

Fire extinguishing installations and equipment on premises —

Part 5: Halon systems —

Section 5.1 Specification for halon 1301 total flooding systems

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Fire Standards Policy Committee (FSM/-) to Technical Committee FSM/18, upon which the following bodies were represented:

- British Automatic Sprinkler Association
- British Fire Protection Systems Association Ltd.
- British Fire Services' Association
- British Nuclear Fuels plc
- Chartered Institution of Building Services Engineers
- Chemical Industries' Association
- Chief and Assistant Chief Fire Officers' Association
- Convention of Scottish Local Authorities
- Department of Health
- Department of the Environment (Building Research Establishment)
- Department of the Environment — Central (DCSS Fire Branch)
- Department of Transport — Marine Directorate
- Electricity Association
- Fire Brigades Union
- Fire Extinguishing Trades' Association
- Health and Safety Executive
- Hevac Association
- Home Office
- Incorporated Association of Architects and Surveyors
- Institute of Petroleum
- Institution of Fire Engineers
- Lloyd's Syndicates Survey Department
- London Fire and Civil Defence Authority
- Loss Prevention Council
- Ministry of Defence
- National Association of Fire Officers
- Royal Institute of British Architects
- Society of Fire Protection Engineers
- Society of Motor Manufacturers and Traders Limited
- United Kingdom Atomic Energy Authority
- Warrington Fire Research Centre

The following bodies were also represented in the drafting of the standard, through subcommittees and panels:

- Engineering Equipment and Materials Users' Association

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Foreword

This Part of BS 5306 has been prepared under the direction of the Fire Standards Policy Committee and supersedes BS 5306-5.1:1982 which is withdrawn.

BS 5306 comprises the following Parts and Sections:

- *Part 0: Guide for the selection of installed systems and other fire equipment;*
- *Part 1: Hydrant systems, hose reels and foam inlets;*
- *Part 2: Specification for sprinkler systems;*
- *Part 3: Code of practice for selection, installation and maintenance of portable fire extinguishers;*
- *Part 4: Specification for carbon dioxide systems;*
- *Part 5: Halon systems;*
- *Section 5.2: Halon 1211 total flooding systems;*
- *Part 6: Foam systems;*
- *Section 6.1: Specification for low expansion foam systems;*
- *Section 6.2: Specification for medium and high expansion foam systems;*
- *Part 7: Specification for powder systems.*

Halon systems are designed to provide a piped supply of gaseous extinguishing medium for the extinction of fire.

Several different methods of piping supplies of halon to, and applying it 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 Section of BS 5306 has been prepared to meet this need.

Advice is given on the selection of the system most suited to a particular need, on suitable methods of operation and on the part these systems may play in general schemes of fire protection on premises. Requirements and recommendations are given on the design, maintenance and efficient operation of systems.

In particular, new requirements and recommendations to eliminate the need to release halon 1301 during testing and commissioning procedures have been included. These are linked to the inclusion of the new fan test method given in Appendix A.

The requirements and recommendations of this Section of BS 5306 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 people appropriately qualified and experienced in the specification, design, installation, testing, approval, inspection, operation and maintenance of halon 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 halon 1301.

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

Product certification. Users of this British Standard are advised to consider the desirability of independent certification of product conformity with this British Standard based on testing and continuing surveillance, which may be coupled with assessment of a supplier's quality systems against the appropriate Part of BS 5750.

NOTE This standard has been written in the form of a practice 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.

Compliance with a British Standard does not of itself confer immunity from legal obligations. In particular, attention is drawn to the Pressure Systems and Transportable Gas Containers Regulations 1981 SI 1981 No. 2169.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 68, 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 other construction work should be considered as a whole. Halon 1301 total flooding 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.

Halon 1301 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.

Halon 1301 total flooding systems convey halon 1301 from storage containers for the protection of a particular part or parts of the building or other construction work against fire. The systems may be piped or otherwise connected, and may use containers at a central location, or dispersed at several locations in the protected area.

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

It is essential that the 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 Section of BS 5306 specifies requirements and gives recommendations for the design, installation, testing, maintenance and safety of halon 1301 total flooding fire extinguishing systems in building or plant, and the characteristics of halon 1301 and the types of fire for which it is a suitable extinguishing medium. This standard covers only systems operating at 25 bar or 42 bar (at 20 °C) with nitrogen propellant; design data for other pressures and propellants are not available at this time.

This standard does not cover explosion suppression systems, systems in which halon is discharged to inert a flammable or explosive gas mixture, or small fixed fire extinguishers which are covered by BS 7327-1.

This Section of BS 5306 covers halon 1301 systems for use in buildings and other construction works. The systems are also widely used on ships and in aircraft, and while its requirements may apply in general for such applications, additional requirements may be necessary. Some information on marine applications is given in Appendix E.

NOTE 1 Unless otherwise specified in this standard all pressures are gauge pressures expressed in bars.

1 bar = 10^5 N/m² = 10² kPa

NOTE 2 The titles of the publications referred to in this standard are listed on inside back cover.

