125 extinguishant
14520.9	Part 9: HFC 227ea extinguishant
14520.10	Part 10: HFC 23 extinguishant
14520.11	Part 11: HFC 236fa extinguishant
14520.12	Part 12: IG-01 extinguishant
14520.13	Part 13: IG-100 extinguishant
14520.14	Part 14: IG-55 extinguishant
14520.15	Part 15: IG-541 extinguishant

The terms ‘normative’ and ‘informative’ have been used in this Standard to define the application of the appendix or annex to which they apply. A ‘normative’ appendix or annex is an integral part of a Standard, whereas an ‘informative’ appendix or annex is only for information and guidance.

This Standard incorporates a Commentary on some clauses. The Commentary directly follows the relevant clause, is designated by ‘C’ preceding the clause number and is printed in italics in a panel. The Commentary is for information only and does not need to be followed for compliance with the Standard.

CONTENTS

	<i>Page</i>
INTRODUCTION	iv
1 Scope	1
2 Normative references	2
3 Terms and definitions	2
4 Use and limitations	5
5 Safety	7
6 System design	10
7 Extinguishant system design	16
8 Commissioning and acceptance	24
9 Inspection, maintenance, testing and training	27
Annex A (normative) Working documents.....	30
Annex B (normative) Determination of flame-extinguishing concentration of gaseous extinguishants by the cup burner method	32
Annex C (normative) Fire extinguishment/area coverage fire test procedure for engineered and pre-engineered extinguishing units	38
Annex D (normative) Method of evaluating inerting concentration of a fire extinguishant.....	58
Annex E (normative) Door fan test for determination of minimum hold time	60
Annex F (informative) System performance verification	75
Annex G (normative) Safe personnel exposure guidelines	76
Annex H (informative) Flow calculation implementation method and flow calculation verification and testing for approvals.....	83
AUSTRALIAN VARIATIONS	
Appendix ZZ (Normative) VARIATIONS TO ISO 14520-1:2006 FOR AUSTRALIA	88
Annex ZA (Normative) MARKING	100
Annex ZB (Normative) MARINE.....	104
Annex ZC (Informative) DISCHARGE TEST	113

INTRODUCTION

Fire fighting systems covered in this part of ISO 14520 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 ISO 14520 has been prepared to meet this need.

In particular, new requirements to eliminate the need to release extinguishants during testing and commissioning procedures are included. These are linked to the inclusion of enclosure integrity testing.

The requirements of this part of ISO 14520 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 ISO 14520 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).

The test protocol contained in Annex C of this International Standard was developed by a special working group of ISO/TC 21/SC 8. Annex C deals with the tests for determination of the extinguishing concentrations and system performance and they are designed in such a way to allow individual installers to use his/her system and carry out all of the extinguishing tests. The need for the tests presented in Annex C was established by the fact that the previously used Class A fire test involved wood crib, heptane pan and heptane can test fires in an enclosure of 100 m³, and did not necessarily indicate extinguishing concentrations suitable for the protection of plastic fuel hazards such as may be encountered in information technology, telecommunications and process control facilities.

As a consequence of the above, the current Annex C of ISO 14520.1 includes polymeric sheet fuel array (polymethyl methacrylate (PMMA)), polypropylene (PP) and acrylonitrile-butadiene-styrene (ABS) fire tests.

Specific parts 3, 4 and 7 have been withdrawn on the basis that the extinguishing media have not been commercialized, and a new agent specific part 5 has been introduced to cover FK-5-1-12 (dodecafluoro-2-methylpentan-3-one) systems.

AUSTRALIAN STANDARD

Gaseous fire-extinguishing systems—Physical properties and system design

Part 1:

General requirements (ISO 14520-1:2006, MOD)

1 Scope

This part of ISO 14520 specifies requirements and gives recommendations for the design, installation, testing, maintenance and safety of gaseous fire fighting systems in buildings, plant 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, plant 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 ISO 14520 is not applicable to explosion suppression.

This part of ISO 14520 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 ISO 14520 is applicable to the extinguishants listed in Table 1. It is essential that it be used in conjunction with the separate parts of ISO 14520 for specific extinguishants, as cited in Table 1.

Table 1 — Listed extinguishant

Extinguishant	Chemical	Formula	CAS No.	International Standard
CF ₃ I	Trifluoroiodomethane	CF ₃ I	2314-97-8	ISO 14520-2
FK-5-1-12	Dodecafluoro-2-methylpentan-3-one	CF ₃ CF ₂ C(O)CF(CF ₃) ₂	756-13-8	ISO 14520-5
HCFC Blend A				
HCFC-123	Dichlorotrifluoroethane	CHCl ₂ CF ₃	306-83-2	
HCFC-22	Chlorodifluoromethane	CHClF ₂	75-45-6	ISO 14520-6
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	ISO 14520-8
HFC 227ea	Heptafluoropropane	CF ₃ CHFCF ₃	2252-84-8	ISO 14520-9
HFC 23	Trifluoromethane	CHF ₃	75-46-7	ISO 14520-10
HFC 236fa	Hexafluoropropane	CF ₃ CH ₂ CF ₃	27070-61-7	ISO 14520-11
IG-01	Argon	Ar	74040-37-1	ISO 14520-12
IG-100	Nitrogen	N ₂	7727-37-9	ISO 14520-13
	Nitrogen (50 %)	N ₂	7727-37-9	
IG-55	Argon (50 %)	Ar	74040-37-1	ISO 14520-14
	Nitrogen (52 %)	N ₂		
IG-541	Argon (40 %)	Ar	74040-37-1	ISO 14520-15
	Carbon dioxide (8 %)	CO ₂	124-38-9	

