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

Part 1:  
**General requirements**

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

*Partie 1: Exigences générales*



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## Foreword

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

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

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

Attention is drawn to the possibility that some of the elements of this part of ISO 14520 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 14520-1 was prepared by Technical Committee ISO/TC 21, *Equipment for fire protection and fire fighting*, Subcommittee SC 8, *Gaseous media fire extinguishing systems*.

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

- Part 1: *General requirements*
- Part 2: *CF<sub>3</sub>I extinguishant*
- Part 3: *FC-2-1-8 extinguishant*
- Part 4: *FC-3-1-10 extinguishant*
- Part 6: *HCFC Blend A extinguishant*
- Part 7: *HCFC 124 extinguishant*
- Part 8: *HCFC 125 extinguishant*
- Part 9: *HFC 227ea extinguishant*
- Part 10: *HFC 23 extinguishant*
- Part 11: *HFC 236fa extinguishant*
- Part 12: *IG-01 extinguishant*
- Part 13: *IG-100 extinguishant*
- Part 14: *IG-55 extinguishant*
- Part 15: *IG-541 extinguishant*

Annexes A to E form a normative part of this part of ISO 14520. Annex F is for information only.

## 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 flammable 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 mediums 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.

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

## Part 1: General requirements

### 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 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. CO<sub>2</sub> 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 extinguishants

Extinguishant	Chemical	Formula	Trade name	International Standard
CF <sub>3</sub> I	Trifluoroiodomethane	CF <sub>3</sub> I	Triodide	ISO 14520-2
FC-2-1-8	Perfluoropropane	CF <sub>3</sub> CF <sub>2</sub> CF <sub>3</sub>	CEA 308	ISO 14520-3
FC-3-1-10	Perfluorobutane	C <sub>4</sub> F <sub>10</sub>	CEA 410	ISO 14520-4
HCFC Blend A			NAF S-III	ISO 14520-6
HCFC-123	Dichlorotrifluoroethane	CHCl <sub>2</sub> CF <sub>3</sub>		
HCFC-22	Chlorodifluoromethane	CHClF <sub>2</sub>		
HCFC-124	Chlorotetrafluoroethane	CHClF <sub>2</sub> CF <sub>3</sub>		
	Isopropenyl-1-methylcyclohexene	C <sub>10</sub> H <sub>16</sub>		
HCFC 124	Chlorotetrafluoroethane	CHClF <sub>2</sub> CF <sub>3</sub>	FE-241	ISO 14520-7
HCFC 125	Pentafluoroethane	CHF <sub>2</sub> CF <sub>3</sub>	FE-25	ISO 14520-8
HFC-227ea	Heptafluoropropane	CF <sub>3</sub> CHF <sub>2</sub> CF <sub>3</sub>	FM-200	ISO 14520-9
HFC 23	Trifluoromethane	CHF <sub>3</sub>	FE-13	ISO 14520-10
HFC 236fa	Hexafluoropropane	CF <sub>3</sub> CH <sub>2</sub> CF <sub>3</sub>	FE-36	ISO 14520-11
IG-01	Argon	Ar	Argotec	ISO 14520-12
IG-100	Nitrogen	N <sub>2</sub>		ISO 14520-13
IG-55	Nitrogen (50 %) Argon (50 %)	N <sub>2</sub> Ar	Argonite	ISO 14520-14
IG-541	Nitrogen (52 %) Argon (40 %) Carbon dioxide (8 %)	N <sub>2</sub> Ar CO <sub>2</sub>	Inergen	ISO 14520-15

## 2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 14520. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 14520 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 3941, *Classification of fires*.

ISO 14520-2, *Gaseous fire-extinguishing systems — Physical properties and system design — Part 2: CF<sub>3</sub>I extinguishant*.

ISO 14520-3, *Gaseous fire-extinguishing systems — Physical properties and system design — Part 3: FC-2-1-8 extinguishant*.

ISO 14520-4, *Gaseous fire-extinguishing systems — Physical properties and system design — Part 4: FC-3-1-10 extinguishant*.

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

ISO 14520-7, *Gaseous fire-extinguishing systems — Physical properties and system design — Part 7: HCFC 124 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*.

IEC 60364-7, *Electrical installation of buildings — Part 7: Requirements for special installations or locations*.

### 3 Terms and definitions

For the purposes of this part of ISO 14520, 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.

For the purposes of this part of ISO 14520, the following terms and definitions apply.

#### 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 may 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 may 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 does not leave a residue upon evaporation (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 fire involving 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 pipe 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

NOTE The design flow rates from nozzles may vary according to the design requirements of the hazard.

**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 within the specified discharge time

**3.10**

**gross 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 into 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 to give maximum assurance that the extinguishing system will operate as intended

NOTE It includes a thorough examination and any necessary repair or replacement of system components.

**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 may include superpressurization.

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

**3.18****modular system**

system consisting of distributed storage containers, usually of the pre-engineered type, in which each unit is designed to protect a given volume which is within its permitted limitations and which in total provide cover for the whole hazard

**3.19****no observed adverse effect level****NOAEL**

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

**3.20****non-liquefied gas**

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

**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****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 to selectively discharge agent to any of several separate hazard enclosures.

**3.24****superpressurization**

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

**3.25****total flooding system**

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

**3.26****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.

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) flammable and combustible liquids and gases;
- d) other high-value assets.

### 4.2 Extinguishants

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.

The extinguishants referred to in ISO 14520 shall not be used on fires involving the following unless relevant testing has been carried out to the satisfaction of the authority:

- 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 employing 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  $-20\text{ }^{\circ}\text{C}$  to  $+50\text{ }^{\circ}\text{C}$ , 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 amounts 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 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	X	Not required	Not required
Above the NOAEL and up to the LOAEL	X	X	Not required
LOAEL and above	X	X	X
<p>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.</p>			

**5.2.2 For normally unoccupied areas**

The maximum concentration shall not exceed the LOAEL for the extinguishant used unless a lock-off valve 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.**

**5.2.3 For unoccupiable areas**

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

**5.3 Occupiable areas**

In areas which are protected by total flooding systems and which 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 from fire to life or property, 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 which 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 that are distinctive from all other alarm signals, that will operate immediately on commencement of time delay upon detection of the fire.
- 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.

#### 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.

**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 <sup>a</sup>	
	To the nearest unscreened live conductor in air (section clearance)	To the nearest part not at earth potential of an insulator <sup>b</sup> 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	

<sup>a</sup> Measured from position of the feet.

<sup>b</sup> 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.

**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 this standard.

**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 that 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 into 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, spelter 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, should 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 not 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, should 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.

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 allowable 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 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)  $\leq 25$  mm pipe  $\leq 100$  mm;
- b)  $> 25$  mm pipe  $\leq 250$  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 considered in the support fixing methods.

### 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.

**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

**6.3.5.2** 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;
- b) the discharge does not unduly splash flammable 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.

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 mm<sup>2</sup> shall be provided with an internal filter capable of preventing obstruction of the orifice.

### **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 may 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
- c) 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 will occur.

#### 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

### 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 as described in this part of ISO 14520, and shall be properly identified. The system design shall be within the manufacturer's specified limitations.

NOTE 1 Variations from the nominal 20 °C storage temperature will 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) each actual or equivalent pipe length from the container to each nozzle are all within 10 % of each other;
- b) the discharge rate of each nozzle is equal (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.

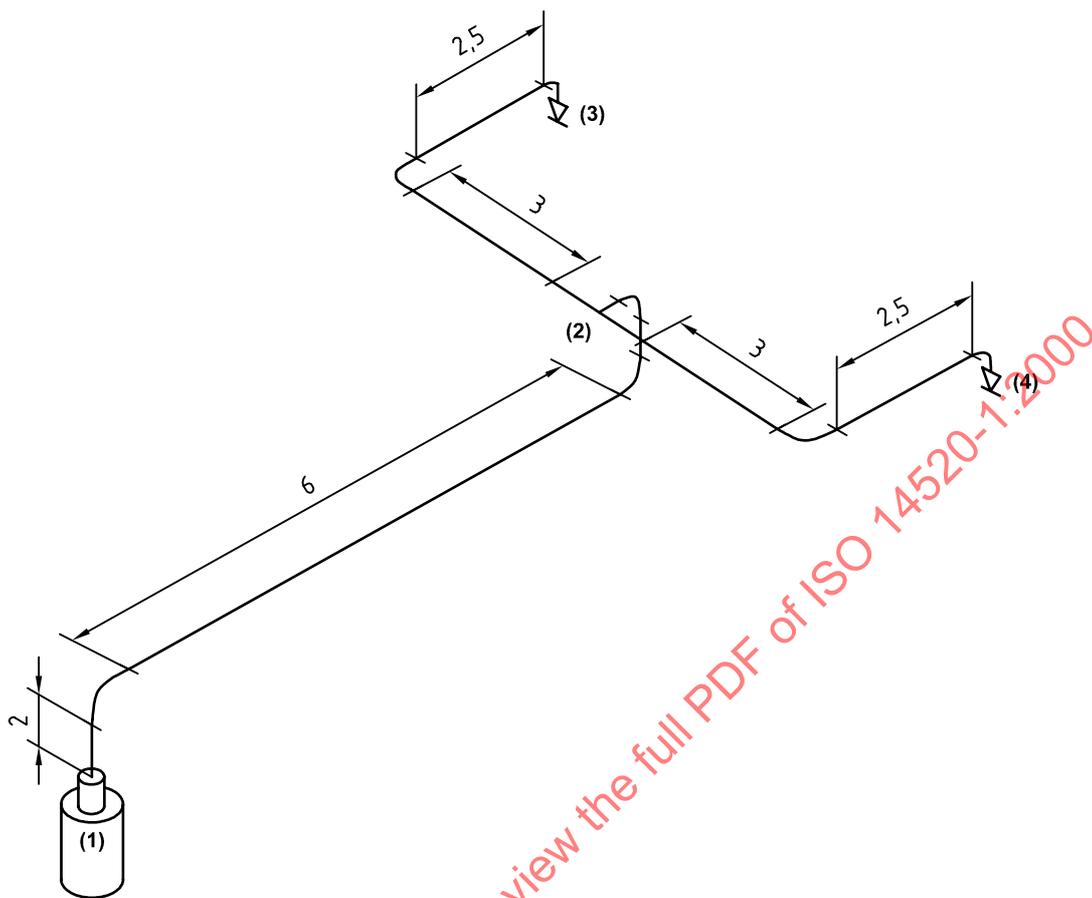
NOTE The flow of a liquefied gas has been demonstrated to be a two-phase phenomenon, the fluid consisting of a mixture of liquid and vapour, the proportions of which are dependent on pressure and temperature. The pressure drop is non-linear, with an increasing rate of pressure loss as the line pressure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