2 Definitions

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

2.1

achievable maximum concentration

concentration (as a percentage by volume) which would be produced in the net volume of the protected enclosure, by the uniform distribution of the halon, including any for extended discharge, discharged by the system

2.2

authority

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

2.3

automatic system

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

2.4

design concentration

concentration (as a percentage by volume) which would be produced in the gross volume of the protected enclosure by the uniform distribution of the halon, excluding any for extended discharge, discharged by the system

2.5

extinguishing concentration

minimum concentration (as a percentage by volume) of halon 1301 necessary to extinguish a flame of a particular fuel under defined experimental conditions

2.6

flooding quantity

mass of halon per unit volume of an enclosure

2.7

gross volume of a protected enclosure

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

2.8

hold time

recommended period of time, measured from when the design concentration is achieved in the enclosure, for which halon is to be retained around the hazard to ensure extinction

2.9

inerting concentration

minimum concentration (as a percentage by volume) of halon 1301 necessary to suppress the propagation of flame through a mixture of particular fuel and air, in any proportion, under defined experimental conditions

2.10

manual system

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

2.11

minimum design concentration

minimum halon concentration given in the design specification (see clause 11)

2.12

net volume of a protected enclosure

gross volume (see 2.7) less the volume of any fittings, fixtures, or furniture in the enclosure, including any enclosed volume in, for example, closed cabinets or drawers

2.13

normally unoccupied area

area, not occupied by people during working hours, that may be entered occasionally for brief periods

2.14

sector value

value used to direct halon into a particular section of pipework

2.15**total flooding system**

automatic or manual fire extinguishing system arranged to fill an enclosed space to the design concentration

2.16**user**

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

3 Characteristics and uses of halon 1301**3.1 General**

Halon 1301 used in the system shall comply with BS 6535-2.1.

COMMENTARY AND RECOMMENDATIONS ON 3.1. *Halon 1301 is bromotrifluoromethane (CBrF₃).*

Halon 1301 is a colourless, odourless, electrically non-conductive gas with a density approximately five times that of air.

BS 6535-2.1 gives details of the physical properties and a specification for halon 1301 which are reproduced in Table 1 and Table 2.

Halon 1301 extinguishes fires by inhibiting the chemical reaction of fuel and oxygen. Any extinguishing effect due to cooling, dilution of oxygen or fuel vapour is minimal.

The most widely accepted theory of the extinguishing effect of halon 1301 is that the vapour breaks down and inhibits the combustion reactions. The decomposition takes place on exposure to a flame, or to a hot surface at a temperature above 480 °C.

Table 1 — Physical properties of halon 1301^a

Property	Value
Relative molecular mass	148.93
Boiling point at 1.013 bar (absolute)	– 57.8 °C
Freezing point	– 168 °C
Critical temperature	67.0 °C
Critical pressure	39.6 bar (absolute)
Critical volume	0.00134 m ³ /kg
Critical density	745 kg/m ³
Vapour pressure at 20 °C	14.63 bar (absolute)
Vapour pressure at 60 °C	34.58 bar (absolute)
Liquid density at 20 °C	1 575 kg/m ³
Saturated vapour density at 20 °C	115.6 kg/m ³
Specific volume of superheated vapour at 1.013 bar (absolute) and 20 °C	0.159 m ³ /kg
^a Reproduced from BS 6535-2.1:1990.	

Table 2 — Specification for halon 1301^a

Property	Requirement
Purity	99.6 % (mol/mol) min.
Acidity	3×10^{-4} % (m/m) max. (3 p.p.m. max.)
Water content	1×10^{-3} % (m/m) max. (10 p.p.m. max.)
Non-volatile residue	0.01 % (m/m) max.
Halon ion	Passes test
Suspended matter or sediment	Non visible

^a Reproduced from BS 6535-2.1:1990.

3.2 Use of halon 1301 systems

Halon 1301 total flooding systems shall be used only for extinguishing fires of class A within the limits specified in 11.2, and class B and class C as defined in BS 4547.

COMMENTARY AND RECOMMENDATIONS ON 3.2. *Class B and class C fires are promptly extinguished by halon 1301 in the appropriate concentration.*

In the case of class C fires, the risk of explosion after extinction should be carefully considered (see 11.1). Where appropriate and possible the flammable gas flow should be isolated before, or as soon as possible after, extinction.

Provided a class A fire is detected quickly and the halon is discharged promptly, and provided that the concentration is maintained for an adequate period of time to allow embers to cool, surface fires and embers associated with the burning of solid materials are also quickly extinguished with halon 1301. (See also 11.2).

Halon 1301 is suitable for use on fires involving live electrical apparatus and is widely used to protect electronic data processing installations (see BS 6266 and BS 5306-0).

Halon 1301 is not effective in extinguishing fires involving:

- a) chemicals containing their own supply of oxygen, such as cellulose nitrate; or
- b) mixtures containing oxidizing agents, such as sodium chlorate or sodium nitrate; or
- c) chemicals capable of undergoing autothermal decomposition, such as some organic peroxides.

Halon 1301 should not be used to fight fires involving:

- 1) reactive metals (such as sodium, potassium, magnesium, titanium and zirconium), reactive hydrides, or metal amides, all of which can react violently with any halon; or
- 2) solid materials in which fires quickly become deep seated (see 11.2) where there may be an extended period of contact with fire conditions.

