

Fire extinguishing installations and equipment on premises —

Part 0: Guide for the selection of installed systems and other fire equipment

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Committees responsible for this British Standard

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 British Gas Corporation
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 Department of Transport (Marine Directorate)
 Electricity Supply Industry in England and Wales
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 Fire Extinguishing Trades Association
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 Fire Offices' Committee
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 Health and Safety Executive
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Foreword

This Part of BS 5306 has been prepared under the direction of the Fire Standards Committee and serves to introduce the other Parts of BS 5306, which give requirements and recommendations for the application of a particular type of fire extinguishing system, discharging a particular extinguishing medium. Taken together, the various Parts of BS 5306 are intended to cover all the main types of extinguishing medium and system in current use, and therefore form a comprehensive guide to all aspects of the subject.

The other Parts of BS 5306 are as follows:

- *Part 1: Code of practice for hydrant systems, hose reels and foam inlets;*
- *Part 2: Code of practice for sprinkler systems;*
- *Part 3: Code of practice for the selection, installation and maintenance of portable fire extinguishers;*
- *Part 4: Specification for carbon dioxide systems;*
- *Part 5: Halon systems;*
- *Section 5.1: Code of practice for Halon 1301 total flooding systems;*
- *Section 5.2: Code of practice for Halon 1211 total flooding systems;*
- *Part 6¹⁾: Specification for foam systems;*
- *Part 7: Specification for extinguishing powder systems (under consideration).*

The aim of this Part of BS 5306 is to aid selection of the extinguishing medium and type of system or equipment by describing the characteristics and most suitable applications of each.

Consideration has been given to other aspects of extinguishing media including toxicity to people, effect of discharge on visibility, danger of use on electrical equipment, etc. in addition to other problems such as monitoring, testing, maintenance and user responsibility.

More detailed consideration of systems and equipment, including safety precautions is given in the other Parts of BS 5306.

In BS 5306-1, consideration is given to fire-fighting facilities which are provided specifically for fire service use, e.g. hydrants, foam inlets and risers. In BS 5306-3, the provision of portable fire extinguishers for first-aid use within the building is considered. These items are an essential part of the fire protection of the building.

Nothing in this standard should be taken as precluding the use of first-aid protection measures, nor as avoiding the necessity of notifying the fire service in case of accidental fire.

This standard is written in SI units, except that pressures are expressed in bars²⁾.

Water discharge densities are expressed as rainfall at floor level, in mm/min (1 mm/min = 0.02 gal per ft² per min = 1 L per m² per min).

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.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 44, 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.

¹⁾ In preparation.

²⁾ 1 bar = 10⁵ N/m² = 100 kPa.

Section 1. General

1 Scope

This Part of BS 5306 gives guidance on the selection, installation and maintenance of automatic water sprinkler and spray systems, carbon dioxide and halon systems, foam and extinguishing powder systems. It also gives guidance on installed equipment for fire service use, and on the application of portable fire extinguishers. It complements the more detailed information given in the other specialized Parts of this standard.

NOTE 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 5306-1 to BS 5306-5 and BS 4422 apply, together with the following.

2.1

extinguishing medium

the substance contained in a fire-extinguishing system that, when discharged on to the fire, is intended to produce extinction

2.2

class A fire

fire involving solid materials, usually of an organic nature, in which combustion normally takes place with the formation of glowing embers

2.3

class B fire

fire involving liquids or liquefiable solids

2.4

class C fire

fire involving gases

2.5

class D fire

fire involving metals

2.6

hazard

a particular area or activity in which a danger of fire can occur, e.g. a paint spraying plant, cotton pickings, carding machinery or a heat-treatment bath

2.7

storage hazard

the general dangers of storage of goods, having regard to their fire grading, flammability, method of packing, storage, etc.