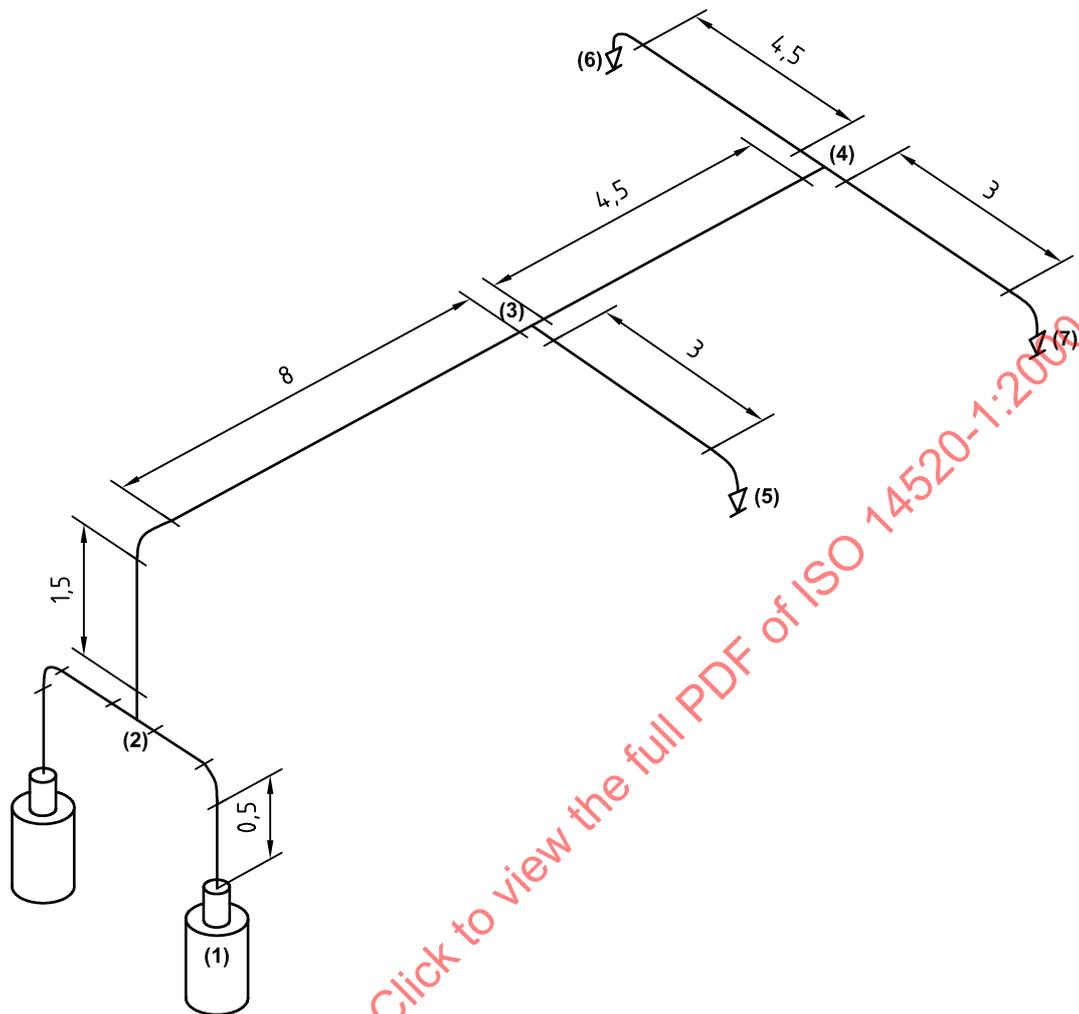
Dimensions in metres



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**

### 7.3.5 Valves and fitting

Valves and fittings 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 and flexible connector.

### 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 that 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.

## 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 under-pressurization 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 heptane using the fire extinguishment/area coverage fire test procedure detailed in annex C. For hazards involving multiple fuels, the value for the fuel requiring the greatest design concentration shall be used.

**7.5.1.3** The extinguishing concentration for Class A surface fires shall be determined by test using the fire test procedure described in annex C. The minimum design concentration for Class A fires shall be the extinguishing concentration plus a safety factor of 1,3. For a non-cellulosic Class A fuel, higher design concentrations may be required.

**CAUTION — It is recognized that the wood crib fire may not indicate extinguishing concentrations suitable for the protection of plastic fuel hazards (e.g. computer and central rooms). More suitable tests are under development for inclusion in the next revision of ISO 14520. Until such time as these tests are finalized, a concentration not less than 90 % of that determined from the heptane fire test should 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, for example 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 flammable limit throughout the enclosure, and
- b) the volatility of the fuel before the fire is sufficient to reach the lower flammable 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 flammable 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 the equations in 3.6.2 or 3.6.3 as appropriate, or from the data in Table 3 *Total flooding quantity* in the parts of this standard for specific extinguishants.

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

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

where

$M$  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);

$S$  is the specific volume, in cubic metres per kilogram:  $S = k_1 + k_2T$

$k_1, k_2$  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 Celsius.

### 7.6.3 Non-liquefied gas

$$Q = V \frac{S_R}{S} \ln \left( \frac{100}{100 - C} \right) \quad (2)$$

where

$Q$  is the total flooding quantity, in cubic metres, at reference filling temperature and pressure;

$C$  is the design concentration, in percent by volume;

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

$S_R$  is the specific volume, in cubic metres per kilogram, at reference filling temperature and pressure:

$S = k_1 + k_2T$ , at temperature  $T$  and 1,013 bar absolute pressure;  $S$  is the specific volume, in cubic metres per kilogram;

$k_1, k_2$  are constants specific to the extinguishant being used, supplied by the extinguishant manufacturer;

$T$  is the minimum anticipated temperature of the protected volume, in degrees Celsius.

### 7.7 Altitude adjustment

The design quantity of the extinguishant shall be adjusted to compensate 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. Correction factors for specific extinguishants will need to be calculated.

Table 5 — Correction factors

Equivalent altitude m	Correction factor (for ideal gases)
-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.

- a) At the start of the hold time, the concentration throughout the enclosure shall be the design concentration.
- b) At the end of the hold time, the extinguishant concentration at the height of the tallest hazard in the enclosure shall be not less than the fire extinguishing concentration.
- c) 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 7.3 or with the approved pre-engineered systems instruction manuals shall be used to demonstrate compliance with this clause.

#### 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 7.3 or with the approved pre-engineered systems instruction manuals shall be used to demonstrate compliance with this clause.

### 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 8.2.2 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, for example, 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 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 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 7.4.1). 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. A.c. and d.c. wiring shall not be combined in a common conduit unless properly shielded and grounded.

**8.2.5.2** All field circuitry shall be tested for ground fault 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 6.4 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 valves, 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.

**8.2.7.5** 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 to the user 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 that are not liquefied, 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 should 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 to the user 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 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 information.

#### A.3.2 Engineered systems

The details on the system shall include the following:

- a) information and calculations on the amount of extinguishant;
- b) container storage pressure;
- c) capacity of the container;
- d) the location, type and flow rate of each nozzle, including equivalent orifice area and pressure-reducing devices, if applicable;
- e) the location, size and equivalent lengths or resistance coefficients of pipe fittings and hoses; pipe size reduction and orientation of tees shall be clearly indicated;
- f) the location and size of the storage facility.

Information shall be submitted pertaining to the location and function of the detection devices, operating devices, auxiliary equipment and electrical circuitry, if used. Apparatus and devices shall be identified. Any special features shall be adequately explained. The version of the flow calculation program shall be identified on the computer calculation printout.