Under both these types of circumstances halons break down forming acid halides and other compounds which are much more toxic than the halon itself.

3.3 Hazard to personnel

Any hazard to personnel created by the discharge of halon 1301 shall be considered in the design of the system.

COMMENTARY AND RECOMMENDATIONS ON 3.3. *Potential hazards are as follows:*

- a) *Toxicity. Hazard may result from one or more of the following:*
 - 1) *the natural halon 1301 itself;*
 - 2) *the breakdown products (principally bromine and halogen acids) that result from exposure of the medium to the fire or other hot surfaces (which though much more toxic than halon 1301 itself will be present in only small amounts);*
 - 3) *the combustion products of the fire.*

Particularly where rapid detection of the fire and release of halon 1301 are employed, the halon 1301 breakdown products will rarely exceed 1 % of the combustion products produced by the fire before extinction. Vastly greater amounts of toxic products will result from an uncontrolled fire.

In practice, exposure to halon 1301 is generally of less concern than the exposure to the breakdown products which in turn is generally of less concern than exposure to the combustion products. However, unnecessary exposure of personnel to either halon 1301 or to the decomposition products should be avoided.

The effects of halon 1301 complying with BS 6535-2.1 on humans have been studied extensively and found to produce minimal, if any, effects on the central nervous system at the concentrations of 5 % to 7 % by volume normally used for fire protection.

Tests on human volunteer subjects have shown that the maximum safe exposure is 7 % (V/V) to 10 % (V/V) of halon 1301 for 1 min.

At these concentrations the volunteers experienced symptoms of dizziness and slight tingling of the fingers and toes after 1 min exposure. Exposures to concentrations less than these for several minutes would be unlikely to produce any significant effect but prolonged exposure to concentrations greater than these is hazardous and should be avoided.

At higher concentrations or for longer exposures, narcotic effects such as dizziness, impaired coordination and reduced mental activity, can occur, with a risk of irregular heart action, particularly in cases where the adrenalin level is raised (see note).

Once halon has been discharged into an enclosure, its presence is difficult to detect through normal human senses; in concentrations above about 3 %, voice characteristics are changed owing to the increased density of the halon/air mixture.

In the case of human exposure an equilibrium concentration is quickly reached in the body. Exposure to fresh air causes this concentration to reduce quickly to zero and halon 1301 is not retained in the body. Recovery from any dizziness or light-headedness is usually rapid and complete.

NOTE Anyone who suffers as a result of exposure to halon 1301 should immediately be removed to fresh air and medical assistance should be sought. Use of epinephrine (adrenalin) and similar drugs should be avoided as they may produce cardiac arrhythmias, including ventricular fibrillation.

The breakdown products of halon 1301 have a characteristic sharp, acrid odour, even in concentrations of only a few parts per million. This provides a built-in warning system for the medium, but at the same time creates a noxious, irritating atmosphere for those who have to enter the area following the fire.

The amount of halon 1301 decomposed in extinguishing a fire depends to a large extent on the size of the fire, the concentration of halon vapour, the duration of contact with flame or heated surfaces, and the temperature. There is little decomposition below 480 °C. If there is very rapid build-up of concentration to the design value, the fire is extinguished quickly, and the decomposition minimized.

The type and sensitivity of detection, coupled with the rate of discharge, should be selected to minimize the exposure time of the vapour to the elevated temperature to reduce the formation of breakdown products.

b) Noise. Discharge of a system can cause noise loud enough to be startling but ordinarily insufficient to cause traumatic injury.

c) Turbulence. High velocity discharge from nozzles may be sufficient to dislodge substantial objects which are close to the nozzles. System discharge may cause enough general turbulence in the enclosures to move light objects such as paper or unsecured tiles in suspended ceilings.

d) Cooling effect. Direct contact with the liquid halon 1301 discharged from the system has a strong chilling effect on objects and can cause cold burns to the skin. The liquid phase vaporizes rapidly when mixed with air and thus limits this hazard to the immediate vicinity of the discharge point(s).

e) Mist formation. Discharge of the medium may create a light mist resulting from condensation of moisture in the air. The mist rarely persists after discharge is completed and little hazard is created by reduced visibility.

f) Dispersal after discharge. The halon 1301/air mixture produced in the enclosure is more dense than air and can accumulate in low spaces, such as cellars, pits and floor voids, if these are not ventilated effectively after system discharge.

4 Types of system

For the purposes of this Section of BS 5306 halon total flooding systems shall be distinguished by the arrangement of the halon storage containers as follows:

- a) central storage systems with one halon container, or two or more halon containers manifolded together with pipework, to protect one or more adjacent or remote hazards; or
- b) distributed storage systems with halon containers in separate locations within or without the hazard area; or
- c) modular systems in which each halon container is complete with a discharge nozzle.

