

Fire extinguishing installations and equipment on premises —

Part 4: Specification for carbon dioxide systems

UDC 614.842.6:614.844.4

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This British Standard, having been prepared under the direction of the Fire Standards Committee, was published under the authority of the Board of BSI and comes into effect on 31 March 1986

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First published October 1979
First revision

The following BSI references relate to the work on this standard:
Committee reference FSM/13
Draft for comment 84/39397

ISBN 0 580 14709 6

Amendments issued since publication

Amd. No.	Date of issue	Comments

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Foreword

This Part of BS 5306, having been prepared under the direction of the Fire Standards Committee, supersedes BS 5306-4:1979, which is withdrawn.

Carbon dioxide systems, with which this Part of BS 5306 is concerned, are designed to provide a piped supply of carbon dioxide for the extinction of fire.

Several different methods of piping supplies of carbon dioxide and applying the gas at the required points 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 standard has been prepared to meet this need. The previous edition of this standard was written in the form of a code of practice. In order to make it more suitable for reference in designs and specifications for actual projects this revision is written as a specification (see note). Its requirements and recommendations are made in the light of the best technical data known to the committee 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 standard that the execution of its provisions is entrusted to appropriately qualified and experienced people.

NOTE This Part has been written in the form of a specification (see clause 6 of PD 6501-1:1982). To comply with this specification, the user has to comply with all its requirements. He may depart from recommendations, but this would be on his own responsibility and he would be expected to have good reasons for doing so.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 42, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

Section 1. General

0 Introduction

It is important that the fire protection of a building or plant should be considered as a whole.

Carbon dioxide (CO₂) 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.

Carbon dioxide has for many years been a recognized effective medium for the extinction of flammable liquid fires and fires in the presence of electrical risks, but it should not be forgotten, in the planning of the comprehensive schemes, that there may be hazards for which this medium is not suitable, or that in certain circumstances or situations there may be dangers in its use, requiring special precautions.

Advice on these matters can be obtained from the appropriate fire authority, the Health and Safety Executive or other enforcing authority under the Health and Safety at Work etc. Act 1974, and the insurers. In addition, reference should be made as necessary to other Parts of BS 5306.

It is essential that fire extinguishing equipment should be carefully maintained to ensure instant readiness when required. This routine is liable to be overlooked or given insufficient attention by supervisors. 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.

1 Scope

This Part of BS 5306 specifies requirements and gives recommendations for the provision of carbon dioxide fire extinguishing systems in buildings or industrial plant.

Such a system consists of an installation designed to convey carbon dioxide from a central source on the premises as and when required for the extinction of fire or the protection of particular plant or parts of the premises against possible fire risk.

Thus this Part does not deal with carbon dioxide portable fire extinguishers or with wheeled appliances for conveying carbon dioxide in containers.

NOTE 1 Carbon dioxide portable fire extinguishers (together with portable fire extinguishers of other types) are covered in BS 5423 and BS 5306-3.

This standard gives requirements and characteristic data for carbon dioxide, the types of fires for which it is a recommended extinguishing medium, and requirements and recommendations for three established types of piped system embodying different concepts, and employing different methods, for the application of carbon dioxide, namely:

- a) the total flooding system;
- b) the local application system; and
- c) the manual hose reel system.

Two methods of operation, namely manual and automatic, are also specified.

Requirements and recommendations are given on the selection of a system and on operational methods, and on the design, maintenance and efficient operation of installations. These are amplified in Appendix A, Appendix B, and Appendix C. Reference is also made to the part that carbon dioxide systems should play in general schemes of fire protection of premises, having regard to safety as well as efficiency.

NOTE 2 Unless otherwise stated in the text all pressures are in bar gauge.

$$1 \text{ bar} = 10^5 \text{ N/m}^2 = 100 \text{ kPa.}$$

NOTE 3 The titles of the publications referred to in this standard are listed on the inside back cover.

2 Definitions

For the purposes of this Part of BS 5306, the definitions given in BS 4422-4 apply, together with the following.