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## Annex B (normative)

### Determination of flame-extinguishing concentration of gaseous extinguishants by the cup burner method

#### B.1 Scope

This annex specifies the minimum requirements for determining the flame-extinguishing concentration of a gaseous extinguishant in air for flammable liquids and gases, employing the cup burner apparatus.

#### B.2 Principle

Diffusion flames of fuels burning in a round reservoir (cup), centrally positioned in a coaxially flowing air stream, are extinguished by addition of a gaseous extinguishant to the air.

#### B.3 Requirements for apparatus

##### B.3.1 General

The cup burner apparatus for these measurements shall be arranged and constructed as in Figure B.1, with the dimensions shown; the tolerance for all dimensions shall be  $\pm 5\%$  unless otherwise indicated.

##### B.3.2 Cup

The cup shall be round and shall be constructed of glass, quartz or steel. It shall have an outside diameter in the range of 28 mm to 31 mm, with a wall thickness of 1 mm to 2 mm. It shall have a 45° chamfer into the top edge of the cup. There shall be a means of measuring the temperature of the fuel inside the cup at a location 2 mm to 5 mm below the top of the cup, and a means of heating the fuel as shown in Figure B.1. The cup shall be substantially similar in shape to the example shown in Figure B.1. A cup intended for use with gaseous fuels shall have means of attaining a uniform gas flow at the top of the cup (e.g. the cup may be packed with refractory materials).

##### B.3.3 Chimney

The chimney shall be of round glass or quartz construction. It shall have an inside diameter of 85 mm  $\pm$  2 mm and a wall thickness of 2 mm to 5 mm, with a height of 535 mm  $\pm$  5 mm.

##### B.3.4 Diffuser

The diffuser shall have a means of fitting to the bottom end of the chimney. It shall have a means of admitting a premixed stream of air and extinguishant; and have a means of uniformly distributing the air/extinguishant flow across the cross-section of the chimney. The temperature of the air/extinguishant mixture within the diffuser shall be 25 °C  $\pm$  10 °C, measured with a calibrated temperature sensor.

##### B.3.5 Fuel supply

A liquid fuel supply shall be capable of delivering liquid fuel to the cup while maintaining a fixed, but adjustable, liquid level therein.

A gaseous fuel supply shall be capable of delivering a fuel gas at a controlled and fixed rate to the cup.

### B.3.6 Manifold

A manifold shall receive air and extinguishant and deliver them as a single mixed stream to the diffuser.

### B.3.7 Air supply

A means for delivering air to the manifold shall allow adjustment of the air flow rate. It shall have a calibrated means of measuring the air flow rate.

### B.3.8 Extinguishant supply

A means for delivering extinguishant to the manifold shall allow adjustment of the extinguishant flow rate. If the method according to B.7.2 is used for the determination of the extinguishant concentration, there shall be a calibrated means of measuring the extinguishant flow rate.

### B.3.9 Delivery system

The delivery system shall deliver a representative and measurable sample of the agent to the cup burner in gaseous form.

## B.4 Requirements for materials

### B.4.1 Air

Air shall be clean, dry and oil-free. The oxygen concentration shall be a volume fraction of  $(20,9 \pm 0,5) \%$ . The source and the oxygen content of the air used shall be recorded.

NOTE "Air" supplied in commercial high-pressure cylinders may have an oxygen content significantly different from 20,9 %.

### B.4.2 Fuel

Fuel shall be of a certified type and quality.

### B.4.3 Extinguishant

The extinguishant shall be of certified type and meet the specifications of the supplier. Multi-component extinguishants should be provided premixed. Liquefied extinguishants shall be provided as pure extinguishant, i.e. not pressurized with nitrogen.

## B.5 Procedure for flammable liquids

**B.5.1** Place the flammable liquid in the fuel supply reservoir.

**B.5.2** Admit fuel to the cup, adjusting the liquid level to within 5 mm to 10 mm from the top of the cup.

**B.5.3** Operate the heating arrangement for the cup to bring fuel temperature to  $25 \text{ °C} \pm 3 \text{ °C}$  or to  $5 \text{ °C} \pm 3 \text{ °C}$  above the open cup flash point, whichever is the higher. During this period, the liquid level in the cup shall be adjusted so that the fuel level is above the means for temperature measurement of the fuel.

NOTE The fuel temperature given in B.5.3 is meant to be the temperature at the start of the test.

**B.5.4** Adjust the air flow to achieve a flow rate of 10 l/min.

**B.5.5** Ignite the fuel.

**B.5.6** Allow the fuel to burn for a period of 60 s to 120 s before beginning the flow of extinguishant. During this period, the liquid level in the cup should be adjusted so that the fuel level is within 1 mm from the top of the cup.

**B.5.7** Begin the flow of extinguishant. Increase the extinguishant flow rate in increments until flame extinguishment occurs, and record the extinguishant and air flow rates at extinguishment. The extinguishant flow rate increment should result in an increase in the extinguishant concentration of no more than 2 % of the previous value. Adjustments in the extinguishant flow rate are to be followed by a brief waiting period (10 s) to allow the new proportions of extinguishant and air in the manifold to reach the cup position. During this period the liquid level shall be maintained within 1 mm from the top of the cup.

NOTE On an initial run, it is convenient to use relatively large flow increments to ascertain the approximate extinguishant flow required for extinguishment, and on subsequent runs to start at a flow rate close to the critical and to increase the flow by small amounts until extinguishment is achieved.

**B.5.8** Determine the extinguishing concentration of the extinguishant in accordance with B.7.

**B.5.9** Prior to subsequent tests, remove the fuel from the cup and remove any deposits of residue or soot that may be present on the cup.

**B.5.10** Repeat B.5.1 to B.5.9 using air flow rates of 20 l/min, 30 l/min, 40 l/min and 50 l/min.

**B.5.11** Determine the plateau region in the extinguishing concentration/air flow plot (i.e. the range of air flows over which the extinguishing concentration is at a maximum and is independent of the air flow) by plotting the extinguishing concentration as determined in B.5.8 versus the air flow rate.

If there is no plateau region found in this plot, further measurements according to B.5.10 shall be carried out using air flow rates higher than 50 l/min.

**B.5.12** Place the flammable liquid in the fuel supply reservoir.

**B.5.13** Admit fuel to the cup, adjusting the liquid level to within 5 mm to 10 mm from the top of the cup.

**B.5.14** Operate the heating arrangement for the cup to bring the fuel temperature to  $25\text{ °C} \pm 3\text{ °C}$  or to  $5\text{ °C} \pm 3\text{ °C}$  above the open cup flash point, whichever is the higher. During this period, the liquid level in the cup shall be adjusted so that the fuel level is above the means for temperature measurement of the fuel.

NOTE The fuel temperature given in B.5.14 is meant to be the temperature at the start of the test.

**B.5.15** Adjust the air flow to achieve a flow rate which is on the plateau region determined in accordance with B.5.11.

**B.5.16** Ignite the fuel.

**B.5.17** Allow the fuel to burn for a period of 60 s to 120 s before beginning the flow of extinguishant. During this period, the liquid level in the cup shall be adjusted so that the fuel level is within 1 mm from the top of the cup.

**B.5.18** Begin the flow of extinguishant. Increase the extinguishant flow rate in increments until flame extinguishment occurs, and record the extinguishant and air flow rates at extinguishment. The extinguishant flow rate increment should result in an increase in the extinguishant concentration of no more than 2 % of the previous value. Adjustments in the extinguishant flow rate are to be followed by a brief waiting period (10 s) to allow the new proportions of extinguishant and air in the manifold to reach the cup position. During this period the liquid level shall be maintained with 1 mm of the top of the cup.

NOTE On an initial run, it is convenient to use relatively large flow increments to ascertain the approximate extinguishant flow required for extinguishment, and on subsequent runs to start at a flow rate close to the critical and to increase the flow by small amounts until extinguishment is achieved.

**B.5.19** Prior to subsequent tests, remove the fuel from the cup and remove any deposits of residue or soot that may be present on the cup.

**B.5.20** Repeat B.5.12 to B.5.19 for four subsequent tests.

**B.5.21** Determine the extinguishing concentration of the extinguishant for the case of unheated fuel in accordance with B.7 by establishing the average from five tests.

**B.5.22** Repeat steps B.5.12 through B.5.20 with the fuel temperature at 5 °C below the boiling point of the fuel, or 200 °C, whichever is the lower. The fuel temperature shall be kept at this defined temperature during the whole test.

**B.5.23** Determine the extinguishing concentration of the extinguishant for the case of heated fuel in accordance with B.7 by establishing the average from five tests.

## B.6 Procedure for flammable gases

**B.6.1** A cup intended for use with gaseous fuels shall have a means of attaining a uniform gas flow at the top of the cup. For example, the cup used for liquid fuels may be packed with refractory materials.

**B.6.2** Gaseous fuel shall be from a pressure-regulated supply with a calibrated means of adjusting and measuring the gas flow rate.

**B.6.3** Adjust the air flow to 10 l/min.

**B.6.4** Begin fuel flow to the cup and adjust the flow rate to attain a gas velocity nominally equal to the air velocity past the cup. The fuel temperature shall be 25 °C ± 10 °C.