COMMENTARY AND RECOMMENDATIONS ON CLAUSE 4. *Halon total flooding systems are also divided into engineered systems in which the quantity of halon and each section of pipework are designed by calculation to give the specified discharge rate at each nozzle, and pre-engineered systems in which the system is not larger than a defined maximum size with a defined number of nozzles and has been tested for performance at the maximum pipe lengths.*

5 Planning

Where a halon 1301 extinguishing system is being considered for new or existing buildings, the following shall be consulted:

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

COMMENTARY AND RECOMMENDATIONS ON CLAUSE 5. *The authorities mentioned above should be informed as early as possible of the type of system to be installed and the system design engineers should be fully informed of the protection required in any area. There may be statutory or local bye-law requirements and other requirements of these authorities to be coordinated in the planning stages of the contract.*

Section 2. Contract arrangements

6 Contract drawings and information documents

6.1 General

The information specified in **6.2** and **6.3**, together with details of the authorities consulted (see clause **5**) and any response to the consultation, shall be provided to the user.

COMMENTARY AND RECOMMENDATIONS ON **6.1**. *The authorities listed in clause 5 may wish to be provided with this or other information before the system is installed.*

6.2 Preliminary or estimating stage

The information provided to the user shall include a general specification of the proposed system(s) including particulars of major items of equipment, and a block plan of the premises showing the type and extent of the system(s).

6.3 Design stage

6.3.1 The information provided to the user prior to installation shall include contract drawings, which shall be to scale or be fully dimensioned with sufficient detail to define clearly the extent of the hazard and the proposed system.

COMMENTARY AND RECOMMENDATIONS ON **6.3.1**. *Details of the hazards should be included to show the materials involved, the location and/or limits of the hazard and any other materials likely to become exposed to the hazard in the event of a fire.*

6.3.2 The location and sizes of piping and nozzles shall be clearly indicated together with the location of the halon 1301 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 be shown, together with details of all calculations used in assessing the quantity of halon 1301.

COMMENTARY AND RECOMMENDATIONS ON **6.3.2**. *Further information, for example, the equivalent lengths of pipe and fittings, flow rates and pressure drops throughout the system, should be given separately if requested by the user.*

7 Commissioning and acceptance

7.1 Tests

The installer of the system or his supervising supplier shall arrange for the completed system to be inspected and tested to determine that it is properly installed and that it will function as designed to the satisfaction of the user and the relevant authorities. A commissioning test programme shall be submitted by the installer to the user.

The programme shall include instructions to:

- a) check that all components of the system have been installed in accordance with the contract drawings; and
- b) check that all nuts, bolts and fittings have been correctly tightened; and
- c) check that all electrical connections are safe and in working order; and
- d) check that closed sections of pipework are gas-tight; and
- e) test discharge a gas (which may be air, carbon dioxide or nitrogen but shall not be halon) into each enclosure to ensure that the piping is continuous and that the nozzles have not become blocked (see **17.1**); and

CAUTION. Do not discharge the test gas into flammable or explosive atmospheres because of the danger of the generation of static electricity (see commentary and recommendations on **11.1**). Take care to avoid this and other hazards to personnel during the test.

- f) determine the hold time using the fan test method described in Appendix A, and if necessary carry out the procedure of Appendix B (see commentary and recommendations on clause **12**).

COMMENTARY AND RECOMMENDATIONS ON **7.1**. *The authorities listed in clause 5 may wish to witness the tests.*

7.2 Completion certificate and documentation

The installer shall provide to the user two copies of a completion certificate, a complete set of instructions and drawings showing the system as installed, and a statement that the system complies with all the appropriate requirements of this standard, and giving details of any departure from appropriate recommendations. The certificate shall give the design and achievable maximum concentrations, the report of the fan test (see **A.9**), and if appropriate the actions taken in accordance with Appendix B (see commentary and recommendations on clause **12**).

COMMENTARY AND RECOMMENDATIONS ON **7.2**. *The user may also require certificates or letters of conformity for pressure vessels, in order to meet obligations under Regulation 5 of the Pressure Systems and Gas Container Regulations 1989.*

Section 3. Restoration after use, inspection, testing and maintenance

8 Restoration after use

The installer shall provide appropriate instruction on restoration and replenishment of the system after discharge.

COMMENTARY AND RECOMMENDATIONS ON CLAUSE 8. *Systems may include a permanently connected duplicate supply of halon. Spare filled replacement containers may be held on the premises, or should be available for delivery in 24 h. It is essential that nozzles are inspected and if necessary cleaned after any discharge.*

9 Inspection, testing and maintenance

9.1 General

The user shall carry out a programme of inspection (see 9.2) and shall arrange a service and maintenance schedule (see 9.3), and shall keep records of the inspections and servicing.

COMMENTARY AND RECOMMENDATIONS ON 9.1. *The continued capability for effective performance of a halon system depends on fully adequate maintenance procedures with, where possible, periodic testing.*

Installers should provide the user with a logbook in which inspection and maintenance records can be entered.

9.2 User's programme of inspection

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

COMMENTARY AND RECOMMENDATIONS ON 9.2. *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 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 for correct reading. Replace any containers showing a loss of more than 10 %.*
- 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 Service and maintenance schedule

The schedule shall include all appropriate requirements for periodic inspection and test given in BS 5430 for halon 1301 and propellant gas containers.

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.