2.1

authority

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

2.2

automatic

pertaining to a fire extinguishing system, that under specified conditions, functions without intervention by a human operator

2.3

automatic/manual or manual only changeover device

a device that can be operated before a person enters a space protected by a fire extinguishing system preventing the fire detection system from activating the automatic release of carbon dioxide

2.4

closed section of pipe

that section between two valves which may be intentionally or unintentionally closed, or between valves and carbon dioxide storage containers including filling and gas balance lines

2.5**competent person**

a person capable of carrying out the inspection and maintenance procedures of clause 8, by reason of experience and access to the requisite information tools and equipment

2.6**deep-seated fire**

a fire involving solids subject to smouldering

2.7**filling density**

the mass of carbon dioxide charge in a container per unit net container volume

2.8**high pressure storage**

storage of carbon dioxide at ambient temperature

NOTE A change in ambient temperature from 10 °C to 21 °C will raise the pressure from 44 bar to 59 bar.

2.9**local application system**

an automatic or manual fire extinguishing system in which a fixed supply of carbon dioxide is permanently connected to fixed piping with nozzles arranged to discharge the carbon dioxide directly to a fire occurring in a defined area that has no enclosure surrounding it, or is only partially enclosed and that does not produce an extinguishing concentration throughout the entire volume containing the protected hazard

2.10**low pressure storage**

storage of carbon dioxide in pressure containers at a controlled low temperature of – 18 °C

NOTE The pressure in this type of storage is approximately 21 bar.

2.11**manual**

pertaining to a fire extinguishing system, that under specified conditions, functions by means of intervention of a human operator

2.12**manual hose reel system**

a manual fire extinguishing system consisting of a hose, stowed on a reel or a rack, with a manually operated discharge nozzle assembly, all connected by a fixed pipe to a supply of carbon dioxide

2.13**material conversion factor (MCF)**

a numerical factor that should be used when the minimum design concentration of carbon dioxide for the material at risk exceeds 34 %, to increase the basic quantity of carbon dioxide [as obtained by application of the volume factor (see 2.18)] required for protection against surface fires

2.14**open-ended pipework**

pipework between a valve (including a relief valve) and open nozzles which cannot be under a continuous pressure

2.15**surface fire**

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

2.16**total flooding system**

an automatic or manual fire extinguishing system in which a fixed supply of carbon dioxide is permanently connected to fixed piping with nozzles arranged to discharge the carbon dioxide into an enclosed space in order to produce a concentration sufficient to extinguish fire throughout the entire volume of the enclosed space

2.17**user**

the person(s) responsible for or having effective control over the fire safety provisions adopted in or appropriate to the premises or the building

2.18**volume factor**

a numerical factor that, when applied to the volume of an enclosure, indicates the basic quantity of carbon dioxide (subject to a minimum appropriate to the volume of the enclosure) required for protection against surface fires

3 Characteristics and uses of carbon dioxide

3.1 General

Carbon dioxide for use in fire extinguishing systems shall comply with BS 6535-1.

COMMENTARY AND RECOMMENDATIONS ON 3.1.

Carbon dioxide at atmospheric pressure is a colourless, odourless and electrically non-conducting inert gas which is almost 1.5 times as dense as air. It is stored as a liquid under pressure, and 1 kg of liquid carbon dioxide expanded to atmospheric pressure will produce about 0.56 m³ of free gas at a temperature of 30 °C.

Carbon dioxide extinguishes fire by reducing the oxygen content of the atmosphere to a point where it will not support combustion. Reducing the oxygen content from the normal 21 % in air to 15 % will extinguish most surface fires, though for some materials a greater reduction is necessary. In some applications the cooling effect of carbon dioxide may assist extinction.

Carbon dioxide may be used to fight fires of classes A and B as defined in BS 4547. Class C fires may also be extinguished by carbon dioxide but in these cases the risk of explosion after extinction should be carefully considered.