NOTE The air velocity past the cup can be calculated from the air flow rate and the difference between the cross-section of the chimney and the cross-section of the cup.

**B.6.5** Ignite the fuel.

**B.6.6** Allow the fuel to burn for a period of 60 s before beginning flow of extinguishant.

**B.6.7** Begin the flow of extinguishant. Increase the extinguishant flow rate in increments until flame extinguishment occurs, and record the air, extinguishant and fuel flow rates at extinguishment. The extinguishant flow rate increment should result in an increase in the extinguishant concentration of no more than 3 % of the previous value. Adjustments in the extinguishant flow rate are to be followed by a brief waiting period (10 s) to allow the new proportions of extinguishant and air in the manifold to reach the cup position.

NOTE On an initial run, it is convenient to employ relatively large flow increments to ascertain the approximate extinguishant flow required for extinguishment, and on subsequent runs to start at a flow rate close to the critical and to increase the flow by small amounts until extinguishment is achieved.

**B.6.8** Upon flame extinguishment, shut off the flow of flammable gas.

**B.6.9** Prior to subsequent tests, remove deposits of residue or soot if present on the cup.

**B.6.10** Determine the extinguishing concentration of the extinguishant in accordance with B.7.

**B.6.11** Repeat steps B.6.4 through B.6.9 at air flow rates of 20 l/min, 30 l/min, 40 l/min and 50 l/min.

**B.6.12** Determine the plateau region in the extinguishing concentration/air flow plot (i.e. the range of air flows over which the extinguishing concentration is at a maximum and is independent of the air flow) by plotting the extinguishing concentration as determined in B.6.10 versus the air flow rate.

If there is no plateau region found in this plot, further measurements according to B.5.11 shall be carried out using higher air flow rates than 50 l/min.

**B.6.13** Adjust the air flow rate to a value on the plateau in the extinguishing concentration/air flow plot.

**B.6.14** Begin fuel flow to the cup and adjust the flow rate to attain a gas velocity equal to the air velocity past the cup. The fuel temperature shall be  $25\text{ }^{\circ}\text{C} \pm 10\text{ }^{\circ}\text{C}$ .

**B.6.15** Ignite the fuel.

**B.6.16** Allow the fuel to burn for a period of 60 s before beginning the flow of extinguishant.

**B.6.17** Begin the flow of extinguishant. Increase the extinguishant flow rate in increments until flame extinguishment occurs, and record the air, extinguishant and fuel flow rates at extinguishment. The extinguishant flow rate increment should result in an increase in the extinguishant concentration of no more than 3 % of the previous value. Adjustments in the extinguishant flow rate are to be followed by a brief waiting period (10 s) to allow the new proportions of extinguishant and air in the manifold to reach the cup position.

NOTE On an initial run it is convenient to employ relatively large flow increments to ascertain the approximate extinguishant flow required for extinguishment, and on subsequent runs to start at a flow rate close to the critical and to increase the flow by small amounts until extinguishment is achieved.

**B.6.18** Upon flame extinguishment, shut off the flow of flammable gas.

**B.6.19** Prior to the subsequent tests, remove deposits of residue or soot if present on the cup.

**B.6.20** Determine the extinguishing concentration of the extinguishant in accordance with B.7.

**B.6.21** Repeat B.6.13 to B.6.20 for four subsequent tests.

**B.6.22** Determine the extinguishing concentration of the extinguishant for the case of unheated fuel in accordance with B.7 by establishing the average of five tests.

## B.7 Extinguishant extinguishing concentration

### B.7.1 Preferred method

The preferred method for determining the concentration of extinguishant vapour in the extinguishant plus air mixture which just causes flame extinguishment is to use a gas-analysing device, calibrated for the concentration range of the extinguishant-air mixtures being measured. The device may have continuous sampling capability (e.g. on-line gas analyser) or may be of a type which analyses discrete samples (e.g. gas chromatography). Continuous measurement techniques are preferred.

Alternatively, the remaining concentration of oxygen in the air/extinguishant mixture in the chimney below the cup can be measured with a continuous oxygen-analysis device. The oxygen concentration value is influenced by the extinguishant concentration. The extinguishant concentration is then calculated as follows:

$$C = 100 \left( 1 - \frac{O_2}{O_2(\text{sup})} \right)$$

where

$C$  is the extinguishant concentration, as a volume fraction in percent;

$O_2$  is the oxygen concentration of the air/extinguishant mixture in the chimney, as a volume fraction in percent;

$O_2(\text{sup})$  is the oxygen concentration in the supply air, as a volume fraction in percent.

### B.7.2 Alternative method

The extinguishant concentration in the extinguishant plus air mixture may, alternatively, be calculated from the measured flow rates of the extinguishant and air. Where mass flow rate devices are employed, the resulting mass flow rates need to be converted to volumetric flow rates as follows:

$$V_i \left( \frac{m_i}{\rho_i} \right)$$

where

$V_i$  is the volumetric flow rate of gas  $i$ , in litres per minute;

$m_i$  is the mass flow rate of gas  $i$ , in grams per minute;

$\rho_i$  is the density of gas  $i$ , in grams per litre.

Care should be taken to use the actual vapour density. The vapour density of many halogenated hydrocarbons at ambient temperature and pressure may differ by several percent from that calculated by the ideal gas law.

**EXAMPLE** The density of HFC-227ea vapour at a pressure of 101,3 kPa and temperature of 295 K is approximately 2,4 % higher than would be calculated for an ideal gas. At a pressure of 6,7 kPa (6,6 %), however, the difference between the actual vapour density and that calculated for an ideal gas is less than 0,2 %.

Published property data should be used where possible. Estimating techniques may be used when published data are lacking. The source of physical property values used should be recorded in the test report.

The concentration of extinguishant as a volume fraction in percent,  $C$ , is calculated as follows:

$$C = \frac{V_{\text{ext}}}{V_{\text{air}} + V_{\text{ext}}} \times 100$$

where

$C$  is the extinguishant concentration, as a volume fraction in percent;

$V_{\text{air}}$  is the volumetric flow rate of the air, in litres per minute;

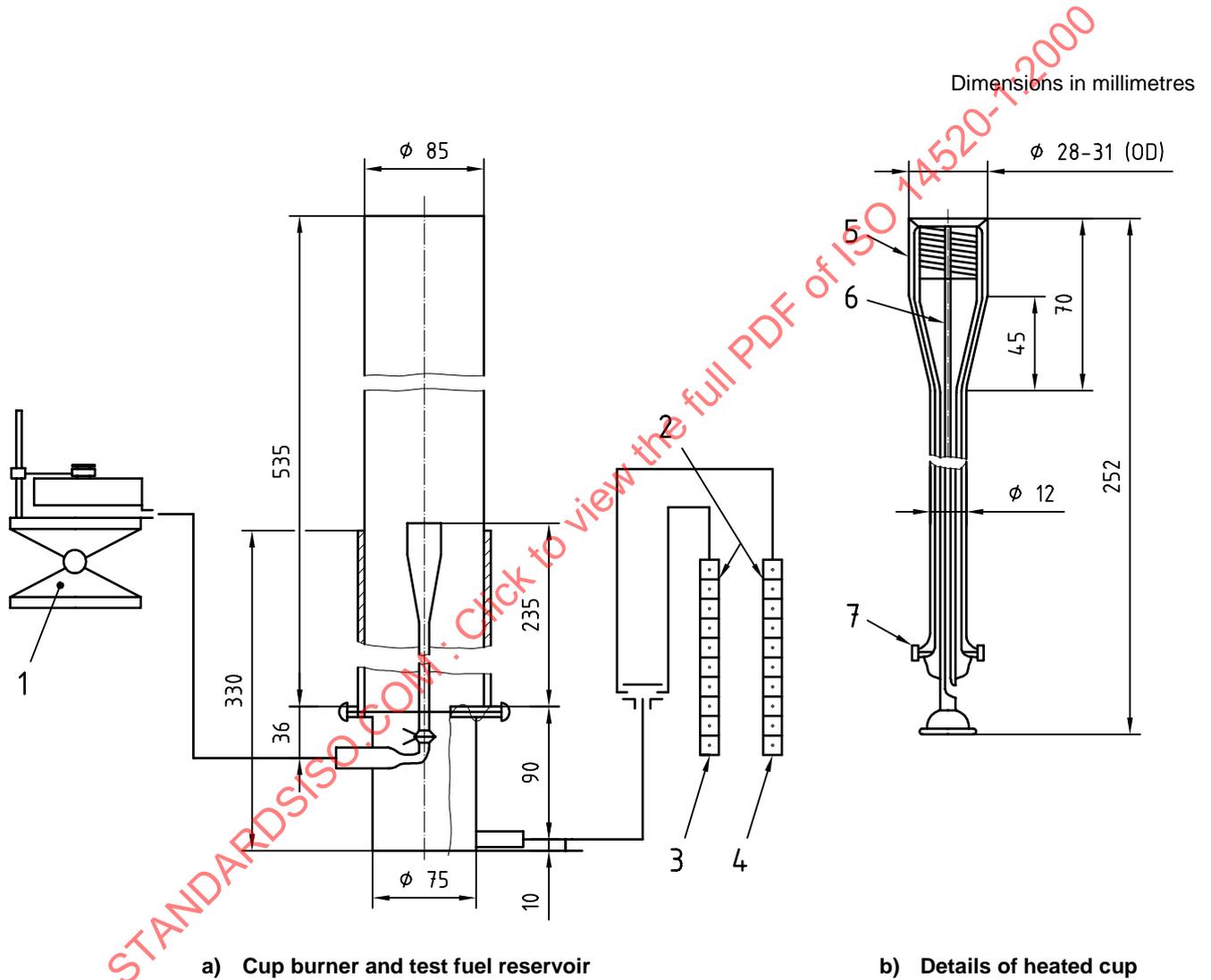
$V_{\text{ext}}$  is the volumetric flow rate of the extinguishant, in litres per minute.