2 Normative references

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

ISO 3941, *Classification of fires*

ISO 5660-1, *Reaction-to-fire tests — Heat release, smoke production and mass loss rate — Part 1: Heat release rate (cone calorimeter method)*

ISO 14520-2, *Gaseous fire-extinguishing systems — Physical properties and system design — Part 2: CF₃I extinguishant*

ISO 14520-5, *Gaseous fire-extinguishing systems — Physical properties and system design — Part 5: FK-5-1-12 extinguishant*

ISO 14520-6, *Gaseous fire-extinguishing systems — Physical properties and system design — Part 6: HCFC Blend A extinguishant*

ISO 14520-8, *Gaseous fire-extinguishing systems — Physical properties and system design — Part 8: HFC 125 extinguishant*

ISO 14520-9, *Gaseous fire-extinguishing systems — Physical properties and system design — Part 9: HFC 227ea extinguishant*

ISO 14520-10, *Gaseous fire-extinguishing systems — Physical properties and system design — Part 10: HFC 23 extinguishant*

ISO 14520-11, *Gaseous fire-extinguishing systems — Physical properties and system design — Part 11: HFC 236fa extinguishant*

ISO 14520-12, *Gaseous fire-extinguishing systems — Physical properties and system design — Part 12: IG-01 extinguishant*

ISO 14520-13, *Gaseous fire-extinguishing systems — Physical properties and system design — Part 13: IG-100 extinguishant*

ISO 14520-14, *Gaseous fire-extinguishing systems — Physical properties and system design — Part 14: IG-55 extinguishant*

ISO 14520-15, *Gaseous fire-extinguishing systems — Physical properties and system design — Part 15: IG-541 extinguishant*

ASTM E1354-04a, *Standard Test Method for Heat and Visible Smoke Release Rates for Materials and Products Using an Oxygen Consumption Calorimeter*

3 Terms and definitions

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

NOTE 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.

3.1

approved

acceptable to a relevant authority (see 3.2)

NOTE In determining the acceptability of installations or procedures, equipment or materials, the authority can base acceptance on compliance with the appropriate 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 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**extinguishant**

electrically non-conducting gaseous fire extinguishant that, upon evaporation, does not leave a residue (see Table 1)

3.5**clearance**

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

3.6 Concentration**3.6.1****design concentration**

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

3.6.2**maximum concentration**

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

3.6.3**extinguishing concentration**

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

3.7**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 ISO 14520

3.8**fill density**

mass of extinguishant per unit volume of container

3.9**flooding quantity**

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

3.10**nett volume**

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

3.11**hold time**

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

3.12**inspection**

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

NOTE 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.

3.13**liquefied gas**

gas or gas mixture (normally a halocarbon) which is liquid at the container pressurization level at room temperature (20 °C)

3.14**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 The actuation of this device provides an indication of system isolation.

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

3.15**lowest observed adverse effect level****LOAEL**

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

3.16**maintenance**

thorough check, comprising a thorough examination and any necessary repair or replacement of system component, to give maximum assurance that the extinguishing system will operate as intended

3.17**maximum working pressure**

equilibrium pressure within a container at the maximum working temperature

NOTE 1 For liquefied gases this is at the maximum fill density and can include superpressurization.

NOTE 2 The equilibrium pressure for a container in transit can differ from that in storage within a building.

3.18**no observed adverse effect level****NOAEL**

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

3.19**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

3.20**normally occupied area**

area intended for occupancy

3.21**normally unoccupied area**

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

3.22**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 No deviation is permitted from the limits specified by the manufacturer or authority.

3.23**safety factor**

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

3.24**sea level equivalent of agent**

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

3.25**sea level equivalent of oxygen**

the 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

3.26**selector valve**

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

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

3.27**superpressurization**

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

3.28**total flooding system**

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

3.29**unoccupiable area**

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

EXAMPLE Shallow voids and cabinets.

4 Use and limitations**4.1 General**

Throughout this part of ISO 14520 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.

4.2 Extinguishants

Any agent that is to be recognized by this part of ISO 14520 or proposed for inclusion in this part of ISO 14520, shall first be evaluated in a manner equivalent to the process used by the U.S. Environmental Protection Agency's (EPA) SNAP Programme or other internationally recognized extinguishing agent approval institutions.