Carbon dioxide may be ineffective on fires involving materials such as metal hydrides, reactive metals such as sodium, potassium, magnesium, titanium and zirconium, and chemicals containing oxygen available for combustion, such as cellulose nitrate.

Carbon dioxide is suitable for use on fires involving live electrical apparatus.

3.2 Hazard to personnel

The discharge of amounts of carbon dioxide to fight fires may cause a hazard to personnel (see also clause 34) and this characteristic shall be considered in the design of the system.

COMMENTARY AND RECOMMENDATIONS ON 3.2.

In addition to being an asphyxiant, carbon dioxide should be regarded as a toxic gas.

Exposure to atmospheres containing about 5 % carbon dioxide leads to shortness of breath and slight headache, while at the 10 % level headache, visual disturbance, ringing in the ears (tinnitus) and tremor are followed by loss of consciousness.

Fire extinguishing concentrations of carbon dioxide, which are normally in excess of 30 %, especially near to the point of discharge from total flooding or local application systems, carry a risk of almost immediate asphyxiation.

The gas is also more dense than air and will drift and accumulate in low spaces, such as cellars, pits and floor voids, which may be difficult to ventilate effectively.

The rapid expansion of large quantities of carbon dioxide results in a substantial localized cooling of the installation and of the air surrounding the point of discharge. This can present a frostburn hazard.

However, historical evidence of the operating experience from over 100 000 CO₂ systems installed in the past 50 years shows that, with the safeguards recommended in clause 34, CO₂ can be used with safety to personnel.

Consideration should also be given to the probable worse effects from a free burning fire if no extinguishing system is installed. Attention is also drawn to the danger of selecting an extinguishing system that is less suitable for the type of fire to be expected, simply because it is less hazardous to life.

4 Types of system

Systems shall comply with the requirements of one of the following types:

- a) total flooding system;
- b) local application system;
- c) manual hose reel system.

COMMENTARY AND RECOMMENDATIONS ON CLAUSE 4.

In the selection of a carbon dioxide extinguishing system account should be taken of:

- a) the field of usefulness of the three systems;
- b) operating requirements dictating either manual or automatic operation;
- c) the nature of the hazard;
- d) the location and degree of enclosure of the hazard;
- e) the degree of hazard to personnel arising from the CO₂ discharge;
- f) other factors discussed in sections 4, 5 and 6.

5 Planning

Where a fixed carbon dioxide extinguishing system is being considered for new or existing buildings the following shall be consulted:

- a) the fire authority;
- b) the insurers;
- c) the appropriate public authorities.

COMMENTARY AND RECOMMENDATIONS ON CLAUSE 5.

The authorities mentioned above should be informed as early as possible of the type of carbon dioxide system to be installed and the system design engineers should be fully informed of the protection required in any area, whether total flooding, local application or hose reel. There may be statutory or local bye-laws requirements and other requirements of these authorities which should be coordinated in the planning stages of the contract.

Section 2. Contract arrangements

6 System layout drawings

Prior to installation, system layout drawings shall be prepared. These shall be to scale or be fully dimensioned with sufficient detail to define clearly both the hazard and the proposed system. Details of the hazards shall be included to show the materials involved, the location and/or limits of the hazard and any other materials that are likely to become exposed to the hazard in the event of a fire. The means of egress from the area to be protected (if it is an automatic total flooding system), if personnel are likely to be present in the area, shall be indicated, together with the number of such persons.

The location and sizes of piping and nozzles shall be clearly indicated together with the location of the carbon dioxide supply, fire detection devices, manual controls and all auxiliary equipment. Features such as dampers, conveyors and doors related to the operation of the system shall also be shown, together with details of all calculations used in assessing the quantity of carbon dioxide. Further information shall be given separately indicating the equivalent lengths of pipe and fittings, flow rates and pressure drops throughout the system.

7 Tests and acceptance

7.1 The installer of the equipment or his supervising supplier shall arrange tests of the completed installation to the satisfaction of the relevant authority, to show that it complies with this standard.

The tests shall include the following except that the discharge [see d)] shall not be carried out in the special cases cited in **34.10**.