COMMENTARY AND RECOMMENDATIONS ON 9.3. *During servicing and maintenance every care and precaution should be taken to avoid release of halon. When containers are emptied for internal inspection, the halon should not be discharged to atmosphere, but should be recovered as recommended in BS 6535-2.2.*

A suitable schedule is as follows.

- a) *Every 3 months. Test and service all actuating mechanisms and electrical detection and alarm systems as recommended in BS 5839-1.*
- b) *Every 6 months. Perform the following checks and inspections.*
 - 1) *Externally examine pipework to determine its condition. Replace or pressure test and repair as necessary pipework showing corrosion or mechanical damage.*
 - 2) *Check all control valves for correct manual function and automatic valves additionally for correct automatic function.*
 - 3) *Externally inspect containers.*
 - 4) *Check weigh, or use a liquid level indicator, to verify correct content of containers. Replace or refill any showing a loss of more than 5 %.*

c) *Every 12 months. Carry out a check of enclosure integrity using the method given in Appendix A. If the measured aggregate area of leakage has changed significantly from that measured during installation, carry out work to reduce the leakage.*

d) *As required by statutory regulations, but otherwise when convenient. Internally inspect containers.*

BS 5430-1, BS 5430-2 and BS 5430-3 specify requirements for the periodic inspection, testing and maintenance of transportable gas containers for seamless steel containers, welded steel containers and seamless aluminium containers, respectively, at prescribed intervals. BS 5430 also specifies that any container that has not been inspected and tested within the specified intervals is not to be refilled.

Section 4. System design

10 Basis of system design

The design of the system shall be based on the fire hazard assumed to exist in the enclosure.

COMMENTARY AND RECOMMENDATIONS ON CLAUSE 10. *The requirements of clauses 11 to 21 ensure that the system will discharge quickly enough to produce a concentration not less than the minimum design concentration throughout the enclosure to be protected, and that halon will be held in the enclosure for long enough for the fire to be extinguished and reignition prevented.*

11 Design concentration

11.1 Class B and C fires (flammable liquids and gases)

The design concentration shall be not less than 5 % (V/V), and as follows:

- a) for class C fires, not less than 1.1 times the inerting concentration;
- b) for class B fires involving a liquid of flashpoint not above 40 °C, not less than 1.1 times the inerting concentration;
- c) for class B fires involving a liquid of flashpoint above 40 °C:
 - 1) not less than 1.1 times the inerting concentration, if the liquid is maintained at a temperature lower than the temperature 20 °C below its flashpoint; or
 - 2) not less than 1.2 times the extinguishing concentration, if the liquid is maintained at a temperature not lower than the temperature 20 °C below its flashpoint.

Extinguishing concentrations not given in Table 3, and inerting concentrations not given in Table 4, shall be determined experimentally using the method of Appendix D.

COMMENTARY AND RECOMMENDATIONS ON 11.1. *After extinction of gases and volatile liquids, a potentially explosive fuel vapour/air/halon mixture may result if the design concentration is based on the extinguishing concentration (see item c) 2) and Table 3). Reignition of such mixtures is prevented at the higher minimum design concentrations based on the inerting concentrations (see items a), b) and c) 1) and Table 4). See also commentary and recommendations on 3.2.*

Halon 1301 systems should be discharged only in the presence of a fire and because of the possible generation of static electricity during the discharge, should not be used for inerting a potentially explosive atmosphere where a spark caused by static electricity would add to the hazard. An explosion could occur if a spark ignited the fuel/air mixture before the system had completely discharged, i.e. before the halon 1301 concentration had reached the inerting value.

11.2 Class A fires

For class A fires the design concentration shall be not less than 5.0 % (V/V).

COMMENTARY AND RECOMMENDATIONS ON 11.2. *Most class A fires burn initially at the surface and at this stage are rapidly and efficiently extinguished by halon 1301 with minimum breakdown of halon. However, many class A materials in later stages of combustion produce significant amounts of glowing embers and may not be totally extinguished by halon 1301 at the concentrations normally employed. Such fires are said to be deep-seated, and whilst halon 1301 will extinguish the flames, smouldering may continue with the production of considerable quantities of breakdown products and tar, which can cause corrosion damage. Halon 1301 is therefore not suitable for this type of fire.*

Fires involving materials such as cloth, rags, cardboard, and shredded or crumpled paper can rapidly become deep-seated.

Materials such as baled cotton, in which fires can start spontaneously from inside a bulk, are similarly deep-seated and halon 1301 is not recommended for use on these.

11.3 Halon 1301 systems protecting electronic data processing installations

For the purposes of this specification, fires in electronic data processing installations shall be regarded as class A fires and the minimum design concentration shall be not less than 5 % (V/V).

12 Predicted minimum hold time

The predicted minimum hold time shall be determined by the method of Appendix A, using the assumptions that at the beginning of the hold time the concentration throughout the enclosure is the design concentration, and one of the following, as applicable.

- Enclosure without mixing. At the end of the hold time the halon concentration at the height of the highest hazard is the design concentration.
- Enclosure with mixing. At the end of the hold time the halon concentration throughout the enclosure is 80 % of the minimum design concentration (see clause 11).