The extinguishants referred to in this part of ISO 14520 are electrically non-conductive media.

The extinguishants and specialized system parameters are each covered individually in the parts of ISO 14520 for specific extinguishants. These parts shall be used in conjunction with this part of ISO 14520.

Unless relevant testing has been carried out to the satisfaction of the authority, the extinguishants referred to in the specific parts of ISO 14520 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.

4.3 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 ISO 14520. Unnecessary exposure to all gaseous extinguishants shall be avoided.

Adherence to ISO 14520 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 must 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 4.2 and 4.3, 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 ISO 14520 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 standard is 5 min. Exposure times longer than 5 min may involve physiological or toxicological effects not addressed by this part of ISO 14520.

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.

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:

- self-contained breathing apparatus should be supplied and personnel trained in its use;
- 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 3 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 3 — 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 ISO 14520.

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 this part of ISO 14520 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.

6.2.4.2 Contents indication

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

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.

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;
- 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, where required.

Over-pressure relief devices shall be designed to operate at a pressure no greater than the test pressure of the pipework, 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 The manifolds to the container and valve assembly shall be hydraulically tested by the manufacturer to a minimum pressure of $1,5 \times$ maximum working pressure (see 3.17), or as required by the appropriate national standards.

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 this calculation, all joint factors and threading, grooving or welding allowances shall be taken into account. If selector valves are used, this lower maximum working pressure shall not be used upstream of the selector valves.

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.

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.

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. If selector valves are used, this lower maximum working pressure shall not be used upstream of the selector valves.

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 4.

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: ≤ 100 mm;

b) > 25 mm pipe: ≤ 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 4 — 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.

6.3.6 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 also Annex C);
- 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;
- 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, including area coverage and height limitations (see also Annex C), or shall be approved under the procedure described in national 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.

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.

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.

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.

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.

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.

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 Hold switches

Hold switches, where provided, shall be located within the protected area and shall be located near the means of egress for the area. The hold switch 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 hold switch when the system is in the quiescent state shall result in a fault indication at the control unit. The hold switch shall be clearly recognizable for the purpose intended.

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 ISO 14520 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 ISO 14520 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 ISO 14520, 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:

- 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).

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.

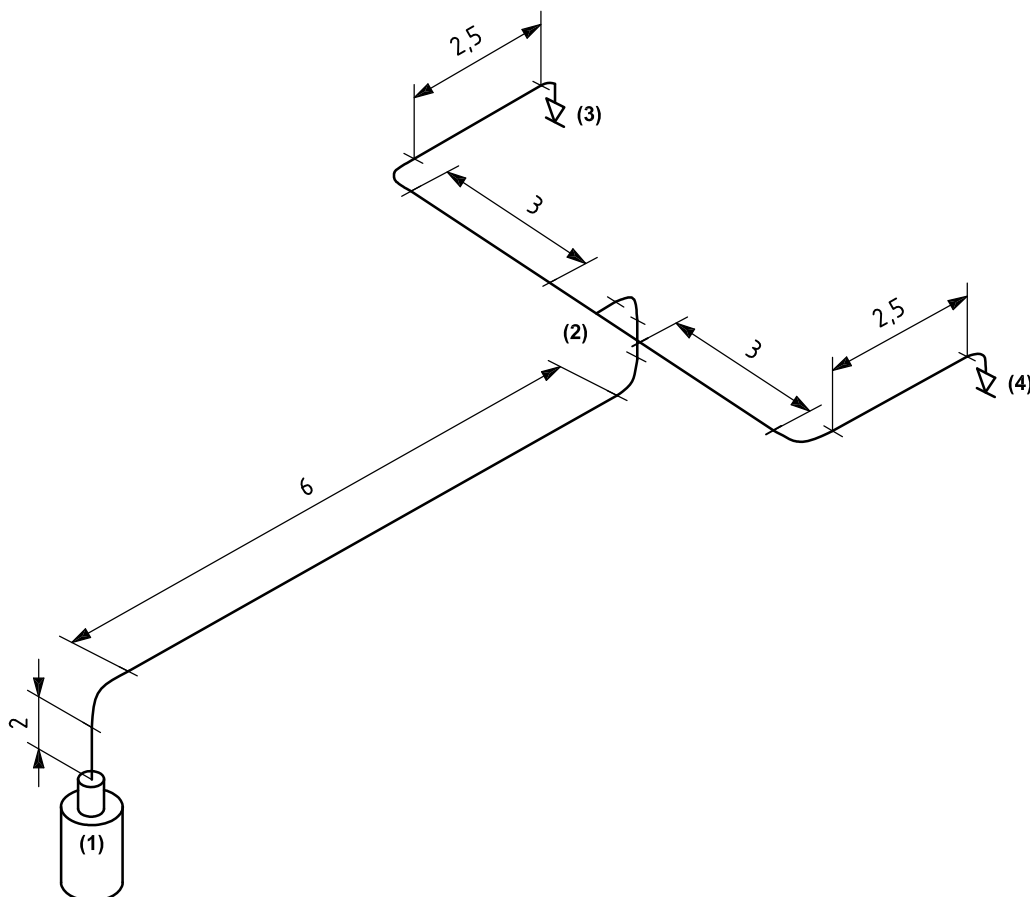
7.3.4 Pressure drop

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 equations 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 cylinder valves shall be listed and shall include syphon tube (where fitted), valve, discharge head, flexible connector and check valve.