- a) A check that all components of the system have been installed in the correct manner.
- b) A check that all nuts, bolts and fittings have been correctly tightened.
- c) A check that all electrical connections are safe and in working order.
- d) Carbon dioxide gas tests to check the tightness of closed sections of pipework. Separate gas discharges shall be made into each space to ensure that the piping is continuous and that the nozzles have not become blocked.

NOTE A minimum of 10 % of the required quantity of gas should be discharged through the system pipework into each space.

7.2 The installer of the equipment or his supervising supplier shall provide a comprehensive check list to enable the authority to witness that the tests are being carried out in a satisfactory manner.

The minimum content of the list shall include the following.

- a) Check that the system has been installed according to the relevant drawings and documents.
- b) Check as follows that all detection equipment functions correctly.
 - 1) In fusible link systems, ensure that control cable lines are free and that operating control weights develop sufficient energy to operate container and/or direction valve control mechanisms.
 - 2) In pneumatic rate of rise systems, check with manometer to ensure correct breathing rate and leak-free capillary lines. Also apply heat to detectors to ensure correct operation and subsequent activation of control mechanisms.
 - 3) In electrical detector systems, check electrical circuitry and supply voltages for integrity. Apply heat, flame and smoke to detectors to check operation of control mechanisms.
- c) Operate manual release devices to ensure correct functioning.
- d) Check operation of all alarm devices.
- e) Check correct operation of all safety devices.
- f) Carry out a test CO₂ gas discharge using an adequate percentage of the total CO₂ capacity to check:
 - 1) that the direction valves, when shut, hold back gas;
 - 2) that feed pipes lead to the correct protected space;
 - 3) that no leaks occur where equipment is fitted to pipework and at pipe fittings;

NOTE A partial discharge is appropriate for most installations, but for others a total discharge with measurement of carbon dioxide concentrations achieved may be desirable.

 - 4) that pressure-operated devices function correctly and the items they control, such as shutters and alarms, function correctly;
 - 5) that, where possible, discharge nozzles pass gas and that none are blocked.
- g) Ensure test containers are replaced and that all containers are filled with the correct quantity of carbon dioxide.
- h) Check that nameplates and instruction plates are correctly worded.

7.3 When the installation has been completed and tested, the purchaser shall be provided with a completion certificate (together with one copy for the authority) and a complete set of instructions and "as installed" drawings.

Section 3. Maintenance

8 General

Every installation shall be inspected at least twice a year by a competent person (see 2.5).

All gas containers shall be periodically maintained, inspected and tested in accordance with BS 5430-1.

All containers shall be weighed or checked with a liquid level indicator.

Any container that shows a loss in net content of more than 10 % shall be refilled or replaced.

Tests shall be made of the principal components, including pressure-operated devices, to ensure that they function correctly. All lamps and electrical connections shall be checked for safety and correct function. All signs shall be checked and replaced if necessary. With low pressure installations the refrigeration unit shall be checked to ensure that the refrigerant charge is intact and that there are no leaks. The object of the inspection shall be to ensure that the system is fully operational and that it will remain so until the next inspection. The use, impairment and restoration of this protection shall be reported promptly to the authority having jurisdiction. Any troubles or impairments shall be corrected at once by competent personnel.

A report of this inspection shall be sent to the user of the system within 30 days of the inspection.

COMMENTARY AND RECOMMENDATIONS ON CLAUSE 8.

It is essential that the system be kept in good working order at all times with this responsibility being in no way diminished by any periodic or regular servicing carried out.

It is recommended that a weekly programme of inspection, or more frequent if necessary, is carried out to ensure that components are free from dust and dirt that might impair the efficiency of the system. This also should include an inspection of the pipework and nozzles to ensure that they are not obstructed, and remain in the designed position, and to ensure that all operating controls are properly set and that components have not been damaged. One way of achieving the minimum six-monthly full inspection may be by means of an inspection and service contract with the installer, his agent or an accredited servicing organization.

