

Australian Standard<sup>®</sup>

**Fire protection equipment—Carbon  
dioxide extinguishing systems for use  
on premises—Design and installation  
(ISO 6183:2009, MOD)**



This Australian Standard® was prepared by Committee FP-011, Special Hazard Fire Protection Systems. It was approved on behalf of the Council of Standards Australia on 10 March 2011.

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  - Engineers Australia
  - Fire Protection Association Australia
  - National Fire Industry Association
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  - Security Providers Association of Australia
- 

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on premises—Design and installation  
(ISO 6183:2009, MOD)**

Originated in part as AS 4214.1—1995 and AS 4214.3—1995.  
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## PREFACE

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

This Standard is an adoption with national modifications and has been reproduced from ISO 6183:2009, *Fire protection equipment—Carbon dioxide extinguishing systems for use on premises—Design and installation*, and has been varied as indicated to take account of Australian conditions. The modifications are specified in Appendix ZZ.

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

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

Detailed requirements for the design and installation of marine CO<sub>2</sub> systems are provided in Annex ZB (Marine) of AS ISO 14520.1 *Gaseous fire-extinguishing systems—Physical properties and system design*, Part 1: *General requirements (ISO 14520-1:2006, MOD)*.

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

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## INTRODUCTION

This International Standard is intended for use by those concerned with purchasing, designing, installing, testing, inspecting, approving, operating and maintaining carbon dioxide (CO<sub>2</sub>) extinguishing systems.

This International Standard applies only to carbon dioxide fixed fire-extinguishing systems in buildings and other premises on land. Although the general principles could well apply to other uses (e.g. maritime use), for these other uses additional considerations will almost certainly have to be taken into account and the application of the requirements given in this International Standard is therefore unlikely to be fully satisfactory. General information about carbon dioxide as an extinguishing medium is given in Annex D. This can be useful background information for those unfamiliar with the characteristics of this medium.

It has been assumed in the preparation of ISO 6183 that the execution of its provisions will be entrusted to those persons 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 carbon dioxide. New requirements to minimize the need to release carbon dioxide during testing and commissioning procedures are included in this edition. These are linked to the inclusion of enclosure integrity testing.

Carbon dioxide has for many years been a recognized effective medium for the extinction of flammable liquid fires as well as fires in the presence of electrical and ordinary Class A hazards. Nevertheless, it ought not be forgotten, in the planning of comprehensive schemes, that there could be hazards for which this media is not suitable, or that in certain circumstances or situations there can be dangers in its use requiring special precautions.

The use of carbon dioxide is no longer recommended for total flooding of occupied areas. ISO 14520 provides requirements for other extinguishing agents that can be more appropriately used in these areas.

It is important that the fire protection of a building or plant be considered as a whole. Carbon dioxide systems form only a part, though an important part, of the available facilities. It cannot 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.

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

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



## AUSTRALIAN STANDARD

**Fire protection equipment—Carbon dioxide extinguishing systems for use on premises—Design and installation (ISO 6183:2009, MOD)****1 Scope**

This International Standard specifies requirements and gives recommendations for the design, installation, testing, maintenance and safety of fixed carbon dioxide firefighting systems in buildings, plant or other structures. It is not applicable to extinguishing systems on ships, in aircraft, on vehicles and mobile fire appliances, or to below-ground systems in the mining industry; nor does it apply to carbon dioxide pre-inerting systems.

Design of systems where unclosable opening(s) exceed a specified area and where the opening(s) can be subject to the effect of wind is not specified, although general guidance on the procedure to be followed in such cases is given (see 7.4.3.2).