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

Figure 1 — Typical balanced system

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

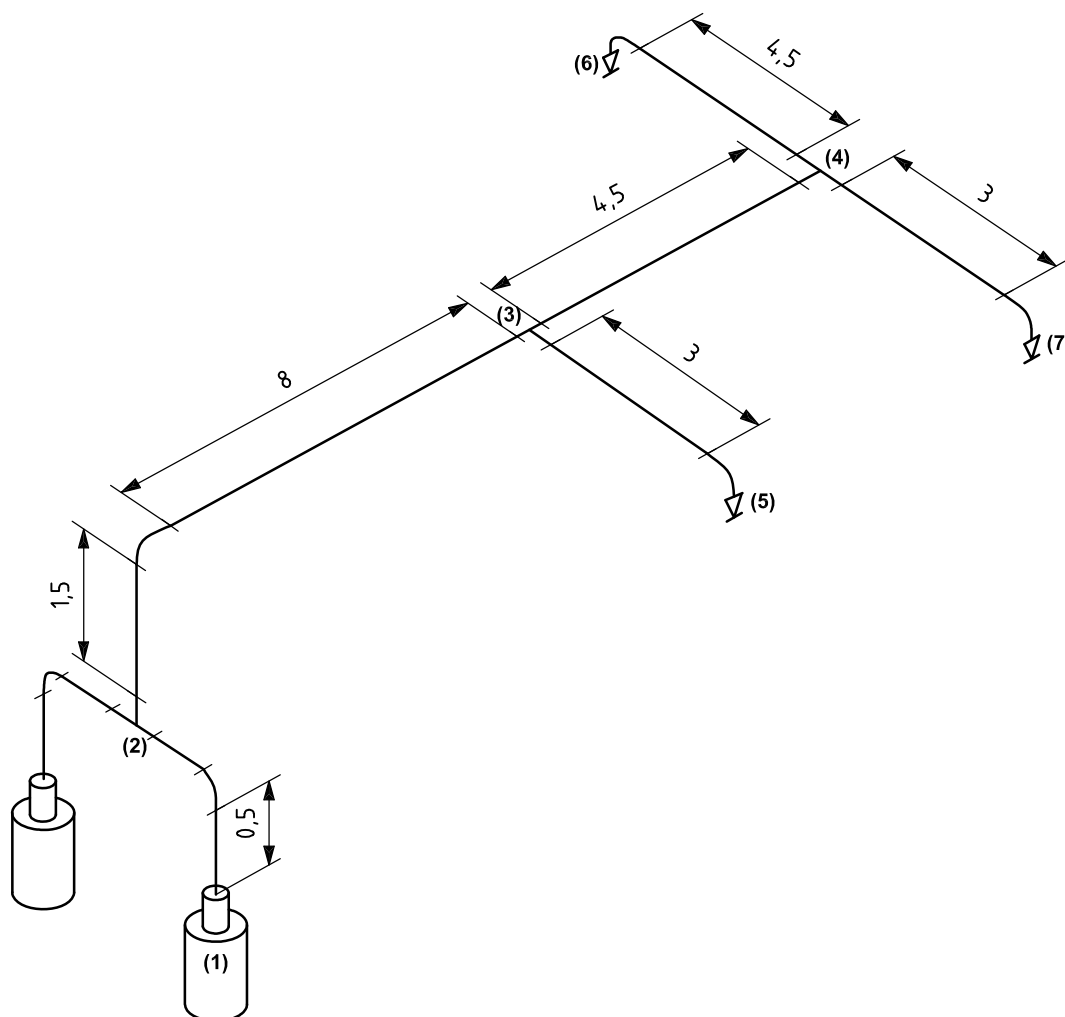
If the final installation varies from the prepared drawings and calculations, new as-installed drawings and calculations shall be prepared.

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 ISO 14520 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.



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

Figure 2 — Typical unbalanced system

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 ISO 3941.

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.5.2. 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 test described in C.6.2, whichever is the greater, should be used under certain conditions. These conditions may include:

- 1) cable bundles greater than 100 mm in diameter;**
- 2) cable trays with a fill density greater than 20 % of the tray cross-section;**
- 3) horizontal or vertical stacks of cable trays (closer than 250 mm);**
- 4) 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 ISO 14520) 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 ISO 14520 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 ISO 14520 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 Equations (1) or (2) as appropriate, or from the data in Table 3 of ISO 14520-2, ISO 14520-5, ISO 14520-8, ISO 14520-9, ISO 14520-10, ISO 14520-11, ISO 14520-12, ISO 14520-13 and ISO 14520-15 and in Table 4 of ISO 14520-6.