2.8

high-racked storage

a storage in which goods are held on high racking so that they are accessible for loading and withdrawal, usually by mechanical means

2.9

high-stacked storage

a storage in which goods are held in high-piled free-standing blocks, or in blocks of stackable free-standing pallets

2.10

process hazard

a hazard in an industrial process

2.11

foam inlet

fixed equipment consisting of an inlet connection, fixed piping and a discharge assembly, enabling the fire service to introduce foam into an enclosed compartment

2.12

dry rising main (dry riser)

a vertical pipe installed in a building for fire-fighting purposes, fitted with inlet connections at fire service access level and landing valves at specified points, which is normally dry but is capable of being charged with water, usually by pumping from fire service appliances

2.13

wet rising main (wet riser)

a vertical pipe installed in a building for fire-fighting purposes, that is permanently charged with water from a pressurized supply and fitted with landing valves at specified points

2.14

landing valve

an assembly comprising a valve and outlet connection from a wet rising main or dry rising main

2.15

fire hose reel (water)

a fire-fighting appliance consisting essentially of a reel, inlet pipe and valve, hose, shut-off nozzle and where required a hose guide (see also 2.33)

2.16

sprinkler system (installation)

an assembly of pipework, graded in size, erected throughout a building, and in which sprinklers are mounted at prescribed intervals. The pipework is connected to a set of system control valves incorporating a hydraulic alarm and is fed by an approved water supply

**2.17
sprinkler**

a device sealing an aperture in a pipe of a sprinkler system, that discharges water automatically in a predetermined pattern over a specified area when it operates at a predetermined temperature

**2.18
control valves**

the valves that control the operation of a sprinkler or spray system

NOTE The valve nearest the supply is termed the mains shut-off valve and serves to cut off the supply when the system is undergoing maintenance or modification. At all times when the system is operative, it is open and is strapped in this position to prevent inadvertent closure. The valve immediately downstream of the mains shut-off valve is termed the alarm valve and serves to separate the water supply from the system. The alarm valve opens automatically when a sprinkler operates in response to the hot gases rising from a fire.

**2.19
water spray system**

a system, similar in principle to a sprinkler system, that is designed to extinguish flammable liquid fires, or to provide cooling to an exposed area likely to be subjected to intense heat radiation from a neighbouring fire

NOTE Spray systems range in size from very small to very large, as described in section five.

**2.20
deluge system**

a system used to protect large buildings against large flammable liquid spillages, e.g. aircraft hangars, aprons, oil processing areas and tanker loading bays. Such systems may be zoned, so that only selected areas are activated according to the location of the fire. They are usually detector-operated, and are often designed to discharge either water or foam

**2.21
ullage**

the vertical distance or free volume between the liquid surface in an open vessel and the rim of the vessel

**2.22
slop over**

the condition that occurs when a water spray (or foam) is applied to the surface of a burning liquid that has developed a hot zone beneath the surface at a temperature in excess of 100 °C. On passing through this zone, the water boils and expands suddenly, causing some of the flammable liquid to pour over the rim of the tank

**2.23
boil over**

a more severe condition than slop over, in which the hot zone is sufficiently deep to reach the water that has drained to the base of the tank, so that a large part of the contents of the tank are expelled violently when the water boils

**2.24
design density of discharge**

a measure of the average quantity of water falling per unit area per minute from a sprinkler system in full operation, over an assumed maximum area of operation

**2.25
assumed maximum area of operation**

the maximum area over which a sprinkler system in full operation is required to maintain the design density of discharge

**2.26
halon**

a halogenated hydrocarbon used as an extinguishing medium

**2.27
liquefied natural gas (LNG)**

term applied to naturally occurring light hydrocarbons that are often associated with crude oil deposits. They exist as gases at normal atmospheric temperature and pressure. They are stored and handled as deeply refrigerated liquids at substantially atmospheric pressure

**2.28
liquefied petroleum gas (LPG)**

light hydrocarbons, which at normal atmospheric temperature and pressure exist as gases, but which are readily liquefied by the application of moderate pressure. They may be stored and handled as liquids under pressure at ambient temperature or as refrigerated liquids at substantially atmospheric pressure. The term liquefied petroleum gas is used to include commercial butane, commercial propane and mixtures of these two

**2.29
total flooding system**

a system in which a gaseous extinguishing medium is discharged into an enclosure to a concentration sufficient to extinguish fire throughout the entire volume of the enclosure

**2.30
recommended extinguishing concentration**

the concentration of a gaseous extinguishing medium necessary to ensure extinction of flaming combustion of a particular material

2.31**inerting concentration**

the concentration of a gaseous extinguishing medium necessary to prevent ignition of a particular material

NOTE The inerting concentration is usually higher than the recommended extinguishing concentration.