**2 Normative references**

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

ISO 1182:2002, *Reaction to fire tests for building products — Non-combustibility test*

ISO 3864-1:2002, *Graphical symbols — Safety colours and safety signs — Part 1: Design principles for safety signs in workplaces and public areas*

ISO 5923:1989, *Fire protection — Fire extinguishing media — Carbon dioxide*

ISO 14520-1:2006, *Gaseous fire extinguishing systems — Physical properties and system design — Part 1: General requirements*

ISO 16003:2008, *Components for fire extinguishing systems using gas — Requirements and test methods — Container valve assemblies and their actuators; selector valves and their actuators; nozzles; flexible and rigid connectors; and check valves and non-return valves*

**3 Terms and definitions**

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

**3.1****approved**

acceptable to a relevant **authority** (3.2)

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

**3.2****authority**

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

**3.3****automatic/manual switch**

means of converting the system from automatic to manual actuation

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

**3.4****clearance**

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

**3.5****deep-seated fire**

fire involving solids subject to smouldering

**3.6****design concentration**

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

**3.7****engineered system**

system in which the supply of carbon dioxide is discharged through a system of pipes and nozzles in which the size of each section of pipe and nozzle orifice has been calculated in accordance with the requirements of this International Standard

**3.8****extinguishing concentration**

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

**3.9****fill density**

mass of carbon dioxide per unit volume of container

**3.10****design quantity**

mass of carbon dioxide required to achieve the design concentration within the protected volume

**3.11****volume**

volume enclosed by the building elements around the protected enclosure

**3.12****high-pressure storage**

storage of carbon dioxide in pressure containers at ambient temperatures

**3.13****hold time**

period of time during which a concentration of carbon dioxide greater than the fire extinguishing concentration is maintained

NOTE See 8.2.3.11.

**3.14****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.

**3.15****liquid discharge time**

time during which predominantly liquid carbon dioxide is present at the nozzle

**3.16****lock-off device**

manually operated shut-off valve installed in the discharge piping downstream of the carbon dioxide containers, or other 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 carbon dioxide into the hazard area when the lock-off device is activated.

**3.17****local application system**

carbon dioxide supply permanently connected to fixed piping with nozzles arranged to discharge the carbon dioxide directly onto the burning material or identified hazard

**3.18****low-pressure storage**

storage of carbon dioxide in pressure containers at a controlled low temperature, normally  $-18^{\circ}\text{C}$  to  $-20^{\circ}\text{C}$

**3.19****maintenance**

thorough check to verify that the extinguishing system will operate as intended

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

**3.20****maximum working pressure**

equilibrium pressure within a container at the maximum working temperature

NOTE 1 For high-pressure storage, at the maximum fill density. For a container in transit, the equilibrium pressure can differ from that in storage within a building.

NOTE 2 For low-pressure storage, the pressure corresponding to the maximum controlled temperature of  $-18^{\circ}\text{C}$ .

**3.21 Occupied and unoccupiable areas****3.21.1****normally occupied area**

area intended for occupancy

**3.21.2****normally unoccupied area**

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

**3.21.3****unoccupiable area**

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

EXAMPLE Shallow voids and cabinets.

**3.22****pre-engineered system**

system that has predetermined flow rates, nozzle placement, and quantities of carbon dioxide and that incorporates specific nozzles and methods of application that can differ from those detailed in this International Standard

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

**3.23****pre-liquid-vapour flow time**

time from the opening of the container or selector valve to the start of predominantly liquid flow at the most unfavourable nozzle

**3.24****safety factor**

multiplier of the carbon dioxide extinguishing concentration, used to determine minimum design concentration

**3.25****selector valve**

valve installed in the discharge piping downstream of the storage containers, used to direct the carbon dioxide to the appropriate hazard

NOTE It is used where one or more storage containers are arranged to selectively discharge carbon dioxide to any of several separate hazards.

**3.26****surface fire**

fire involving combustible or flammable liquids, gases and solids not subject to smouldering

**3.27****total flooding system**

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

**4 Use and limitations****4.1 General**

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

**4.2 Uses for carbon dioxide systems**

Carbon dioxide, local application and total flooding fire-extinguishing systems are useful within the limits of this International Standard in extinguishing fires involving specific hazards or equipment. The following are typical of such hazards, but the list is not exhaustive:

- a) combustible or flammable liquid and gases;
- b) electrical hazards such as transformers, switches, circuit breakers, rotating equipment, and electronic equipment;
- c) engines utilizing gasoline and other flammable liquid fuels;
- d) ordinary combustibles such as paper, wood, and textiles.