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

$$Q = \left(\frac{C}{100 - C} \right) \frac{V}{v} \quad (1)$$

7.6.3 Non-liquefied gas

$$Q = \frac{V}{v} \ln \left(\frac{100}{100 - c} \right) \quad (2)$$

where

- Q is the total flooding quantity, in kilograms;
- c is the design concentration in percent by volume;
- V is the net volume of the hazard, in cubic metres (i.e. enclosed volume minus fixed structures impervious to extinguishant);
- v is the specific volume, in cubic metres per kilogram: $v = k_1 + k_2 \times T$;
- k_1, k_2 are constants specific to the extinguishant being used, supplied by the extinguishant manufacturer;
- T is the minimum anticipated ambient temperature of the protected volume, in degrees centigrade.

NOTE 1 For some purposes (e.g. filling of containers) it may be convenient to express the flooding quantity as volume at given reference (standard) conditions. For those cases the total flooding quantity is equivalent to

$$Q_R = Q \times v_R$$

where

- Q_R is the total flooding quantity, in cubic metres, expressed at ambient pressure (1,013 bar absolute) and T_R ;
- Q is the total flooding quantity, in kilograms;
- v_R is the specific volume at reference temperature, in cubic metres per kilogram: $v_R = k_1 + k_2 \times T_R$;
- k_1, k_2 are constants specific to the extinguishant being used, supplied by the extinguishment manufacturer;
- T_R is the reference temperature, in degrees centigrade;

7.7 Altitude adjustment

The design quantity of the extinguishant shall be adjusted to compensate only for ambient pressures that vary more than 11 % (equivalent to approximately 1 000 m of elevation change) from standard sea level pressure (1,013 bar absolute). The ambient pressure is affected by changes in altitude, pressurization or depressurization of the protected enclosure, and weather-related barometric pressure changes. The extinguishant quantity is determined by multiplying the quantity determined in 7.6 by the ratio of the average ambient enclosure pressure to the standard sea level pressure. Correction factors for gaseous agents are shown in Table 5.

Table 5 — Correction factors

Equivalent altitude m	Correction factor
–1 000	1,130
0	1,000
1 000	0,885
1 500	0,830
2 000	0,785
2 500	0,735
3 000	0,690
3 500	0,650
4 000	0,610
4 500	0,565

7.8 Duration of protection

7.8.1 It is important that an effective extinguishant concentration not only be achieved, but is maintained for a sufficient period of time to allow effective emergency action. This is equally important in all classes of fires since a persistent ignition source (e.g. an arc, heat source, oxyacetylene torch, or “deep-seated” fire) can lead to resurgence of the initial event once the extinguishant has dissipated.

7.8.2 It is essential to determine the likely period during which the extinguishing concentration will be maintained within the protected enclosure. This is known as the hold time. The predicted hold time shall be determined by the door fan test specified in Annex E, or a full discharge test based on the following criteria.

- At the start of the hold time, the concentration throughout the enclosure shall be the design concentration.
- At the end of the hold time, the extinguishant concentration at 10 %, 50 % and 90 % of the enclosure height shall be not less than 85 % of the design concentration.
- The hold time shall be not less than 10 min, unless otherwise specified by the authority.

7.9 System performance

7.9.1 Discharge time

7.9.1.1 Liquefied extinguishant

The liquefied extinguishant discharge shall be completed as quickly as possible to suppress the fire and limit the formation of decomposition products. In no case shall the discharge time required to achieve 95 % of the design concentration exceed 10 s at 20 °C, or as otherwise required by the authority.

The discharge time period is defined as the time required to discharge from the nozzles 95 % of the extinguishant mass required to achieve the design concentration at 20 °C. For liquefied extinguishants, this can be approximated as the interval between the first appearance of liquid at the nozzle and the time when the discharge becomes predominantly gaseous. Flow calculations performed in accordance with 6.3 or with the approved pre-engineered systems instruction manuals shall be used to demonstrate compliance with this.

7.9.1.2 Non-liquefied extinguishant

The discharge time required to achieve 95 % of the design concentration for non-liquefied extinguishants shall not exceed 60 s at 20 °C, or as otherwise required by the authority. Flow calculations performed in accordance with 6.3 or with the approved pre-engineered systems instruction manuals shall be used to demonstrate compliance with this.

7.9.2 Extended discharge

When an extended discharge is necessary, the rate shall be sufficient to maintain the desired concentration for the required hold time.

8 Commissioning and acceptance

8.1 General

This clause sets out the minimum requirements for the commissioning and acceptance of the gaseous extinguishing system.

8.2 Tests

8.2.1 General

The completed system shall be reviewed and tested by a competent person to meet the approval of the authority. Only equipment and devices designed to national standards shall be used in the systems. To determine that the system has been properly installed and will function as specified, the tests specified in 7.2.2 to 8.2.9 shall be performed.