2.32**local application system**

a system in which the extinguishing medium is retained in a container storage bank, and is fed through a piped system to nozzles located to discharge simultaneously on to specific areas of risk

2.33**manual hose-reel (gaseous) system**

a fire extinguishing system consisting of a hose, stowed on a reel or rack, with a manually operated discharge assembly, all connected by a fixed pipe to a supply of carbon dioxide or halon (see also 2.15)

2.34**surfactant**

a surface-active agent, i.e. a chemical that reduces the surface tension of water

2.35**surfactant fluorinated**

a particular type of surfactant that gives greater reduction of surface tension

2.36**foam-making branchpipe**

a hand-held foam generating and discharge device in which the foam solution is aerated, expanded and discharged as a jet or spray

2.37**foam branch**

a similar device to the foam-making branchpipe, except that it does not induce air, the foam being made further upstream at an in-line generator, and reaches the branch as expanded foam

2.38**foam monitor**

a similar device in principle to the foam branch or foam branchpipe, but mounted on a swivelling base, so that its greater output can be discharged without reaction on the operator. The base unit may be fixed at one place, or may be trolley-mounted or vehicle-mounted

2.39**engineered systems**

piped systems from a centralized cylinder storage bank. They are individually calculated and designed to give the required flow rates to each of the individual discharge nozzles, which are located to suit the nature and distribution of the combustible

2.40**modular systems**

systems that comprise one or more storage units that all discharge simultaneously through their own outlet nozzle, the pressure and flow rate of which are predetermined. They may or may not be piped systems

NOTE If they are piped systems, the permissible pipe sizes and pipe lengths, and the number and type of fittings and nozzles have to be specified by the manufacturer for each unit.

3 Range of information

A complex range of information needs to be considered by the prospective specifier or installer of a fire extinguishing system, in order that the most suitable medium and type of system may be selected to meet the needs of the particular risk. The architect, the insurer, the fire authority and the manufacturers are all able to contribute to the overall picture, and their advice should be sought where appropriate. There may be consequential loss and insurance considerations and possible effects on adjacent areas or buildings, or there may be secondary effects.

The information necessary for success is given in sections two to twelve. More detailed information is given in the other specialist Parts of BS 5306.

Appendix A gives examples of risks and occupancies for which particular systems are suitable, and appendix B provides a bibliography of suggested sources of additional information.

Fire extinguishing systems are usually, though not invariably, made from a series of standardized approved components. The variation between risks will usually require that each system, while constructed from the standardized components, is nevertheless designed to meet the application in hand. This is a task for the expertise of the designer and manufacturer.

Section 2. Value of installed fire extinguishing systems

4 Historical development

The use of fire extinguishing systems has developed, since the 19th century, largely as a result of the insurers requiring adequate protection of the risks for which they were financially liable. Since these risks were mostly in the cotton and woollen industries, it was natural that the water-dispensing systems, i.e. automatic sprinkler and spray systems, should predominate. The growth of new industries has meant the much more widespread use of the water systems, and also the development of new media and new systems to meet the needs of a whole new range of risks. Current thinking has passed far beyond the need to safeguard insurance investment, to the point of regarding each risk as an asset to be protected in its own right.

5 Relation to other means of fire protection

Installed fire extinguishing systems are one link in the chain which makes up the complete range of fire protection of the asset. While each link is independent of the other, they are mutually supportive and have to be regarded as a whole. The degree of importance of each depends upon the nature of the particular risk, as described in this clause. The individual links are as follows.

- a) First-aid fire fighting, e.g. extinguishers, hose reels and fire-blankets.
- b) The installed fire extinguishing system.
- c) Action by the fire service (including use of their own equipment, and installed equipment such as hydrants, risers and foam inlets).

d) The built-in fire protective measures of contents and building, e.g. fire-protective packaging, fire resistance and fire compartmentation.

e) Special considerations apply to gaseous fires, where if the flow of gas is not quickly stopped after extinguishing the fire a serious danger of explosion would arise. The prime consideration in gaseous fires is to isolate the leak and if necessary protect adjacent hazards with water.

It is clear that the success of a) may avoid the need to involve b), c) and d). Similarly, b) may obviate the need for c), or may reduce it from a major operation to a watch-and-guard measure. The actions of c) can prevent d) becoming deeply involved. An important point to appreciate is that for some risks, some activity at a), b), c) and d) is expected, because of the nature of the occupancy and the type of fire extinguishing system which is installed. In other cases the whole responsibility for detecting and extinguishing the fire rests upon the installed system, and there is no alternative to this. In other cases, the installed system is designed to meet the major part of the risk, with some back-up and stand-by from the fire service.