### B.8 Reporting of results

As a minimum, the following information should be included in the report of results:

- schematic diagram of apparatus, including dimensions and description of materials used;
- source and assay of the extinguishant, fuel and air;
- for each test, the fuel temperature at the start of the test, the fuel temperature at the time of extinguishment, and the temperature of the air/extinguishant mixture at extinguishment;
- extinguishant, gaseous fuel and air flow rates at extinguishment; if method B.7.1 is used, the extinguishant concentration or the oxygen concentration instead of the extinguishant flow rate;
- method employed to determine the extinguishing concentration;

- f) extinguishant concentration at extinguishment for each test;
- g) extinguishing concentration for unheated fuel and for the fuel heated to 5 °C below its boiling point or 200 °C, whichever is the lower;
- h) measurement error analysis;
- i) extinguishing concentration/air flow plot and the extinguishant concentration at extinguishment for the tests according to B.5.9 to B.5.11 and B.6.10 to B.6.12.



**Key**

- |                  |                                              |
|------------------|----------------------------------------------|
| 1 Levelling jack | 5 Heating wire between inner and outer walls |
| 2 Rotameters     | 6 Thermocouple tube                          |
| 3 Air            | 7 Heater terminal                            |
| 4 Extinguishant  |                                              |

**Figure B.1 — Cup burner apparatus**

## Annex C (normative)

### Fire extinguishment/area coverage fire test procedure for engineered and pre-engineered extinguishing units

#### C.1 Requirements

**C.1.1** An engineered or pre-engineered extinguishing system unit shall mix and distribute its extinguishant and shall totally flood an enclosure when tested in accordance with this test method under the maximum design limitations and most severe installation instructions. (See also C.1.2.)

**C.1.2** When tested as described in C.5 and C.6.2 and C.6.3, an extinguishing system unit shall extinguish all visible flaming within 30 s after the end of the extinguishant discharge. When tested as described in C.6.1, an extinguishant system unit shall prevent re-ignition of the wood crib after a 10-min soak period.

#### C.2 Type of test

The tests described herein consider the intended use and limitations of the extinguishing system unit, with specific reference to the following:

- a) the area coverage for each type of nozzle;
- b) the operating temperature range of the system;
- c) location of nozzles in the protected area; the nozzle used in these tests shall not deliver the agent directly onto the test fire;
- d) either the maximum length and size of piping and number of fittings to each nozzle, or the minimum nozzle pressure;
- e) maximum discharge time;
- f) maximum fill density; and
- g) extinguishing concentrations for specific fuels.

The tests to be conducted are given in Table C.1.

**Table C.1 — Tests to be conducted**

Test objective	Enclosure size	Test fires	Clause
Nozzle min. height/max. area coverage	To suit nozzle	Heptane test cans	C.5
Nozzle max. height/extinguishing concentration	$\geq 100 \text{ m}^3$ no side less than 4 m height to suit nozzle (not less than 3,5 m)	a) wood crib b) heptane pan c) heptane test cans	C.6.1 C.6.2 C.6.3
NOTE All tests should be conducted with the same type and style of nozzle.			

### C.3 Extinguishing system

C.3.1 The extinguishing system shall be assembled as follows.

- a) Pre-engineered-type extinguishing system unit, using its maximum piping limitations with respect to the number of fittings and length of pipe to the discharge nozzles and nozzle configuration(s), as specified in the manufacturer's design and installation instructions.
- b) Engineered-type extinguishing system unit, using a piping arrangement that results in the minimum nozzle design pressure at  $20^{+2}_0$  °C.

C.3.2 Except for the heptane pan and wood crib extinguishing tests, the agent containers shall be conditioned to the minimum operating temperature specified in the manufacturer's installation instructions.

C.3.3 For the heptane pan and wood crib extinguishing tests, the agent containers are to be conditioned at  $20\text{ °C} \pm 2\text{ °C}$  for a minimum period of 16 h prior to conducting the test. In these tests the jet energy from the nozzles shall not influence the development of the fire.

C.3.4 The extinguishing system shall be arranged and dimensioned with regard to the following.

- a) For liquefied extinguishants, the time for the discharge of the pre-liquid gas phase plus the two-phase flow shall be 8 s to 10 s.
- b) For non-liquefied extinguishants, the time for the discharge shall be 50 s to 60 s.

### C.4 Extinguishing concentration

C.4.1 The extinguishing concentration for each test shall be 76,92 % (i.e. 100 divided by the safety factor, where the safety factor is 1,3) of the intended end-use design concentration specified in the manufacturer's design and installation instructions at an ambient temperature of approximately 20 °C within the enclosure. The concentration within the enclosure for all extinguishants shall be calculated using equations (1) and (2) in 7.6. If significant test enclosure leakage does exist, the formula used to determine the test enclosure concentration of extinguishant may be modified to account for the leakage measured.

C.4.2 A cold discharge test using the same quantity of extinguishant shall be conducted to verify the actual concentration of extinguishant.

### C.5 Nozzle minimum height/maximum area coverage test

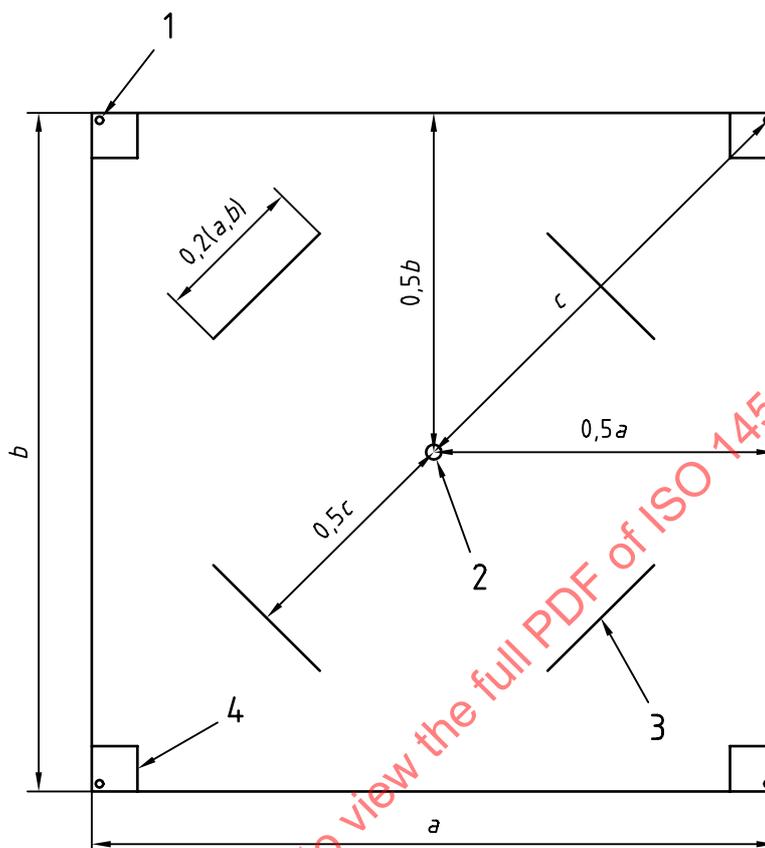
#### C.5.1 Test facility

##### C.5.1.1 Construction

The test facility shall meet the following requirements.

- a) The area ( $a \times b$ ) and height ( $H$ ) of the enclosure (see Figure C.1) shall correspond to the maximum nozzle area coverage and minimum nozzle height specified by the manufacturer.
- b) It shall be constructed of appropriate material; if plywood, this shall be at least 9,5 mm thick.
- c) A means of pressure relief shall be provided.
- d) Closeable openings shall be provided directly above the test cans to allow for venting prior to system actuation.

- e) A baffle shall be installed between the floor ( $a, b$ ) and ceiling ( $H$ ) halfway between the nozzle location and the walls of the enclosure. The baffle shall be perpendicular to the direction of nozzle discharge, and shall be 20 % of the length or width of the enclosure, whichever is appropriate with respect to the nozzle location.



#### Key

- |            |                                    |
|------------|------------------------------------|
| 1 Test can | 3 Baffle                           |
| 2 Nozzle   | 4 Closeable opening above test can |

$H$  is the minimum nozzle height specified by manufacturer for the nozzle;

$a \times b$  is the maximum nozzle area coverage for a single nozzle.