8.2.2 Enclosure check

Determine that the protected enclosure is in general conformance with the plans.

8.2.3 Review of mechanical components

8.2.3.1 The piping distribution system shall be inspected to determine that it is in compliance with the design and installation documents.

8.2.3.2 Nozzles and pipe size and, if appropriate, pressure-reducing devices, shall be in accordance with system drawings. The means for pipe size reduction and attitudes of tees shall be checked for conformance to the design.

8.2.3.3 Piping joints, discharge nozzles and piping supports shall be securely fastened to prevent unacceptable vertical or lateral movement during discharge. Discharge nozzles shall be installed in such a manner that piping cannot become detached during discharge.

8.2.3.4 During assembly, the piping distribution system shall be inspected internally to detect the possibility of any oil or particulate matter which could soil the hazard area or affect the extinguishant distribution due to a reduction in the effective nozzle orifice area.

8.2.3.5 The discharge nozzles shall be oriented in such a manner that optimum extinguishant dispersal can be effected.

8.2.3.6 If nozzle deflectors are installed, they shall be positioned to obtain the maximum benefit.

8.2.3.7 The discharge nozzles, piping and mounting brackets shall be installed in such a manner that they will not potentially cause injury to personnel. Extinguishant shall not directly impinge on areas where personnel may be found in the normal work area, or on any loose objects or shelves, cabinet tops or similar surfaces where loose objects could be present and become missiles.

8.2.3.8 All extinguishant storage containers shall be properly located in accordance with 'approved for construction' set of system drawings.

8.2.3.9 All containers and mounting brackets shall be securely fastened in accordance with the manufacturer's requirements.

8.2.3.10 A discharge test for extinguishants is generally not recommended. However, if a discharge test is to be conducted, the mass of extinguishant shall be determined by weighing or other approved methods. Concentration measurements should be made at a minimum of three points, one at the highest hazard level.

Other assessment methods may normally be used to reduce unnecessary discharge into the environment, e.g. the door fan pressurization test specified in Annex E. However, a discharge test may be conducted if acceptable to the authority.

8.2.3.11 An adequate quantity of extinguishant to produce the desired specified concentration shall be provided. The actual enclosure volumes shall be checked against those indicated on the system drawings to ensure the proper quantity of extinguishant. Fan rundown and damper closure time shall be taken into consideration.

8.2.3.12 Unless the total piping contains not more than one change in direction fitting between the storage container and the discharge nozzle, and unless all piping has been physically checked for tightness, the following tests shall be carried out.

- a) All open-ended piping shall be pneumatically tested in a closed circuit for a period of 10 min at 3 bar. At the end of 10 min, the pressure drop shall not exceed 20 % of the test pressure.
- b) 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 for 2 min during which there shall be no leakage. On completion of the test, the pipework shall be purged to remove moisture.

It is recommended that hydrostatic testing be carried out at the manufacturer's works where practicable.

WARNING — Pneumatic pressure testing creates a potential risk of injury to personnel in the area, as a result of airborne projectiles if rupture of the piping system occurs. Prior to conducting the pneumatic pressure test, the protected area shall be evacuated and appropriate safeguards shall be provided for test personnel.

8.2.3.13 A test using nitrogen, or a suitable alternative, shall be performed on the piping network to verify that flow is continuous and that the piping and nozzles are unobstructed.

8.2.4 Review of enclosure integrity

All total flooding systems shall have the enclosure checked in order to locate and then effectively seal any significant air leaks that could result in a failure of the enclosure to hold the specified extinguishant concentration level for the specified holding period (see also 6.4.1). Unless otherwise required by the authority, the test specified in Annex E shall be used.

8.2.5 Review of electrical components

8.2.5.1 All wiring systems shall be properly installed in compliance with the appropriate national standard and the system drawings. The a.c. and d.c. wiring shall not be combined in a common conduit unless properly shielded and earthed.

8.2.5.2 All field circuitry shall be tested for earthing faults and short circuit condition. When testing field circuitry, all electronic components (such as smoke and flame detectors or special electronic equipment for other detectors, or their mounting bases) shall be removed and jumpers properly installed to prevent the possibility of damage within these devices. Replace components after testing the circuits.

8.2.5.3 Adequate and reliable primary standby sources of energy which comply with 5.4 shall be used to provide for operation of the detection, signalling, control and actuation requirements of the system.

8.2.5.4 All auxiliary functions (such as alarm sounding or displaying devices, remote annunciators, air handling shutdown, power shutdown, etc.) shall be checked for proper operation in accordance with system requirements and design specifications.

Alarm devices shall be installed so that they are audible and visible under normal operating and environmental conditions.

Where possible, all air-handling and power cut-off controls should be of the type that, once interrupted, require manual restart to restore power.

8.2.5.5 Check that for systems using alarm silencing, this function does not affect other auxiliary functions such as air handling or power cut-off where they are required in the design specification.

8.2.5.6 Check the detection devices to ensure that the types and locations are as specified in the system drawings and are in accordance with the manufacturer's requirements.