COMMENTARY AND RECOMMENDATIONS ON CLAUSE 12. *The hold time is necessary to ensure extinction and/or prevent reignition (see 2.8). For most applications 10 min is sufficient but for some applications longer may be necessary. If the predicted minimum hold time determined by the method of Appendix A is less than the necessary value see Appendix B. Appendix C gives an example of the application of the fan test method to an enclosure, and the use of Appendix B.*

**Table 3 — Halon 1301 extinguishing and minimum design concentrations
[in air at 1.013 bar (absolute)]**

Fuel	Measured extinguishing concentration (at 25 °C unless otherwise stated)	Minimum design concentration
	% (V/V)	% (V/V)
acetone	4.0	5.0
acrylonitrile	4.7	5.6
aviation gasoline	4.2	5.0
benzene	4.2	5.0
biphenyl/diphenyl ether eutectic	2.1 (at 200 °C)	5.0
buta-1, 3-diene	4.5	5.4
<i>n</i> -butane	4.0	5.0
crankcase oil (typical marine grade)	2.4 (at 250 °C)	5.0
diesel fuel	2.1	5.0
diethyl ether	4.2	5.0
ethane	5.0	5.3
ethanediol	5.7	5.0
ethanol	4.1	5.0
ethyl acetate	4.2	5.0
ethylene	6.8	8.2
fuel oil (typical residual grade)	1.5 (at 185 °C)	5.0
gasoline, 94 octane	3.0	5.0
gasoline, 98 octane	3.5	5.0
heat transfer oil (typical mineral grade)	2.9 (at 230 °C)	5.0
<i>n</i> -hexane	4.5	5.0
<i>n</i> -heptane	4.1	5.0
hydraulic oil (typical aviation grade)	3.1 (at 150 °C)	5.0
hydraulic oil (typical marine grade)	3.7 (at 220 °C)	5.0
isobutane	3.8	5.0
isopropanol	3.9	5.0
methane	4.2	5.0
methanol	7.5	9.0
methyl ethyl ketone	4.1	5.0
methyl methacrylate	6.2	7.4
nitromethane	7.7 (at 85 °C)	9.2
<i>n</i> -pentane	3.6	5.0
propane	4.3	5.2
pyridine	3.7	5.0
tetrahydrofuran	4.7	5.6
toluene	3.5	5.0
xylene (mixed)	3.1	5.0

Table 4 — Halon 1301 inerting and minimum design concentrations [in air at 1.013 bar (absolute)]

Fuel	Measured inerting concentration, at 25 °C	Minimum design concentration
	% (V/V)	% (V/V)
acetone	6.9	7.6
benzene	4.5	5.0
ethanol	10.1	11.1
ethylene	12.0	13.2
<i>n</i> -heptane	6.3	6.9
hydrogen	28.4	31.4
methane	7.0	7.7
propane	6.1	6.7

The discharge of halon 1301 into an enclosure results in an air/halon mixture that has a density greater than that of the air surrounding the enclosure. Any opening in the enclosure will allow the heavier air/halon mixture to flow out of the enclosure and to be replaced with lighter outside air flowing into the enclosure through the same, or another, opening. The rate at which halon is lost through openings will depend upon the locations and sizes of the opening(s), the concentration of halon, and the height of the enclosure.

In enclosures without mechanical or other means of mixing, the incoming air will collect towards the top of the enclosure, forming an interface between the air/halon mixture and fresh air. As leakage proceeds, the interface will move toward the bottom of the opening. The space below the interface will contain essentially the design concentration whereas the upper space may be completely unprotected. The rate at which the interface moves downwards increases with increasing concentrations of halon so that simply using a higher design concentration may not provide protection for a longer period.

In enclosures with mechanical or other means of mixing, the incoming air mixes with the air/halon mixture. No interface is formed and the halon concentration throughout the enclosure is uniform but decreases as leakage continues.

13 Quantity of halon

13.1 General

13.1.1 Systems at sea-level

The quantity of halon discharged from the system (assumed to be equal to the quantity of halon in the halon containers) shall be the sum of the basic quantity specified in **13.2**, plus the additional quantities specified in **13.3** to compensate for leakage or ventilation.

13.1.2 Systems not at sea-level

The quantity of halon discharged from the system shall be the quantity specified in **13.1.1** for a system at sea-level multiplied by the appropriate value of the correction factor, β , given in Table 5.

Table 5 — Correction factor for halon quantity in systems not at sea-level

Altitude above sea-level	Correction factor, β
m	
– 4 500	1.770
– 4 000	1.640
– 3 500	1.540
– 3 000	1.450
– 2 500	1.360
– 2 000	1.275
– 1 500	1.205
– 1 000	1.130
– 750	1.105
– 500	1.060
– 250	1.025
0	1.000
+ 250	0.975
+ 500	0.945
+ 750	0.915
+ 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

NOTE 1 Values may be interpolated
NOTE 2 The specific volume of halon 1301 at any altitude is equal to the specific volume at 1.013 bar (i.e. at sea-level) divided by the correction factor