The extent of interdependency of these links varies with the type of system and the characteristics of the risk. The need for a particular link may be reduced or eliminated by the success of others, but in some cases all the links may be required. An installed fire extinguishing system can be a highly effective link in the fire protective chain because it is immediately available and designed specifically to meet the risk.

Section 3. Extinguishing media

6 General

The extinguishing media available are:

- a) water;
- b) gaseous extinguishing media, including carbon dioxide, nitrogen and the halons (halogenated hydrocarbons);
- c) foams;
- d) extinguishing powders.

Each of these is discussed individually in clauses 7 to 10.

7 Water

Water is the most widely used extinguishing medium, and its properties make it likely that it will remain so. It is cheap and usually readily available, has a high heat capacity absorbing large amounts of heat as a liquid and even greater amounts by its conversion to steam. This makes it an effective medium in cooling and extinguishing class A fires, even when these fires are deep-seated. As fires in these materials represent the majority of the risks, it follows that the applications of water in jet or spray form are manifold. Water in spray form can also be used against class B fires, particularly those of a high fire point (about 65 °C and above) such as diesel oil, transformer oil, lubricating oil, etc. It is not so effective against petrol, naptha, etc., nor against alcohols, though it can achieve a useful cooling of the fire zone. Water spray is very effective in cooling exposures such as doors and windows irradiated by an adjacent, fire, or fuel storage tanks which are adjacent to a blaze. These aspects are dealt with in section four.

Water is not so efficient, on a mass basis, as some of the other media, but where this is not a consideration, e.g. where supplies are pumped to the fire from a large reservoir or other supply, this is not a primary consideration. Water can be applied to fires indoors, e.g. in large storage buildings and hangars, or it can be used just as readily outdoors in circumstances where a fixed system or mobile equipment can be utilized, e.g. in the protection of outside oil-cooled transformers or cooling of tanks in tank farms.

Water has some disadvantages, notably:

- a) its ability to conduct electricity which makes it dangerous to apply it to high voltage electrical equipment;
- b) its property of expanding on freezing which can damage pump casings and pipework;
- c) its corrosive effects on unprotected steel;
- d) consequential water damage.

The efficiency of water can be increased by the use of additives and with appropriate equipment can be used for applications unsuitable for water alone.

8 Gaseous extinguishing media

The gaseous media available for fire extinction include Halon 1211 and Halon 1301, carbon dioxide and nitrogen. Halon 1211 and Halon 1301 play a similar role to carbon dioxide, but there are certain differences. Halon 1211 has a boiling point of -4 °C at normal atmospheric pressure, and it is possible to design nozzles that can throw a liquid stream of the agent which rapidly vaporizes, thus utilizing the latent heat of vaporization in cooling the fire. Halon 1301 has a boiling point of -58 °C at normal pressure and is gaseous on release from its container. Both are suitable for total flooding of enclosures, and Halon 1211 is being considered for local application at danger points in an enclosure. Although halons extinguish fires at lower concentration (by volume) than carbon dioxide, their high densities mean that similar masses of the three agents are required.

The halons will break down if exposed to fire conditions for an extended period, especially if the fire is deep-seated as with certain class A fires. Certain burning metals will react violently with halons breaking them down in the same way. This breakdown results in the formation of acid halides which are much more toxic than the medium itself (see section four), and to avoid this a high rate of discharge is required to achieve the design concentration rapidly. A maximum time of discharge of 10 s is recommended in BS 5306-5. To obtain good distribution at the high rate of discharge, special designs of nozzles are produced to disperse the medium rapidly within the protected enclosure (see section five).

Halons or carbon dioxide should not be used to fight fires in chemicals that contain their own oxygen for combustion, e.g. cellulose nitrate, and will not extinguish these. Some burning metals will extract oxygen from carbon dioxide (or even react with nitrogen) and cannot be extinguished with these media.