8.2.5.7 Check that manual release devices are properly installed, and are readily accessible, accurately identified and properly protected to prevent damage.

8.2.5.8 Check that all manual release devices used to release extinguishants require two separate and distinct actions for operation. They shall be properly identified. Particular care shall be taken where manual release devices for more than one system are in close proximity and could be confused or the wrong system actuated. Manual release devices in this instance shall be clearly identified as to which hazard enclosure they protect.

8.2.5.9 Check that for systems with a main/reserve capability, the main/reserve switch is properly installed, readily accessible and clearly identified.

8.2.5.10 Check that for systems using hold switches requiring constant manual force, these are properly installed, readily accessible within the hazard area and clearly identified.

8.2.5.11 Check that the control panel is properly installed and readily accessible.

8.2.6 Preliminary functional tests

8.2.6.1 Where a system is connected to a remote central alarm station, notify the station that the fire system test is to be conducted and that an emergency response by the fire department or alarm station personnel is not required. Notify all concerned personnel at the end-user's facility that a test is to be conducted and instruct them as to the sequence of operation.

8.2.6.2 Disable or remove each extinguishant storage container release mechanism and selector valve, where fitted, so that activation of the release circuit will not release extinguishant. Reconnect the release circuit with a functional device in lieu of each extinguishant storage container release mechanism.

For electrically actuated release mechanisms, these devices may include suitable lamps, flash bulbs or circuit breakers. Pneumatically actuated release mechanisms may include pressure gauges. Refer to the manufacturer's recommendations in all cases.

8.2.6.3 Check each resettable detector for proper response.

8.2.6.4 Check that polarity has been observed on all polarized alarm devices and auxiliary relays.

8.2.6.5 Check that all required end-of-line devices have been installed.

8.2.6.6 Check all supervised circuits for correct fault response.

8.2.7 System functional operational test

8.2.7.1 Operate the detection initiating circuit(s). All alarm functions shall occur according to the design specification.

8.2.7.2 Operate the necessary circuit to initiate a second alarm circuit if present. Verify that all second alarm functions occur according to design specifications.

8.2.7.3 Operate the manual release device. Verify that manual release functions occur according to design specifications.

8.2.7.4 Where appropriate, operate the hold switch. Verify that functions occur according to the design specifications. Confirm that visual and audible supervisory signals are received at the control panel.

8.2.7.5 Check the function of all resettable valves and activators, unless testing the valve will release extinguishant.

"One-shot" valves, such as those incorporating frangible discs, should not be tested.

8.2.7.6 Check pneumatic equipment, where fitted, for integrity, to ensure proper operation.

8.2.8 Remote monitoring operations (if applicable)

8.2.8.1 Disconnect the primary power supply, then operate one of each type of input device while on standby power. Verify that an alarm signal is received at the remote panel after the device is operated. Reconnect the primary power supply.

8.2.8.2 Operate each type of alarm condition and verify receipt of fault condition at the remote station.

8.2.9 Control panel primary power source

8.2.9.1 Verify that the control panel is connected to a dedicated unswitched circuit and is labelled properly. This panel shall be readily accessible but access shall be restricted to authorized personnel only.

8.2.9.2 Test a primary power failure in accordance with the manufacturer's specification, with the system fully operated on standby power.

8.2.10 Completion of functional tests

When all functional tests are complete (8.2.6 to 8.2.9), reconnect each storage container so that activation of the release circuit will release the extinguishant. Return the system to its fully operational design condition. Notify the central alarm station and all concerned personnel at the end-user's facility that the fire system test is complete and that the system has been returned to full service condition by following the procedures specified in the manufacturers' specifications.

8.3 Completion certificate and documentation

The installer shall provide the user with a completion certificate, a complete set of instructions, calculations and drawings showing the system as-installed, and a statement that the system complies with all the appropriate requirements of this part of ISO 14520, and giving details of any departure from appropriate recommendations. The certificate shall give the design concentrations and, if carried out, reports of any additional test including the door fan test.

9 Inspection, maintenance, testing and training

9.1 General

This clause specifies the requirements for inspection, maintenance and testing of a gaseous fire-extinguishing system and for the training of inspection and maintenance personnel.

9.2 Inspection

9.2.1 General

9.2.1.1 At least annually, or more frequently as required by the authority, all systems shall be thoroughly inspected and tested for proper operation by competent personnel.

9.2.1.2 The inspection report with recommendations shall be filed with the owner.

9.2.1.3 At least every 6 months, the container contents shall be checked as follows.

- a) Liquefied gases: for halocarbon extinguishants, if a container shows a loss in extinguishant quantity of more than 5 % or a loss in pressure (adjusted for temperature) of more than 10 %, it shall be refilled or replaced.
- b) Non-liquefied gases: for inert gas extinguishants, pressure is an indication of extinguishant quantity. Unless otherwise specified by the authority, if an inert gas extinguishant container shows a loss in pressure (adjusted for temperature) of more than 5 %, it shall be refilled or replaced. Where container pressure gauges or weight-monitoring devices are used for this purpose, they shall be compared to a separate calibrated device at least annually.