### 4.3 Limitations for carbon dioxide systems

Carbon dioxide cannot extinguish fires involving certain types of materials such as

- a) chemicals containing their own supply of oxygen, such as cellulose nitrate, or
- b) metals and chemicals which react with carbon dioxide, e.g. alkali metals and metal hydrides.

While carbon dioxide will not extinguish certain fuels containing their own oxygen of combustion, it will not react dangerously with these materials or increase their burning rate. Carbon dioxide, if used in this situation in a total flooding system, will provide protection for adjacent combustibles or can be successfully used if the reactive metals or hydride are first covered by another material. Examples of the latter condition are sodium stored or used under kerosene, cellulose nitrate in solution of lacquer thinner, and magnesium chips covered with heavy oil.

### 4.4 Temperature limitations

All devices shall be designed for the service they will encounter and shall not be readily rendered inoperative or susceptible to accidental operation. Devices shall normally 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 manufacturer's 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

The discharge of carbon dioxide in fire-extinguishing concentration creates serious hazards to personnel, such as suffocation and reduced visibility during and after the discharge period. Hazards to personnel created by the discharge of carbon dioxide shall be considered in the design of the system.

Carbon dioxide gas is heavier than air and will collect in pits, wells, shaft bottoms or other low-lying areas, and can migrate into adjacent places outside the protected space. Consideration shall also be given to places to which the carbon dioxide can migrate or collect in the event of a discharge from a safety relief device of a storage container.

Conformance with this International Standard does not remove the user's statutory responsibility to comply with the appropriate safety regulations.

**NOTE** The safety precautions required by this International Standard do not address toxicological or physiological effects associated with the products of combustion caused by fire.

### 5.2 Safety precautions

#### 5.2.1 Normally occupied and normally unoccupied areas

The use of carbon dioxide is not recommended for total flooding of normally occupied and normally unoccupied areas as long as comparable alternative firefighting methods are available. However, where carbon dioxide systems are used to protect these areas, they shall be provided with the following.

- a) A non-electrical time delay device and an electrical and pneumatic pre-discharge alarm that is distinct from all other alarm signals or other approved combination of devices providing equivalent level of safety and reliability. The pre-discharge alarm shall operate immediately on commencement of the time delay. 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.
- b) Automatic/manual switch, with associated status indication.

- c) Lock-off device, supervised to indicate a system fault if the valve is more than one eighth closed.

NOTE The purpose of the lock-off device is to physically prevent discharge of carbon dioxide into the protected space — for example, during maintenance or if safe evacuation is not possible during the pre-warning time.

- d) Emergency lighting and adequate direction signs for exit routes: continuous visual and audible alarms at entrances and designated exits inside the protected area and continuous visual alarms outside the protected area that operate until the protected area has been declared safe.
- e) Designated exit doors that are outward swinging, self-closing and able to be opened from the inside, even when locked from the outside.
- f) Appropriate warning and instruction signs (see 5.2.2).
- g) Means for prompt natural or forced-draft ventilation of such areas after any discharge of carbon dioxide. 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 carbon dioxide is heavier than air.

Where it is possible for carbon dioxide gas to collect in pits, wells, shaft bottoms or other low-lying areas, consideration shall be given to adding an odoriferous substance to the carbon dioxide.

Instructions to, and drills of, all personnel within or in the vicinity of protected areas, including maintenance or construction personnel who could be brought into the area, shall be given to ensure their correct actions when the system operates. Following discharge of the system, personnel should not enter the enclosure until it has been declared as being safe to do so. Additional safety aspects such as breathing apparatus should be considered.

The need to comply with national regulations or standards requiring other precautions shall be considered.

### 5.2.2 Warning notices for occupiable areas

Notices shall be provided at the following locations:

- a) at all entrances to the protected enclosure (see Figures 1 and 2, and below);
- b) at each emergency manual release point (see Figure 3);
- c) at each lock-off valve (see Figure 4).

Where a lock-off valve is fitted, the notice illustrated in Figure 2 is complementary to the notice in Figure 1 and should be located adjacent to it. Alternatively, the text may be incorporated in the same display notice.

Warning notices shall be coloured in accordance with ISO 3864-1 and shall be of a letter size equal to or greater than that shown in Figures 1 to 4.