COMMENTARY AND RECOMMENDATIONS ON 13.1.2. *At elevations above sea-level, halon 1301 has a greater specific volume because of the reduced atmospheric pressure. A system designed for sea-level conditions will therefore develop an actual higher concentration at levels above sea-level and an actual lower concentration at levels below sea-level. For example, a system designed to produce a 6 % halon 1301 concentration at sea-level would actually produce an 8.7 % concentration if installed at 3 000 m elevation, which is higher than the maximum concentration specified for automatic operation in normally occupied areas (see 15.3.2).*

13.2 Basic quantity

13.2.1 Single enclosures

The basic quantity, in kilograms, of halon 1301 discharged from the system shall be:

$$\frac{V_g}{v_{\min.}} \times \frac{c \times \beta}{100 - c}$$

where

$v_{\min.}$ = $0.14781 + 0.000567 T_{\min.}$, and is the specific volume of halon 1301 at temperature $T_{\min.}$ (in m^3/kg);

c is the design concentration at temperature $T_{\min.}$ [in % (V/V)];

- $T_{\min.}$ is the design temperature, the expected minimum ambient temperature in the hazard area (in °C);
- V_g is the gross volume of the enclosure (in m³);
- β is the altitude correction factor (see Table 5).

COMMENTARY AND RECOMMENDATIONS ON 13.2.1. *Table 6 gives the specific volume at the design temperature $V_{\min.}$ and the value of the flooding quantity, $c/\{v(100 - c)\}$, at an absolute pressure of 1.013 bar at various temperatures and values of concentration c .*

13.2.2 Two interconnected enclosures

Where halon may flow freely between two or more enclosures, the quantity of halon shall be the sum of the quantities calculated for each enclosure. If a higher minimum design concentration is specified for one enclosure, that minimum design concentration shall be applied to all enclosures.

13.3 Additional quantity for extended discharge in enclosures with mixing

Where the basic quantity of halon is insufficient to give a satisfactory hold time, additional halon shall be provided (see clause 12).

COMMENTARY AND RECOMMENDATIONS ON 13.3. *Throughout the hold time, halon 1301 should be added at a rate that will compensate for leakage out of the enclosure. The halon should be discharged in such a way that the concentration of halon and air is uniformly maintained at not less than 80 % of the minimum design concentration. This method is particularly suitable for enclosed rotating electrical apparatus, such as generators and converters, but should not be used to compensate for leakage which can be eliminated or reduced (see 16.3).*

14 Design discharge time

The design discharge time used in calculations shall be not more than 10 s, and the quantity of halon calculated as discharged in 10 s, with the halon 1301 container(s) at the normal ambient storage temperature, shall be not less than the basic quantity specified in 13.2.

15 System operation

15.1 General

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; and
- b) a mechanical device for direct operation of the system.

The mechanical device shall be outside the protected area and 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.

COMMENTARY AND RECOMMENDATIONS ON 15.1. *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.*

15.2 Manual operation

Direct emergency manual operation of the system shall be possible.

Each manual control shall be prominently labelled to identify the hazard protected.

Manual release push buttons or pull handles shall be housed in a box with a quick access front.

Manual controls shall not require a pull of more than 150 N or a movement of more than 300 mm to effect operation.

COMMENTARY AND RECOMMENDATIONS ON 15.2. *Manual control points should be designed so that they cannot be confused with fire alarm manual call points.*

The design of fire alarm manual call points is specified in BS 5839-2.

Emergency manual operation of individual system components is usually by direct manual operation of the device to be operated.

Consideration should be given to the incorporation of a time delay and predischARGE alarm between actuation of the manual control and the commencement of system discharge, to allow time for personnel to leave the hazard area.

Table 6 — Specific volumes and flooding quantities at various concentrations of halon 1301 at different temperatures [at 1.013 bar (absolute)]