9.2.1.4 All extinguishant removed from containers during service or maintenance procedures shall be collected and recycled, or disposed of in an environmentally sound manner, and in accordance with existing laws and regulations.

Inert gas mixtures based on those gases normally found in the earth's atmosphere are exempted from this requirement.

9.2.1.5 The date of inspection and the name of the person performing the inspection shall be recorded on a tag attached to the container.

9.2.2 Container

Containers shall be subjected to periodical tests as required by the relevant national standard.

9.2.3 Hose

All system hoses shall be examined annually for damage. If visual examination shows any defect, the hose shall be replaced.

9.2.4 Enclosures

9.2.4.1 At least every 12 months it shall be determined whether boundary penetration or other changes to the protected enclosure have occurred that could affect leakage and extinguishant performance. If this cannot be visually determined, it shall be positively established by repeating the test for enclosure integrity in accordance with Annex E.

9.2.4.2 Where the integrity test reveals increased leakage that would result in an inability to retain the extinguishant for the required period, remedial action shall be carried out.

9.2.4.3 Where it is established that changes to the volume of the enclosure or to the type of hazard within the enclosure, or both, have occurred, the system shall be redesigned to provide the original degree of protection.

It is recommended that the type of hazard within the enclosure, and the volume it occupies, be regularly checked to ensure that the required concentration of extinguishant can be achieved and maintained.

9.3 Maintenance

9.3.1 General

The user shall carry out a programme of inspection, arrange a service schedule, and keep records of the inspections and servicing.

NOTE The continued capability for effective performance of a fire fighting system depends on fully adequate service procedures with, where possible, periodic testing.

Installers shall provide the user with a record in which inspection and service details can be entered.

9.3.2 User's programme of inspection

The installer shall provide the user with an inspection programme for the system and components. The programme shall include instructions on the action to be taken in respect of faults.

The user's inspection programme is intended to detect faults at an early stage to allow rectification before the system may have to operate. A suitable programme is as follows.

- a) Weekly: Visually check the hazard and the integrity of the enclosure for changes which might reduce the efficiency of the system. Carry out a visual check that there is no obvious damage to pipework and that all operating controls and components are properly set and undamaged. Check pressure gauges and weighing devices, if fitted, for correct reading and take the appropriate action specified in the users' manual.
- b) Monthly: Check that all personnel who may have to operate the equipment or system are properly trained and authorized to do so and, in particular, that new employees have been instructed in its use.

9.3.3 Service schedule

A service schedule shall include requirements for periodic inspection and test for the complete installed system, including pressurized containers, as specified in the appropriate national standards.

The schedule shall be carried out by a competent person who shall provide the user with a signed, dated report of the inspection, advising any rectification carried out or needed.

During servicing, every care and precaution shall be taken to avoid release of extinguishant. A suitable schedule is provided in Annex F.

9.4 Training

All persons who may be expected to inspect, test, maintain or operate fire-extinguishing systems shall be trained and kept adequately trained in the functions they are expected to perform.

Personnel working in an enclosure protected by a gaseous extinguishant shall receive training in the operation and use of the system, in particular regarding safety issues.

Annex A (normative)

Working documents

A.1 General

These documents shall be prepared only by persons fully experienced in the design of extinguishing systems. Deviation from these documents shall require permission from the authority.

A.2 Working documents

Working documents shall include the following items:

- a) drawings, to an indicated scale of extinguishant distribution system, including containers, location of containers, piping and nozzles, valves and pressure-reducing devices (if fitted) and pipe hanger spacing;
- b) name of owner and occupant;
- c) location of building in which hazard is located;
- d) location and construction of protected enclosure walls and partitions;
- e) enclosure cross-section, full height or schematic diagram, including raised access floor and suspended ceiling;
- f) type of extinguishant being used;
- g) extinguishing or inerting concentration, design concentration and maximum concentration;
- h) description of occupancies and hazards to be protected against;
- i) specification of containers used, including capacity, storage pressure and mass including extinguishant;
- j) description of nozzle(s) used, including inlet size, orifice port configuration, and orifice size/code and orifice size of pressure-reducing devices, if applicable;
- k) description of pipes, valves and fittings used, including material specifications, grade and pressure rating;
- l) equipment schedule or bill of materials for each piece of equipment or device, showing device name, manufacturer, model or part number, quantity and description;
- m) isometric view of extinguishant distribution system, showing the length and diameter of each pipe segment and node reference numbers relating to the flow calculations;
- n) enclosure pressurization and venting calculations;
- o) description of fire detection, actuation and control systems.

A.3 Specific details

A.3.1 Pre-engineered systems

For pre-engineered systems, the end-user shall be provided with the manufacturer's system design and maintenance information.

A.3.2 Engineered systems

For engineered systems, the end-user shall be provided with the manufacturer's system design and maintenance information.