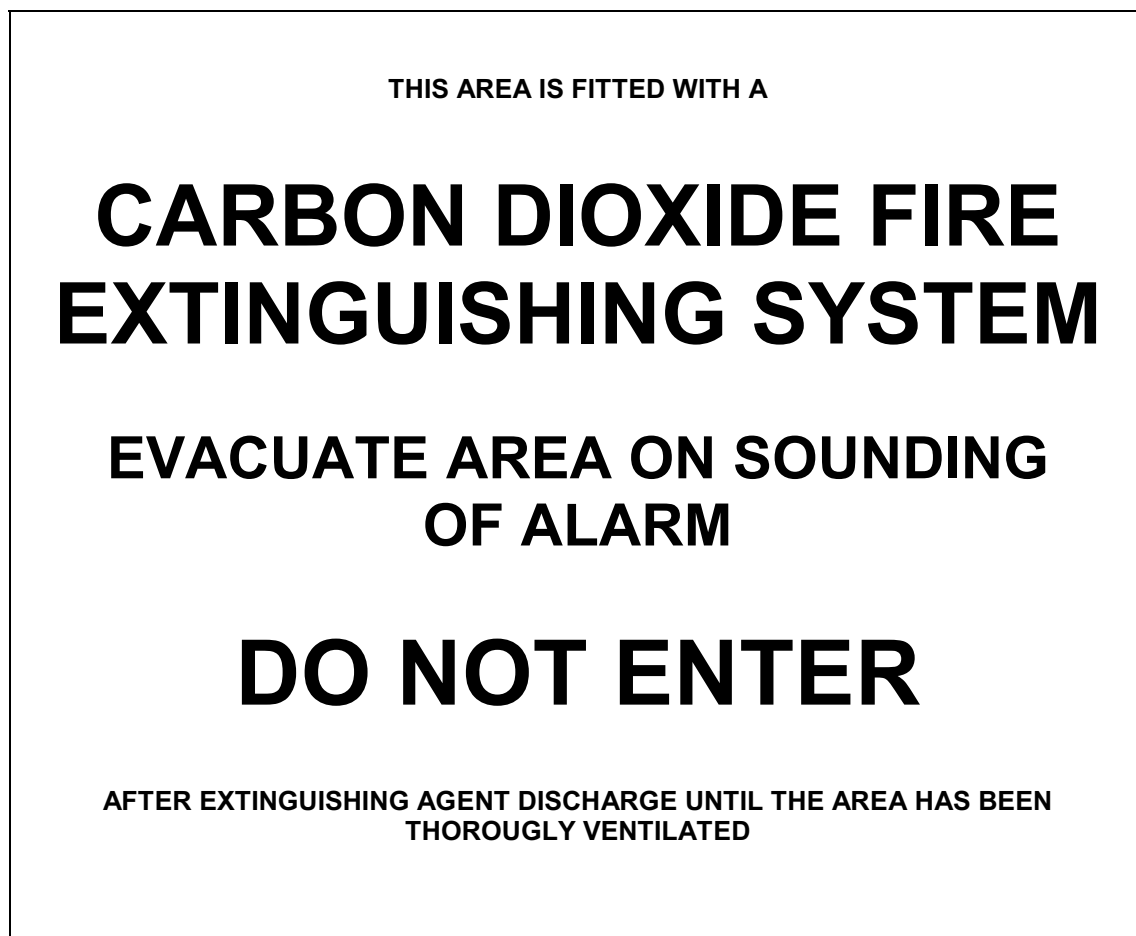


Figure 1 — Typical instruction notice to be displayed at each entry to the protected area or enclosure