9 Extensions or alterations

Any extension or alteration to an existing system complying with this standard shall also comply with the requirements of this standard.

COMMENTARY AND RECOMMENDATIONS ON CLAUSE 9.

Any extension or alteration to the carbon dioxide installation should be carried out by the installer or his agent, and the relevant authority (see clause 5) should be notified promptly. Storage containers should be sited where they will be readily accessible for inspection, testing, recharging or maintenance with the minimum of interruption of protection.

Section 4. Total flooding systems

10 Uses

Total flooding systems shall comply with section 1, except as varied in this section.

COMMENTARY AND RECOMMENDATIONS ON CLAUSE 10. *Fires that can be extinguished or controlled by total flooding methods are:*

- a) *surface fires involving flammable liquids, gases and solids;*
- b) *deep-seated fires involving solids subject to smouldering.*

11 General design

11.1 The quantity of carbon dioxide, which will vary according to the hazard and permitted openings, shall be sufficient to reduce the oxygen content of the atmosphere within the enclosure to a point where combustion can no longer be sustained. The rate of application and the time necessary to maintain the extinguishing concentration shall be determined according to the hazard, and as specified in clauses 13, 14 and 15.

COMMENTARY AND RECOMMENDATIONS ON 11.1. *The distribution of the carbon dioxide should be so arranged that it is evenly and thoroughly mixed with the existing atmosphere. Special venting may be required to avoid excessive pressure build-up resulting from the volume of carbon dioxide discharged into the hazard area (see 12.3).*

11.2 The system shall be designed for either:

- a) automatic and manual operation;
- b) manual operation only.

NOTE This may be dependent upon the requirements of the authority having jurisdiction.

12 Enclosure

12.1 General

The protected volume shall be enclosed by elements of construction having a fire resistance of not less than 30 min when tested in accordance with BS 476-8, and classified as non-combustible when tested in accordance with BS 476-4. Where openings can be closed, these shall be arranged to close before or at the start of gas discharge. Where carbon dioxide can flow freely between two or more interconnected volumes, the quantity of carbon dioxide shall be the sum of quantities calculated for each volume using the respective volume and material conversion factors. If one volume requires higher than normal concentration, the higher concentration shall be used in all interconnected volumes. The volume of the enclosure shall be the gross volume. The only permitted reductions shall be permanent, impermeable building elements within the enclosure.

COMMENTARY AND RECOMMENDATIONS ON 12.1. *A well enclosed space is required to maintain the extinguishing concentration of carbon dioxide.*

12.2 Maximum area of unclosable openings

12.2.1 *Surface fire hazard.* Where surface fires are involved, the area of unclosable openings shall not exceed:

- a) an area which, expressed in square metres, is numerically equivalent to 10 % of the volume in cubic metres; or
- b) 10 % of the total area of all sides, top and bottom in square metres,

whichever calculation gives the smaller result.

Unclosable openings shall be compensated for by additional gas at the rate of 5 kg/m² of opening (multiplied if necessary by the material conversion factor; see Table 2). Where openings exceed these limitations, the system shall be designed to comply with the requirements of a local application system (see section 5).

12.2.2 *Deep-seated fire hazard.* Where deep-seated fires are involved, there shall be no unclosable openings (see clause 14).

12.3 Area of opening required for venting

The venting of flammable vapours and release of pressure caused by the discharge of quantities of carbon dioxide into closed spaces shall be considered, and provision shall be made for venting where necessary.

COMMENTARY AND RECOMMENDATIONS ON 12.3. *The pressure venting consideration involves such variables as enclosure strength and injection rate.*

Leakage around doors, windows, ducts and dampers, though not apparent or easily determined, may provide sufficient venting relief for normal carbon dioxide systems without special provisions being made.

For otherwise airtight enclosures, the area necessary for free venting, X, (in mm²) may be calculated from the following equation:

$$X = 23.9 \frac{Q}{\sqrt{P}}$$

where

- Q is the calculated carbon dioxide flow rate (in kg/min);*
- P is the permissible strength (internal pressure) of enclosure (in bar).*

In many instances, particularly when hazardous materials are involved, relief openings are already provided for explosion venting. These and other available openings often provide adequate venting.