**Figure C.1 — Example of configuration for nozzle minimum height/maximum area coverage test**

#### C.5.1.2 Instrumentation

##### C.5.1.2.1 Oxygen concentrations

The oxygen level shall be measured by a calibrated oxygen analyser capable of measuring the percentage oxygen to within at least one decimal place (0,1 %). The sensing equipment shall be capable of continuously monitoring and recording the oxygen concentration inside the enclosure throughout the duration of the test. At least three sensors shall be located within the enclosure (see Figures C.2 and C.3).

The three sensors shall be located at a horizontal distance from the centre of the room of between 850 mm and 1 250 mm and at the following heights above the floor ( $H$  is the height of the enclosure):

0,1 $H$ , 0,5 $H$  and 0,9 $H$

**C.5.1.2.2 Carbon dioxide and extinguishing gas concentrations**

In addition to the oxygen concentrations, there should also be monitoring of the CO<sub>2</sub> concentration and possibly the concentration of the extinguishant gas. The accuracy of the measuring devices shall not be influenced by any of the fire products.

**C.5.1.2.3 Nozzle pressure**

The nozzle pressure during system discharge shall be recorded.

**C.5.1.2.4 Enclosure temperature**

At least the temperature at a horizontal distance from the centre of the room of between 850 mm and 1 250 mm and 0,5H (*H* is the room height) above the floor shall be recorded (see Figures C.2 and C.3). It is recommended to use K type thermocouples (Ni-CrNi), of diameter 1 mm.

The extinguishing process should be observed with an infrared camera.

**C.5.1.2.5 Near nozzle temperature**

For liquefied extinguishants, the temperature 10 mm to 30 mm in front of the nozzle, within the nozzle jet, shall additionally be recorded.

**C.5.2 Fuel specification**

**C.5.2.1 Test cans**

The test cans shall be cylindrical, 76,2 mm to 88,9 mm in diameter and at least 100 mm high.

**C.5.2.2 Heptane**

The heptane shall be commercial grade, having the following characteristics.

a) Distillation:

- 1) initial boiling point 90 °C
- 2) 50 % 93 °C
- 3) dry point 96,5 °C

b) Specific gravity (15,6 °C/15,6 °C) 0,719

c) Reid vapour pressure 2,0 psi

d) Research octane rating 60

e) Motor octane rating 50

**C.5.2.3 Fire configuration and placement**

**C.5.2.3.1** The test cans may contain either heptane or heptane and water. If they are to contain heptane and water, the heptane shall be at least 50 mm deep. The level of heptane in the cans shall be at least 50 mm below the top of the can.

Dimensions in millimetres

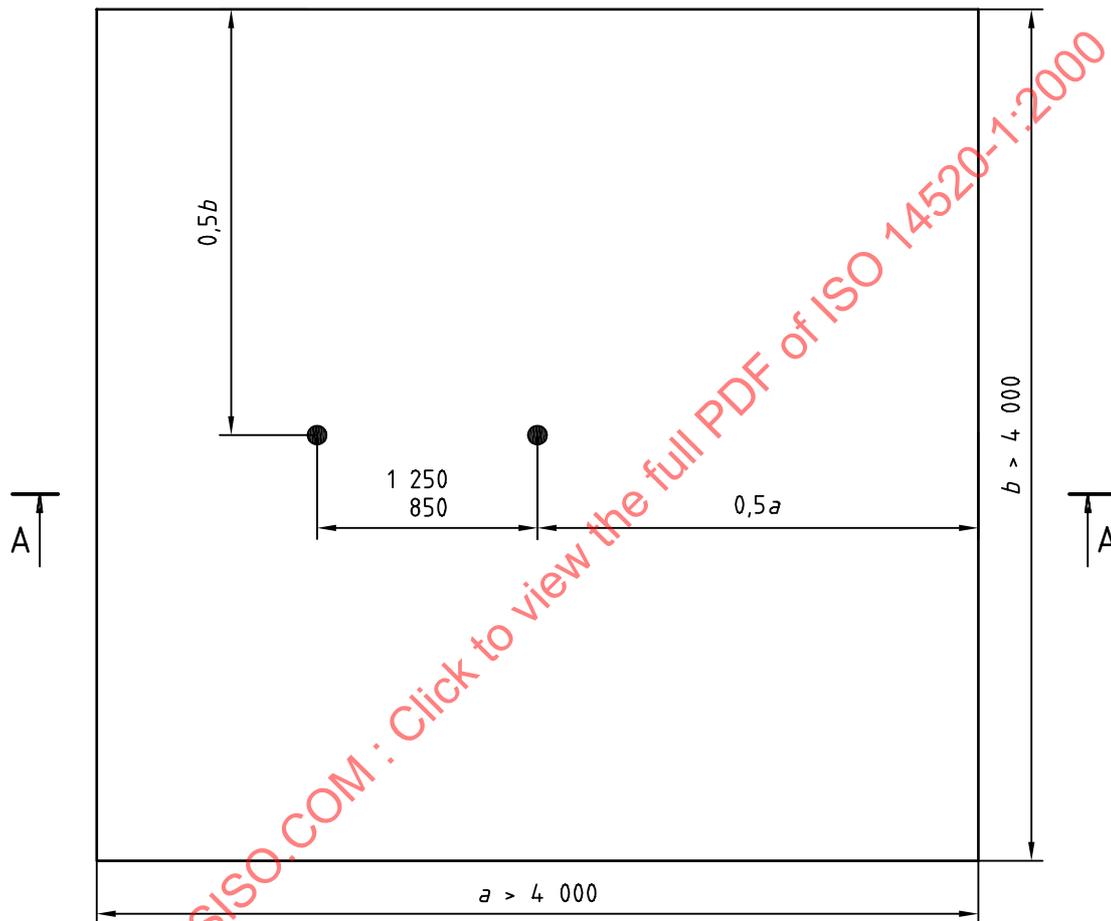
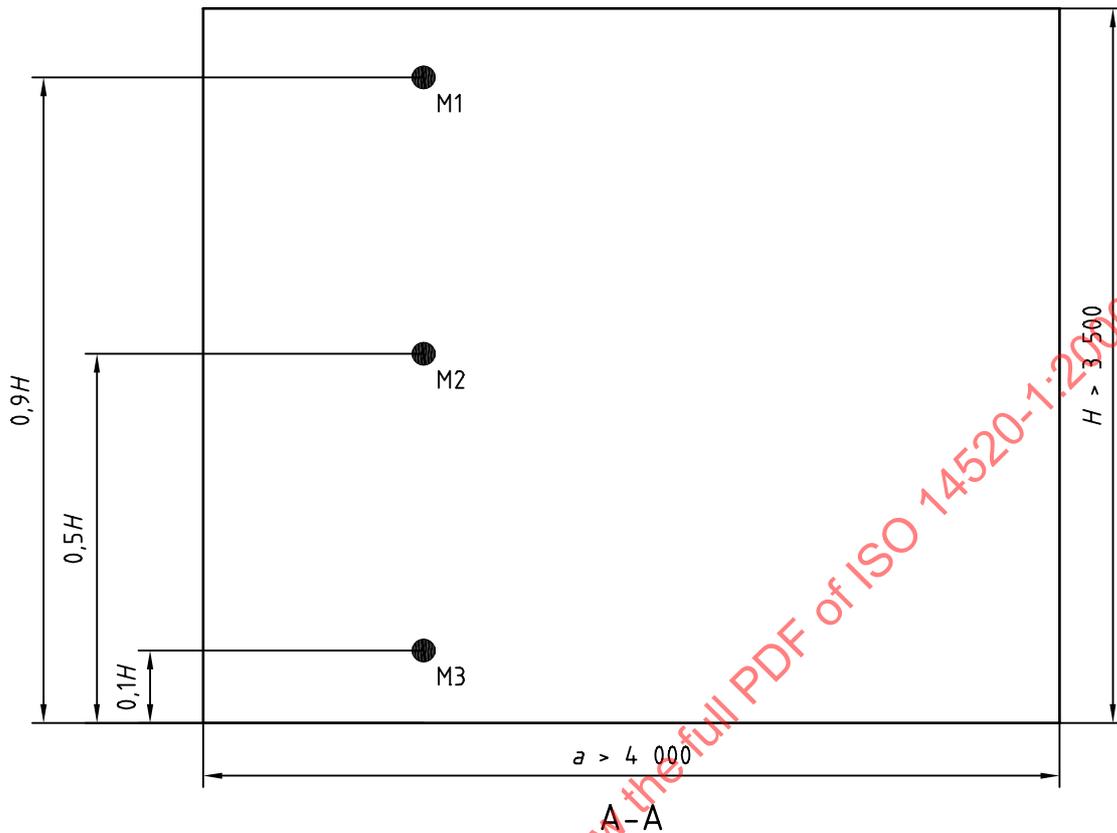


Figure C.2 — Plan view of instrumentation placement for nozzle minimum height/maximum area coverage test



**Measuring points:**

- M1 Record O<sub>2</sub> concentration
- M2 Record O<sub>2</sub> concentration and temperature
- M3 Record O<sub>2</sub> concentration

**Figure C.3 — Side view of instrumentation placement for nozzle minimum height/maximum area coverage test**

**C.5.2.3.2** The test cans shall be placed within 50 mm of the corners of the test enclosure, directly behind the baffle (see C.5.1.1), and located vertically within 300 mm of the top or bottom of the enclosure, or both top and bottom if the enclosure permits such a placement.