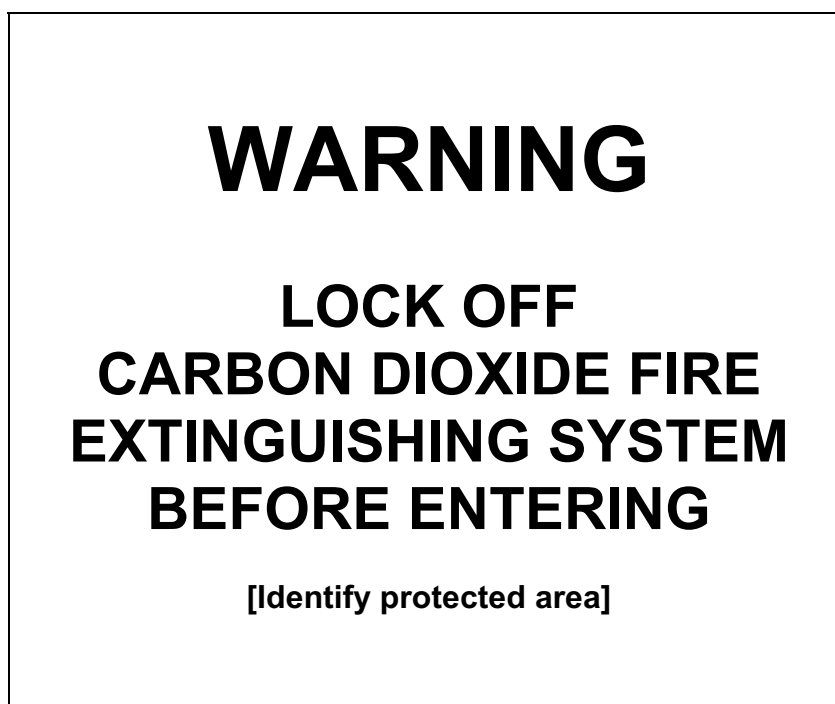


Figure 2 — Typical lock-off warning system notice

**CARBON DIOXIDE FIRE EXTINGUISHING  
SYSTEM**

**MANUAL RELEASE FOR**

[identify protected area]

**WARNING**

**ENSURE AREA IS EVACUATED BEFORE  
OPERATING**

Figure 3 — Typical instruction notice to be displayed at the manual release

**CARBON DIOXIDE FIRE  
EXTINGUISHING SYSTEM  
LOCK-OFF VALVE FOR**

[identify protected area]]

**WARNING**

**ENSURE AREA IS CLEAR OF  
PERSONNEL BEFORE OPENING  
VALVE**

[identify protected area]

Figure 4 — Typical lock-off valve notice

### 5.2.3 Warning notices for unoccupiable areas

For carbon dioxide systems protecting unoccupiable areas, appropriate warning and instruction signs shall be provided adjacent to access points to the protected space. An example of a typical notice is shown in Figure 5.

Additional notices may be provided at each emergency manual release point (see Figure 3).

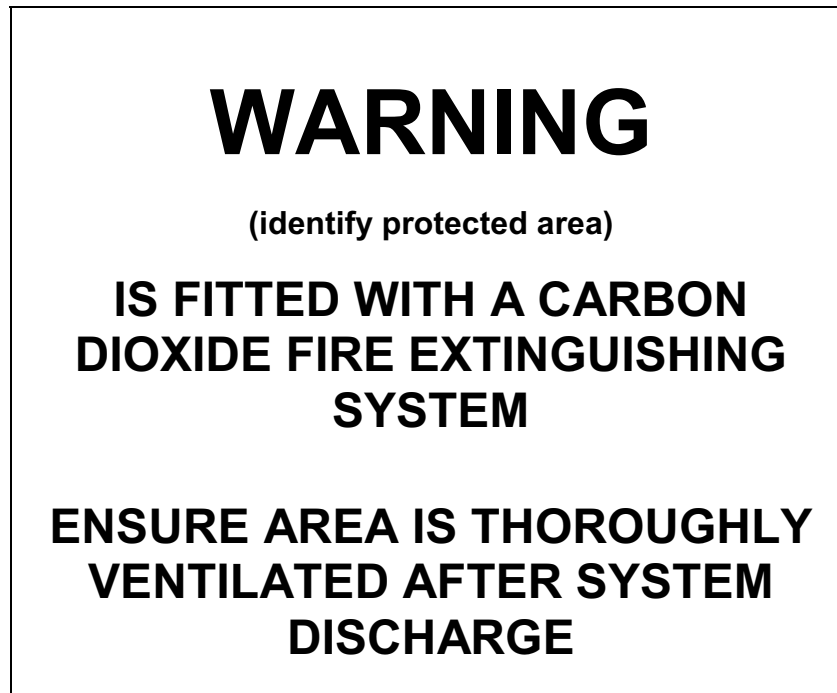


Figure 5 — Typical warning notice to be displayed at access point to the protected unoccupiable area

### 5.3 Electrical hazards

Where exposed electrical conductors are present, clearances no smaller than those given in Table 1 shall be provided, where practicable, between the electrical conductors and all parts of the system able to 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 arranged so that all normal operations can be carried out safely by the operator.