13 Carbon dioxide for surface fires

13.1 Volume factor

The volume factor used to determine the basic quantity of carbon dioxide to protect an enclosure containing a material requiring a design concentration up to 34 % shall be in accordance with Table 1. For materials requiring a design concentration over 34 %, the basic quantity of carbon dioxide calculated from the volume factor given in Table 1 shall be increased by multiplying this quantity by the appropriate conversion factor given in Table 2.

Where forced air ventilating systems are involved, they shall, if possible, be shut down and/or closed automatically before, or simultaneously with, the start of the carbon dioxide discharge. Where ventilation systems cannot be shut down and/or closed, the design shall allow for additional carbon dioxide to be supplied to achieve and maintain the design concentration. Services within the enclosure that are likely to contribute to the fire hazard, e.g. heating, fuel supply and paint spraying, shall be arranged to be shut down automatically prior to, or simultaneously with, the discharge of carbon dioxide.

For materials not given in Table 2, the minimum carbon dioxide design concentration shall be obtained from some recognized source or determined from the test method described in Appendix A.

NOTE Examples illustrating the application of carbon dioxide requirements for surface fires are given in Appendix B.

Table 1 — Volume factors

Volume of space	Volume factor (mass of CO ₂ per unit volume of enclosed space)	Calculated minimum quantity of CO ₂
m ³	kg/m ³	kg
≤ 4	1.15	—
> 4 ≤ 14	1.07	4.5
> 14 ≤ 45	1.01	16.0
> 45 ≤ 126	0.90	45.0
> 126 ≤ 1 400	0.80	110.0
> 1 400	0.74	1 100.0

Table 2 — Minimum carbon dioxide concentration for extinction

Material	Minimum design CO ₂ concentration	Material conversion factor
	%	
Acetylene	66	2.5
Acetone	31	1.0
Benzol, benzene	37	1.1
Butane	34	1.0
Buta-1,3-diene	41	1.3
Carbon disulphide	72	3.0
Carbon monoxide	64	2.4
Coal gas or natural gas	37	1.1
Cyclopropane	37	1.1
Diethyl ether	46	1.5
Dowtherm	46	1.5
Ethane	40	1.2
Ethanol	43	1.3
Ethylene	49	1.6
Ethylene dichloride	25	1.0
Ethylene oxide	53	1.75
Hexane	35	1.1
Hydrogen	75	3.3
Isobutane	36	1.1
Kerosene	34	1.0
Methane	30	1.0
Methanol	40	1.2
Pentane	35	1.1
Petroleum spirit	34	1.0
Propane	36	1.1
Propene	36	1.1
Quenching, lubricating oils	34	1.0

13.2 Compensation for abnormal temperatures

Where there are abnormal temperatures, additional quantities of gas shall be provided as follows.

- Where the normal temperature of the enclosure is above 100 °C, 2 % carbon dioxide shall be added for each additional 5 °C over 100 °C.
- Where the normal temperature of the enclosure is below – 20 °C, 2 % carbon dioxide shall be added for each 1 °C below – 20 °C.

14 Carbon dioxide for deep-seated fires

14.1 The quantity of carbon dioxide for deep-seated fires shall be obtained from Table 3 and is based on reasonably airtight enclosures, i.e. well fitting self-closing closures and doors that are not normally locked open. The system and enclosure shall be designed so that the design concentration is held for a period of not less than 20 min. Table 1 is not applicable to deep-seated fires and shall not be used.

COMMENTARY AND RECOMMENDATIONS ON CLAUSE 14.

In some instances, a much longer holding period may be necessary to ensure that all smouldering is extinguished and material is sufficiently cooled to prevent re-ignition. Any possible leakage should be given special consideration since no allowance is included in the basic factors listed in Table 3.

Ventilation fans should be switched off and dampers closed in conjunction with the discharge of carbon dioxide.