**C.5.3 Test procedure**

- C.5.3.1** Prior to commencing the tests, the composition of the extinguishing gas shall be analysed.
- C.5.3.2** The heptane-filled test cans shall be ignited and allowed to burn for 30 s with the closeable openings above in the open position.
- C.5.3.3** After 30 s, all openings shall be closed and the extinguishing system shall be manually actuated. At the time of actuation of the system, the amount of oxygen within the enclosure shall not be more than 0,5 % lower than the normal atmospheric oxygen concentration. During the test, the oxygen concentration shall not change by more than 1,5 % due to fire products. This change shall be determined by comparing the oxygen concentration calculated from the extinguishant concentration with the measured oxygen concentration.

## C.6 Nozzle maximum height coverage tests

### C.6.1 Wood crib test

#### C.6.1.1 Test facility

##### C.6.1.1.1 Construction

The test enclosure shall meet the following requirements.

- a) The test enclosure shall have a minimum volume of 100 m<sup>3</sup>. The height shall be at least 3,5 m. The floor dimensions shall be at least 4 m wide by 4 m long.
- b) The test enclosure shall have the maximum ceiling height as specified in the manufacturer's installation instructions.
- c) It shall be constructed with either indoor- or outdoor-grade plywood, minimum 9,5 mm thick, or equivalent material.
- d) A means of pressure relief shall be provided.

##### C.6.1.1.2 Instrumentation

###### C.6.1.1.2.1 Oxygen concentrations

The oxygen concentration shall be measured by a calibrated oxygen analyser capable of measuring the percentage oxygen to within at least one decimal place (0,1 %). The sensing equipment shall be capable of continuously monitoring and recording the oxygen concentration inside the enclosure throughout the duration of the test. At least three sensors shall be located within the enclosure (see Figures C.4 and C.5).

One sensor shall be located at the equivalent height of the top of the test object from the floor, 0,6 m to 1 m away from the test object. The other two sensors shall be located at  $0,1H$  and  $0,9H$  ( $H$  is the height of the enclosure) (see Figures C.4 and C.5).

###### C.6.1.1.2.2 Carbon dioxide and extinguishing gas concentrations

In addition to the oxygen concentrations, there should also be monitoring of the CO<sub>2</sub> concentration and, possibly, the concentration of the extinguishant gas. The accuracy of the measuring devices shall not be influenced by any of the fire products.

###### C.6.1.1.2.3 Nozzle pressure

The nozzle pressure during system discharge shall be recorded.

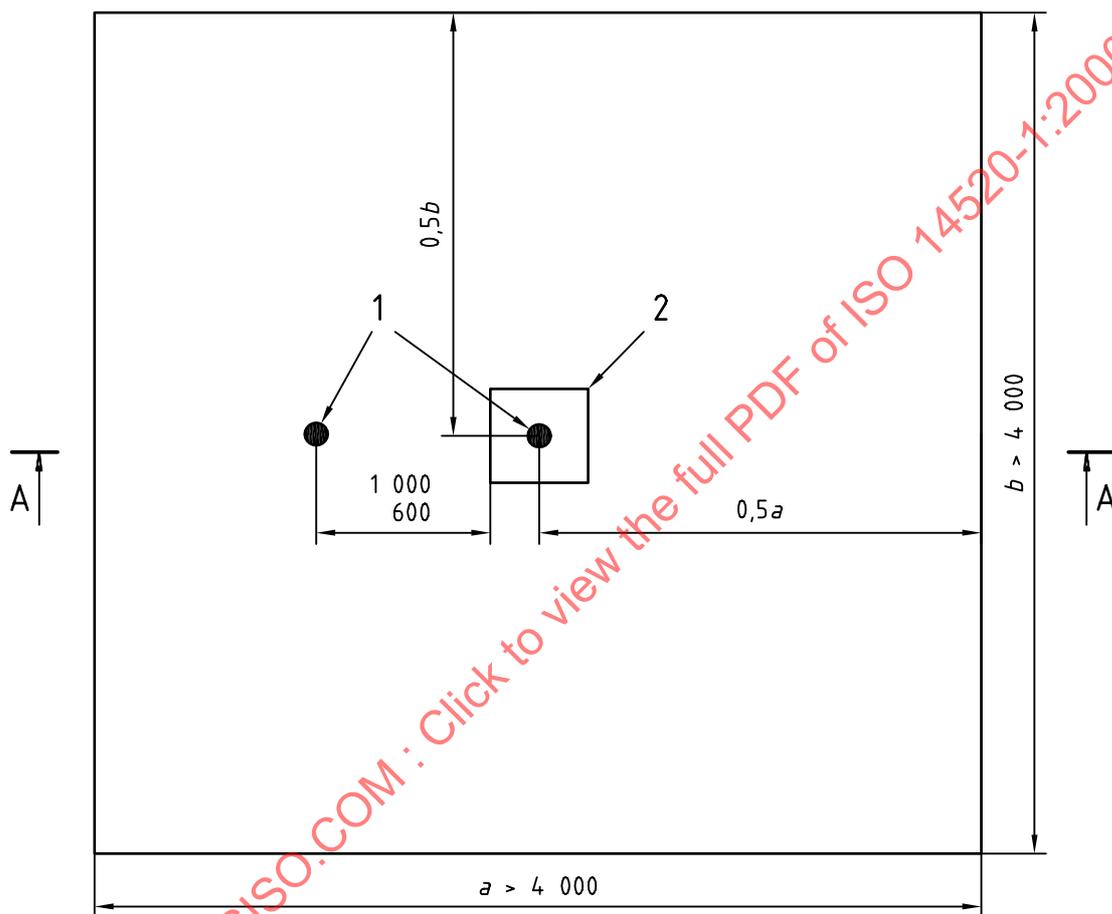
###### C.6.1.1.2.4 Enclosure temperature

Temperature sensors shall be located centred 100 mm and  $0,9H$  ( $H$  is the room height) above the test object, and a third sensor at the equivalent height of the top of the test object from the floor, horizontally 0,6 m to 1 m away from the test object (see Figures C.4 and C.5). It is recommended to use K type thermocouples (Ni-CrNi), of diameter 1 mm. The extinguishing process should be observed with an infrared camera.

###### C.6.1.1.2.5 Near nozzle temperature

For liquefied extinguishants, the temperature 10 mm to 30 mm in front of the nozzle, within the nozzle jet, shall additionally be recorded.

Dimensions in millimetres

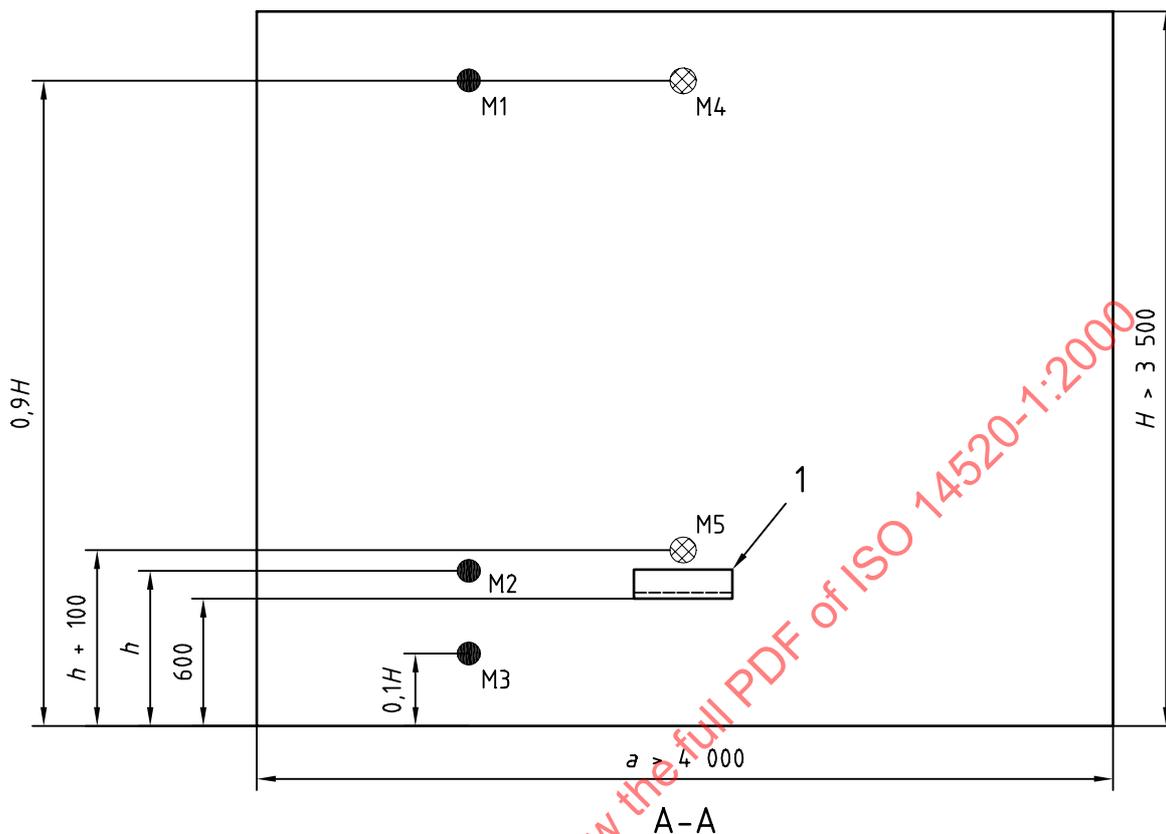


**Key**

- 1 Measuring point
- 2 Test object

**Figure C.4 — Plan view of instrumentation placement for nozzle maximum height extinguishing concentration test**

Dimensions in millimetres

**Key**

1 Test object

**Measuring points:**

- M1 Record O<sub>2</sub> concentration
- M2 Record O<sub>2</sub> concentration and temperature
- M3 Record O<sub>2</sub> concentration
- M4 Record temperature
- M5 Record temperature