**Table 1 — 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.

## 5.4 Electrical earthing

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

## 5.5 Electrostatic discharge

**CAUTION —** Care should be taken when discharging carbon dioxide into potentially explosive atmospheres. Electrostatic charging of conductors not bonded to earth can occur during the discharge of carbon dioxide. These conductors can discharge to other objects with sufficient energy to initiate an explosion.

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.

The need for ancillary systems and components to comply with national regulations or standards shall be considered.

### 6.1.1 Specifications

Specifications for carbon dioxide fire-extinguishing systems shall be prepared under the supervision of a person fully experienced in the design of such 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.

### 6.1.2 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.

## 6.2 Carbon dioxide supply

### 6.2.1 Quality

The carbon dioxide shall comply with ISO 5923.

### 6.2.2 Quantity

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

**6.2.2.2** If several extinguishing zones are served by one carbon dioxide battery or one container system, a selector valve shall be provided for each extinguishing zone. Selector valves for cylinder systems shall open automatically before or at the same time as the operation of the cylinder valves.

**6.2.2.3** The determined carbon dioxide quantity required shall be stored so as to be available at all times and shall not be used for other purposes.

**6.2.2.4** Additional quantities of carbon dioxide shall be stored in accordance with the following.

#### a) Low-pressure systems

- 1) In order to equalize charge or drain tolerances and gas residues, the quantities of carbon dioxide to be stored for low-pressure systems as determined for the largest extinguishing zone shall be increased by at least 10 %.
- 2) If there is a possibility that liquid carbon dioxide might remain in the piping between storage container and nozzle pipe system, the carbon dioxide store shall be increased by this remaining quantity, in addition to the 10 % increase specified in item 1) above.

#### b) High-pressure systems

In the case of local application systems, the design quantity of carbon dioxide shall be increased by 40 % to determine nominal container storage capacity, since only the liquid portion of the discharge is effective.

**6.2.2.5** In low-pressure systems, selector valves shall open automatically and close automatically after discharge of the required quantity of carbon dioxide.

**6.2.2.6** The reserve quantity shall be as many multiples of the main supply as required.

**6.2.2.7** The time needed to obtain carbon dioxide for replenishment to restore systems to the operating conditions shall be considered as a major factor in determining the reserve supply needed.

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

### 6.2.3 Container arrangement

#### 6.2.3.1 General

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

**6.2.3.1.2** 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.

**6.2.3.1.3** Containers shall be located as near as is practical to the hazard they protect. They may be located within the hazard area but shall not be positioned where they will be exposed to a fire or explosion in these hazards.

**6.2.3.1.4** 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. Storage containers shall be sheltered from direct exposure to the weather.

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

#### 6.2.3.2 Arrangement for high-pressure containers

When two or more containers are connected into the same manifold, automatic means (such as check valves) shall be provided to prevent loss of carbon dioxide 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 carbon dioxide, and
- c) interchangeable.

### 6.2.4 Storage containers

#### 6.2.4.1 General

Containers shall be designed to hold carbon dioxide. The need for containers used in these systems to be designed and marked to meet the requirements of relevant national standards shall be considered.

#### 6.2.4.2 Marking

Each carbon dioxide container shall have a permanent name-plate or other permanent marking specifying the carbon dioxide, tare and gross mass.

Containers without a dip tube shall be appropriately marked.

#### 6.2.4.3 High-pressure containers

Fill density shall be appropriate for the maximum ambient temperatures listed in Table 2.

The need for the container and valve assembly to be fitted with a pressure relief device that complies with national regulations or standards shall be considered.