Design temperature in hazard area, t	Specific volume of halon 1301 vapour at the design temperature $V_{min.}$	Flooding quantity $\frac{c}{v(100-c)}$					
		5 % (V/V)	6 % (V/V)	7 % (V/V)	8 % (V/V)	9 % (V/V)	10 % (V/V)
°C	m ³ /kg	kg/m ³	kg/m ³	kg/m ³	kg/m ³	kg/m ³	kg/m ³
– 50	0.119 46	0.440 6	0.534 3	0.630 1	0.727 9	0.827 9	0.930 1
– 45	0.122 30	0.430 4	0.521 9	0.615 5	0.711 0	0.808 7	0.908 5
– 40	0.125 13	0.420 6	0.510 5	0.601 5	0.694 9	0.790 4	0.887 9
– 35	0.127 97	0.411 3	0.489 8	0.588 2	0.679 5	0.722 9	0.868 3
– 30	0.130 80	0.402 4	0.488 0	0.575 4	0.664 8	0.756 1	0.849 5
– 25	0.133 64	0.393 8	0.477 8	0.563 2	0.650 7	0.740 1	0.831 4
– 20	0.136 47	0.385 7	0.467 7	0.551 5	0.637 2	0.724 7	0.814 2
– 15	0.139 31	0.377 8	0.458 2	0.540 3	0.624 2	0.709 9	0.797 6
– 10	0.142 14	0.370 3	0.449 1	0.529 5	0.611 8	0.695 8	0.781 7
– 5	0.144 98	0.363 0	0.440 3	0.519 2	0.599 8	0.682 2	0.766 4
0	0.147 81	0.356 1	0.431 8	0.509 2	0.588 3	0.669 1	0.751 7
5	0.150 65	0.349 4	0.423 7	0.499 6	0.577 2	0.656 5	0.737 6
10	0.153 48	0.342 9	0.415 9	0.490 4	0.566 6	0.644 4	0.723 9
15	0.156 32	0.336 7	0.408 3	0.481 5	0.556 3	0.632 7	0.710 8
20	0.159 15	0.330 7	0.401 1	0.472 9	0.546 4	0.621 4	0.698 1
25	0.161 99	0.324 9	0.394 0	0.464 7	0.536 8	0.610 5	0.685 9
30	0.164 82	0.319 3	0.387 3	0.456 7	0.527 6	0.600 0	0.674 1
35	0.167 66	0.313 9	0.380 7	0.448 9	0.518 7	0.589 9	0.662 7
40	0.170 49	0.308 7	0.374 4	0.441 5	0.510 0	0.580 1	0.651 7
45	0.173 33	0.303 7	0.368 3	0.434 3	0.501 7	0.570 6	0.641 0
50	0.176 16	0.298 9	0.362 3	0.427 3	0.493 6	0.561 4	0.630 7
55	0.179 00	0.294 0	0.356 6	0.420 5	0.485 8	0.552 5	0.620 7
60	0.181 83	0.289 5	0.351 0	0.431 9	0.478 2	0.543 9	0.611 1
65	0.184 67	0.285 0	0.345 6	0.407 6	0.470 9	0.535 6	0.601 7
70	0.187 50	0.280 7	0.340 4	0.401 4	0.463 8	0.527 5	0.592 6
75	0.190 34	0.276 5	0.335 3	0.395 4	0.456 9	0.519 6	0.583 8
80	0.193 17	0.272 5	0.330 4	0.389 6	0.450 1	0.512 0	0.575 2
85	0.196 01	0.268 5	0.325 6	0.384 0	0.443 6	0.504 6	0.566 9
90	0.198 94	0.264 7	0.321 0	0.378 5	0.437 3	0.497 4	0.558 8
95	0.201 68	0.261 0	0.316 5	0.373 2	0.431 2	0.490 4	0.550 9

The label identifying the hazard is additional to that specified in 21.4.1. The manual control point or points should be located outside the protected enclosure so as to be conveniently and easily accessible at all times, including the time of fire. It may be a mechanical, or electromechanical device.

If the housing is protected by a frangible glass front this should be of a type which when broken does not leave jagged or sharp edges which might cause injury when the manual release is operated.

15.3 Automatic operation

15.3.1 General

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 BS 5839-1. The electric power supply shall be independent of the supply for the hazard area with an emergency secondary power supply with automatic changeover in case the primary supply fails.

Where two or more rapid response fire detectors are used, such as those for detecting smoke or flame, the system shall operate only after signals from two detectors have been received.

Electrically operated actuation systems shall comply with BS 7273-1.

Provision shall be made for manual operation (see 15.2) of the fire extinguishing system by means of a control situated outside the protected space or adjacent to the main exit from the space.

15.3.2 Safety limitations for automatic operation

15.3.2.1 General

If the achievable maximum concentration is greater than 6 % (V/V) in normally or intermittently occupied areas, arrangements shall be made to limit the automatic operation of the system as specified in 15.3.2.2 or 15.3.2.3.

COMMENTARY AND RECOMMENDATIONS ON 15.3.2.1. *The achievable maximum concentration is based on the mass of halon initially discharged, i.e. excluding any extended discharge but including any initial excess, and the net volume of the enclosure, and is calculated from the following equation:*

$$C_{\max.} = \frac{100 M v_{\max.}}{V_n + M v_{\max.}}$$

where

$C_{\max.}$	is the achievable maximum concentration [in % (V/V)];
M	is the mass of halon initially discharged (in kg);
$v_{\max.}$	is the specific density of halon 1301 at the expected maximum ambient temperature $t_{\max.}$ (in kg/m ³);
V_n	is the net volume of the protected enclosure (in m ³).

If $C_{\max.}$ is not greater than 6 % (V/V), the system may function in the automatic mode at all times, except during periods of maintenance of the extinguishing system.

To allow personnel to evacuate the protected area prior to discharge of halon 1301, a time delay may be incorporated in the automatic system. The delay period will depend upon the potential speed of fire spread and the means of escape from the protected area, but it should not normally exceed 30 s.

Where time delays are incorporated in the system, the system may also be equipped with a biased switch, located within the protected area, the manual operation of which at any time during the delay period can prevent halon discharge. A fault signal should be given if the switch is operated in the non-alarm mode.

Systems protecting areas that cannot be occupied at any time may function in the automatic mode at any concentration of halon 1301 provided there would be no adverse effect on adjacent areas that may be occupied.

15.3.2.2 Achievable maximum concentration greater than 6 % (V/V) but less than 10 % (V/V)

Automatic systems protecting normally or intermittently occupied areas where the achievable maximum concentration (see 2.1) is greater than 6 % (V/V) and less than 10 % (V/V) shall be provided with a device which can be used to prevent automatic operation of the system.