**Figure C.5 — Side view of instrumentation placement for nozzle maximum height extinguishing concentration test**

**C.6.1.2 Fuel specification****C.6.1.2.1 Crib igniter fuel**

Ignition of the crib is achieved by burning commercial-grade heptane (specified in C.5.2.2) on a layer of water of 12,5 l in a square steel pan 0,25 m<sup>2</sup> in area, not less than 100 mm in height, and with a wall thickness of 6 mm (specified in C.6.2.2.2).

**C.6.1.2.2 Fire configuration and placement**

**C.6.1.2.2.1** The wood crib shall consist of four layers of six, approximately 40 mm by 40 mm by 450 mm long, of kiln spruce or fir lumber having a moisture content between 9 % and 13 %. Place the alternate layers of wood members at right angles to one another. Evenly space the individual wood members in each layer to form a square determined by the specified length of the wood members. Staple or nail together the wood members to form the outside edges of the crib.

**C.6.1.2.2.2** The crib shall be pre-burned outside the enclosure on a stand supporting the crib 300 mm above the pan holding the igniter fuel.

After the pre-burn period, the crib shall be moved into the enclosure and be located on a stand supporting the crib centrally within the enclosure 600 mm above the floor.

### C.6.1.3 Test procedure

#### C.6.1.3.1 Operation

**C.6.1.3.1.1** Prior to commencing tests the composition of the extinguishing gas shall be analysed.

**C.6.1.3.1.2** Centre the crib with the bottom of the crib approximately 300 mm above the top of the pan on a test stand constructed so as to allow for the bottom of the crib to be exposed to the atmosphere. The pre-burning shall take place outside the enclosure, if possible in a sufficiently large room (at least five times the volume of the test enclosure). In any case, the pre-burning shall not be influenced by weather conditions such as rain, wind, sun, etc. The maximum wind speed in the proximity of the fire shall be  $3 \text{ m s}^{-1}$ . If necessary, adequate means for protection against wind, etc. may be used. Record the weather conditions including the location of the pre-burn, air temperature, humidity and wind speed.

**C.6.1.3.1.3** Ignite the heptane and allow the crib to burn freely. The 1,5 l of heptane will provide a burn time of approximately 3 min. After the heptane is exhausted, the crib shall be allowed to burn freely for an additional time of 3 min, resulting in a total pre-burn time of  $6 \text{ min } \left( \begin{smallmatrix} +10 \\ 0 \end{smallmatrix} \text{ s} \right)$  outside the test enclosure.

**C.6.1.3.1.4** Just prior to the end of the pre-burn period, move the crib into the test enclosure and place it on a stand so that the bottom of the crib is 600 mm above the floor. Seal the enclosure and actuate the system. The time required to position the burning crib in the enclosure and the actuation of the system discharge shall not exceed 15 s.

**C.6.1.3.1.5** At the time of actuation of the system, the amount of oxygen within the enclosure at the level of the crib shall not be more than 0,5 % lower than the normal atmospheric oxygen concentration. During the test, the oxygen concentration shall not change more than 1,5 % due to fire products. This change shall be determined by comparing the oxygen concentration calculated from the extinguishant concentration with the measured oxygen concentration.

**C.6.1.3.1.6** After the end of system discharge, the enclosure shall remain sealed for a total of 10 min. After the 10-min soak period, remove the crib from the enclosure and observe to determine that sufficient fuel remains to sustain combustion and for signs of re-ignition. The following shall be recorded:

- a) the presence and location of burning embers;
- b) whether or not the glowing embers or the crib re-ignites; and
- c) the mass of the crib after the test.

**C.6.1.3.1.7** If necessary, amend the extinguishant concentration and repeat the experimental programme until three successive, successful extinguishments are achieved.

#### C.6.1.3.2 Recording of results

After the required pre-burn period, record the following data for each test:

- a) the calculated discharge time of the extinguishant, i.e. the time needed to reach 95 % of the laboratory extinguishant concentration, in seconds;
- b) the effective discharge time, i.e. for liquefied extinguishants the time of the pre-liquid gas phase plus the time of the two-phase flow; for non-liquefied extinguishants the time from opening the container valve(s) to cutting off the discharge;

- c) the time required to control the fire or to achieve extinguishment, in seconds;
- d) the total mass of extinguishant discharged into the test enclosure;
- e) the soaking time (time from the end of system discharge until the opening of the test enclosure);
- f) the temperature profile of the wood crib, preferably using an infrared camera.

### C.6.1.3.3 Determination of design extinguishant concentration

The laboratory extinguishant concentration is that concentration which achieves satisfactory extinction of the fire over three successive tests. The design concentration is the laboratory concentration multiplied by an appropriate 'safety factor'.

## C.6.2 Heptane pan test

### C.6.2.1 Test facility

#### C.6.2.1.1 Construction

The construction of the enclosure shall be as described in C.6.1.1.1.

#### C.6.2.1.2 Instrumentation

Instrumentation of the enclosure shall be as described in C.6.1.1.2.

### C.6.2.2 Fuel specification

#### C.6.2.2.1 Heptane

The heptane shall be commercial grade as specified in C.5.2.2.

#### C.6.2.2.2 Fire configuration and placement

The fire shall be in a square steel pan of base 0,25 m<sup>2</sup>, height 200 mm, with a wall thickness of 6 mm. The test pan shall contain 50 mm of heptane with the heptane level 50 mm below the top of the pan, i.e. 12,5 l of heptane. The steel pan shall be located in the centre of the test enclosure with the bottom 600 mm above the floor of the test enclosure.

### C.6.2.3 Test procedure

#### C.6.2.3.1 Operation

Prior to commencing the tests, the composition of the extinguishing gas shall be analysed.

Ignite the heptane and allow it to burn for 30 s. After 30 s all openings shall be closed and the extinguishing system shall be manually actuated. At the time of actuation of the system, the amount of oxygen within the enclosure shall not be more than 0,5 % lower than the normal atmospheric oxygen concentration. During the test, the oxygen concentration shall not change by more than 1,5 % due to fire products. This change shall be determined by comparing the oxygen concentration calculated from the extinguishant concentration with the measured oxygen concentration.

#### C.6.2.3.2 Recording of results

Results shall be recorded as specified in C.6.1.3.2 with the exception of items e) and f).

#### C.6.2.4 Determination of design extinguishant concentration

Determination of design extinguishant concentration shall be as specified in C.6.1.3.3.

### C.6.3 Heptane test cans

#### C.6.3.1 Test facility

##### C.6.3.1.1 Construction

Construction of the enclosure shall be as described in C.6.1.1.1.

##### C.6.3.1.2 Instrumentation

Instrumentation of the enclosure shall be as described in C.5.1.2.

#### C.6.3.2 Fuel specification

##### C.6.3.2.1 Heptane

The heptane shall be commercial grade as specified in C.5.2.2.

##### C.6.3.2.2 Fire construction and placement

Specification of test cans is as described in C.5.2.1. The test can filling requirements and placement within the enclosure are as described in C.5.2.3.

#### C.6.3.3 Test procedure

##### C.6.3.3.1 Operation

Prior to commencing tests, the composition of the extinguishing gas shall be analysed.

Ignite the heptane and allow it to burn for 30 s. After 30 s all openings shall be closed and the extinguishing system shall be manually actuated. At the time of actuation of the system, the amount of oxygen within the enclosure shall not be more than 0,5 % lower than the normal atmospheric oxygen concentration. During the test, the oxygen concentration shall not change more than 1,5 % due to fire products. This change shall be determined by comparing the oxygen concentration calculated from the extinguishant concentration with the measure oxygen concentration.

##### C.6.3.3.2 Recording of results

Results are to be recorded as specified in C.6.1.3.2 with the exception of items e) and f).

#### C.6.3.4 Test requirement

The laboratory extinguishant concentration is that concentration which achieves satisfactory extinguishment (all test cans extinguished within 30 s after the end of agent discharge) over three successive tests. The design concentration is the laboratory concentration multiplied by an appropriate 'safety factor'.