The flooding factors specified in Table 3 result from practical tests for specific hazards under average use and storage conditions.

15 Rates of application

15.1 General

For surface fires, the design concentration shall be achieved within 1 min.

For deep-seated fires, the design concentration shall be achieved within 7 min but the rate shall be not less than that required to develop a concentration of 30 % in 2 min.

COMMENTARY AND RECOMMENDATIONS ON 15.1. *The times specified above are considered adequate for the usual surface or deep-seated fire. Where the materials involved are likely to give a higher spread of fire, rates higher than the minimum should be used. Where a hazard contains materials that will produce both surface and deep-seated fires, the rate of application should be at least the minimum required for surface fires.*

Table 3 — Hazard factors

Hazard		Design concentration	Flooding factor
Electrical equipment	Enclosed rotating equipment	50	1.35
	Dry Electrical wiring		
	Electrical insulating materials		
Electronic data processing installation ^a	Central processing area and equipment	53	1.50
	Data processing	68	2.25
	Tape controlled machinery and tape storage		
Stores	Service voids	65	2.00
	Record stores and archives for paper documents		
	Fur storage vaults		
	Dust collectors	75	2.70
NOTE 1 The table is based on an expansion ratio of 0.52 m ³ /kg at a temperature of 10 °C.			
NOTE 2 Flooding factors for other deep-seated fires should be agreed with the appropriate authority before adoption.			
^a See also BS 6266.			

15.2 Extended discharge

The minimum design concentration shall be achieved within the time limit specified in **15.1**. The extended rate of discharge shall be sufficient to maintain the design concentration.

COMMENTARY AND RECOMMENDATIONS ON **15.2**.

Where leakage is appreciable and the design concentration has to be obtained quickly and maintained for an extended period of time, carbon dioxide provided for leakage compensation may be applied at a reduced rate. This method is particularly suited to enclosed rotating electrical apparatus, such as generators and alternators, but it may also be used on normal room flooding systems where suitable.

15.3 Rotating electrical machinery

For enclosed rotating electrical machinery, a minimum concentration of 30 % shall be maintained for the deceleration period of the machine. This minimum concentration shall be held for the deceleration period or 20 min whichever is the longer.

COMMENTARY AND RECOMMENDATIONS ON **15.3**.

Table 4 may be used as a guide to estimate the quantity of gas needed for the extended discharge to maintain the minimum concentration. The quantities are based on the internal volume of the machine and the deceleration time assuming average leakage. For damped, non-recirculating type machines, 35 % should be added to the quantities given in Table 4.

16 Distribution systems

16.1 Design

Piping for total flooding systems shall be designed in accordance with clauses **40** and **41** to deliver the required rate of application at each nozzle.

COMMENTARY AND RECOMMENDATIONS ON **16.1**. *High pressure storage temperatures may range from – 18 °C to 55 °C without requiring special methods of compensating for changing flow rates. Storage temperatures outside those limits require special design considerations to ensure proper flow rates.*

Appendix C gives a method and examples of pipe size determination.

16.2 Nozzle selection and distribution

Rooms with ceiling heights above 7.5 m shall have discharge nozzles at two or more levels, depending upon the height.

COMMENTARY AND RECOMMENDATIONS ON **16.2**.

Nozzles used in total flooding systems should be of the type most suitable for the intended purpose, and they should be properly located to achieve the best results. The lower ring of nozzles should be located approximately one-third of the height from the floor but no higher than 2.5 m.

The nozzles should be arranged in the protected space in a manner that will ensure adequate, prompt and equal distribution of the carbon dioxide. Special consideration should be given to areas within the space that are of particular danger.

The type of nozzle selected and the disposition of the individual nozzles should be such that the discharge will not splash flammable liquids, dislodge ceiling tiles or create dust clouds that might extend the fire, create an explosion or otherwise adversely affect the contents of the enclosure. Nozzles vary in design and discharge characteristics and should be selected on the basis of their adequacy for the use intended.