Table 2 — Maximum storage temperature

| Fill density<br>kg/l                                                                                                                                                                                                                    | Maximum ambient temperature<br>°C |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|
| 0,75                                                                                                                                                                                                                                    | 40                                |
| 0,68                                                                                                                                                                                                                                    | 49                                |
| 0,55                                                                                                                                                                                                                                    | 65                                |
| NOTE If it is likely that the ambient storage temperature will be below 0 °C, then special measures (e.g. insulation, addition of a permanent gas) might have to be taken in order to comply with the discharge times given in Table 6. |                                   |

#### 6.2.4.4 Low-pressure containers

**6.2.4.4.1** The design shall ensure that the temperature of the carbon dioxide in the container shall be maintained at  $-18^{+2}_0$  °C and at a pressure of approximately 2 MPa (20 bar). Means shall be provided continuously to indicate the quantity of carbon dioxide.

**6.2.4.4.2** The container shall be fitted with a pressure gauge and a safety valve.

**6.2.4.4.3** An automatic refrigerating system shall ensure that the temperature and pressure of carbon dioxide are kept within the required limits.

**6.2.4.4.4** On low-pressure containers, an over-pressure alarm shall be provided which will sound prior to the operation of the safety valves.

**6.2.4.4.5** The container shall have sufficient insulation to limit the loss of carbon dioxide to not more than 1,5 % (at 3 t to 6 t charge), not more than 0,8 % (over 6 t to 10 t charge) and not more than 0,5 % (over 10 t charge) in 24 h in the event of a failure of the refrigerating system at the highest expected ambient temperature.

**6.2.4.4.6** Any loss of more than 10 % of the carbon dioxide in any container shall be automatically indicated.

**6.2.4.4.7** Each low-pressure container shall be equipped with a liquid level gauge or a weighing device and a high-/low-pressure supervisory alarm set to alarm at not more than 0,1MPa (1 bar) below the vessel's design maximum allowable working pressure and not less than 1,724 MPa (17,24bar).

**6.2.4.4.8** Insulation materials shall be fitted with metal sheeting to avoid mechanical damage.

**6.2.4.4.9** Care should be taken that the temperature of the carbon dioxide during the filling of the containers corresponds to the value necessary for proper functioning of the system.

#### 6.2.4.5 Operating temperatures

Unless otherwise approved, in-service container operating temperatures shall not exceed 50 °C; nor shall they be less than -20 °C. (See also 7.2.1.)

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 be non-combustible and shall be able to withstand the expected pressures and temperatures without damage. The need for pipework and fittings to comply with national regulations or standards shall be considered.

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

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

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

- a) indication of carbon dioxide trapped in piping;
- b) means for safe manual venting (see 6.3.1.5);
- c) automatic relief of over pressures, where required.

**6.3.1.4** Over-pressure relief devices shall be designed to operate at a pressure not greater than the maximum working pressure of the pipework.

**6.3.1.5** Pressure relief devices, which can include the selector valve, shall be fitted so that the discharge, in the event of operation, will not injure or endanger personnel.

**6.3.1.6** 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.

**6.3.1.7** The manifolds to the container and valve assembly shall be hydrostatically tested by the manufacturer to a minimum pressure of 1,5 times maximum working pressure for 2 min, or according to national regulations or standards, where mandatory. The manifolds shall withstand the hydrostatic pressure without leakage or rupture.

**6.3.1.8** 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 need for the thickness of the pipe wall to be calculated in accordance with national regulations or standards shall be considered. If higher operating temperatures are approved for a given system, the design pressure shall be adjusted to the developed pressure at maximum temperature. In performing this calculation, all joint factors and threading, grooving or welding allowances shall be taken into account. If selector valves are used, this lower maximum working pressure shall not be used upstream of the selector valves.

**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 carbon dioxide pressure and maximum and minimum temperatures.

**6.3.2.4** Piping for low-pressure systems shall be designed for test pressures of 4 MPa (40 bar).

**6.3.2.5** Closed sections of high-pressure systems piping shall be designed for test pressures of 21,0 MPa (210 bar). All other sections of pipework for high-pressure systems shall be designed for a test pressure of 9,0 MPa (90 bar).

### 6.3.3 Fittings

**6.3.3.1** Fittings shall have a minimum rated working pressure greater than or equal to the piping design pressure.

**6.3.3.2** Cast iron fittings shall not be used.

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

**6.3.3.4** The need for welding to be performed in accordance with national regulations or standards shall be considered.

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

### 6.3.4 Pipe and valve supports

Pipe and valve supports shall be of non-combustible material, shall be suitable for the expected temperature and shall be able to withstand the dynamic and static forces involved. Due allowance shall be made for the stresses induced in the pipework 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 3.

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 the following:

- a)  $\leq 25$  mm pipe  $\leq 100$  mm;
- b)  $> 25$  mm pipe  $\leq 250$  mm.

Movement of pipework caused by temperature fluctuations arising from the environment or the discharge of carbon dioxide could be considerable, particularly over long lengths, and should be considered in the support fixing methods.

**Table 3 — Maximum pipework spans**

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

### 6.3.5 Valves

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

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

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

**6.3.5.4** Valves shall be of approved materials and shall be suitable for service at the anticipated carbon dioxide pressure and maximum and minimum temperatures according to ISO 16003.

### 6.3.6 Nozzles

#### 6.3.6.1 Nozzle choice and location

**6.3.6.1.1** 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, or as otherwise approved,
- 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, and
- c) the velocity of discharge does not adversely affect the enclosure or its contents.

**6.3.6.1.2** 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 that they will not injure personnel.

**6.3.6.1.3** Nozzles shall be suitable for the intended use and shall be approved for discharge characteristics, including area coverage and height limitations.

For rooms of a height from 5 m to 10 m, additional nozzles should be provided at a level of approximately one-third of the room height.

For rooms exceeding 10 m height, additional nozzles should be installed at a level of one-third and two-thirds of the room height.

**6.3.6.1.4** 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.

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

**6.3.6.1.6** The cross-sections of the openings of the nozzles shall be calculated in accordance with Annex B, or any other approved method, with a minimum pressure at the entrance to the nozzles of 1,4 MPa (14 bar) for high-pressure systems and 1 MPa (10 bar) for low-pressure systems.

**6.3.6.1.7** Local application system nozzles shall be designed and installed so as to direct carbon dioxide on to the object to be protected without dispersing burning material and shall be connected and supported so that they cannot readily be put out of adjustment.

### 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.

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.

## 6.4 Enclosures (total flooding)

### 6.4.1 Structural strength

Automatic pressure relief shall be provided at the highest point of any room which is tightly closed and which would otherwise be subjected to a dangerous increase of pressure when carbon dioxide is introduced.

The protected enclosure shall have sufficient structural strength and integrity to contain the carbon dioxide discharge. Venting shall be provided to prevent excessive over-pressurization of the enclosure. For very tight enclosures, the necessary area of free venting shall be calculated from Equation (1):

$$X = \frac{239Q}{\sqrt{P}} \quad (1)$$

where

$X$  is the free venting area, in square millimetres;

$Q$  is the calculated carbon dioxide flow rate, in kilograms per minute;

$P$  is the allowable strength of enclosure, in kilopascals.

Pressure relief devices shall be open only in the case of overpressure in the enclosure. They shall close automatically when the excess pressure has decreased.

### 6.4.2 Loss through openings

**6.4.2.1** To prevent loss of carbon dioxide through openings to adjacent hazards or work areas, openings shall be permanently sealed or equipped with automatic closures.

**6.4.2.2** Openings are not permitted when a hold time is required, unless additional carbon dioxide is applied to maintain the required concentration during the specified hold time period.

**6.4.2.3** If the quantity of carbon dioxide required for compensation exceeds the basic quantities required for flooding without leakage, the system shall be permitted to be designed for local application.

**6.4.2.4** For deep-seated fires, such as those involved with solids, unclosable openings shall be restricted to those bordering, or actually in, the ceiling.

**6.4.2.5** To prevent fire from spreading through openings to adjacent hazards or work areas that can be possible re-ignition sources, such openings shall be provided with automatic closures or local application nozzles. The quantity of carbon dioxide required for such protection shall be in addition to the normal requirement for total flooding.