Carbon dioxide, like nitrogen, is a naturally occurring gas. It is stored as a liquid/vapour mixture under its own vapour pressure, and when released it discharges as a cold vapour which has an initial cooling effect. It can be used against flammable liquid fires and solid fuel fires. The design concentrations required to extinguish fires in various combustibles are given in BS 5306-4, and vary from about 30 % (V/V) to 70 % (V/V), dependent upon the combustible, most gases and flammable liquids being in the 30 % (V/V) to 40 % (V/V) range. Slightly higher concentrations are required to inert an enclosure, i.e. to prevent a fire occurring within it. Carbon dioxide is approximately 1.5 times as dense as air, and discharged into an enclosure containing air, tends to settle at the lower levels.

Nitrogen in gaseous form at normal temperatures has little cooling effect. It requires a relatively high concentration [nearly 50 % (V/V)] to extinguish flammable liquid fires and even more to extinguish burning solids. It finds its best application in inerting enclosures containing flammable materials, e.g. in the vapour spaces of fuel tanks, rather than as an extinguishing agent. Its vapour density is almost the same as that of air (of which it forms the major part) and it will remain mixed with air in a volume, without separating out. Dry nitrogen is also used under pressure as a propellant for other extinguishing media, e.g. extinguishing powders.

The gaseous media are clean, i.e. they do not adversely affect the materials against which they are discharged, and leave no cleaning-up problems within the affected area, other than venting the area after use to remove fumes.

Under some conditions it is possible for electrostatic discharges to be produced during the discharge of carbon dioxide and to a lesser extent of halons. The effect can be minimized in systems by bonding and earthing the pipework, but this cannot be done with portable fire extinguishers. The effect is not important during fire fighting but the use of the gaseous media for the pre-inerting of potentially explosive atmosphere should be avoided.

The gaseous extinguishing media are particularly useful in extinguishing fires in enclosed labyrinths where other media, e.g. foam, powders and water sprays, might not be able to penetrate effectively. Examples are concealed spaces under floors or in ceiling voids and enclosed machinery spaces. The gaseous media are particularly effective in penetrating electrical equipment, and if the extinction is rapid, the equipment can be saved from unnecessary damage from the fire, and there will be very little cleaning up after extinction. Since they are not electrically conductive, they are safe to use in this way, even against high voltage equipment.

Gaseous media can fulfil specialist applications far more effectively than the other media. They are best used in enclosed spaces with controllable ventilation where the extinguishing concentration can be built up very rapidly and maintained long enough to ensure cooling of the fire zone.

9 Foams

Foams consist essentially of a bubble-structure formed by aerating and agitating a solution of a foam concentrate in water.

Foams are classified by their expansion ratio (expansion), the ratio of the volume of the made foam to the volume of the solution from which it is made, as follows.

- a) Low expansion foams, with expansions between 1 and 20, are intended primarily for application to the surface of flammable liquid fires.
- b) Medium expansion foams, with expansions between 21 and 200, are intended for surface application or for application to fires which require a certain depth of foam to obtain coverage, e.g. up to depths of 4 m.
- c) High expansion foams, with expansions between 201 and 1 000, are intended for filling enclosures within which a number of fires may be burning at different levels up to 10 m.

Protein foams are made from concentrates based on proteinaceous products alone and with the addition of fluorinated additives to give fluoroprotein foams. Another development is a mixture of hydrocarbon and fluorinated surfactant materials with stabilizers to form aqueous film-forming foam (AFFF) type concentrates. These are used for the extinction of fires in hydrocarbons and other water-immiscible flammable liquids.

Modifications of fluoroprotein and AFFF foams have been developed that are suitable for use on fires in water-miscible flammable liquids, e.g. alcohols and ketones. These are the alcohol resistant (AR) foams or general purpose foams.

Medium expansion foams can be made from low expansion foam concentrates, but it is more usual to make them from a surfactant concentrate based on ammonium lauryl ether sulphate. High expansion foams are also made from this concentrate.

The use of low expansion foams is restricted largely to the extinction of flammable liquid fires, but there is no reason why they should not be applied to solid fuels also, provided adequate coverage can be obtained to exclude air as much as possible. In practice, low expansion foams may either be applied to the surface of a burning liquid (surface application), or beneath the surface so that the foam stream floats to the surface and spreads to form a protective layer or blanket upon it (sub-surface application). The first method is the more common, and can be used against spill fires, fires in banded areas, fuel tanks, etc., using the appropriate equipment.

Medium expansion foams are generally applied to the surface of flammable liquid fires, either by hand-held foam-making branches, or from fixed foam makers. This medium can also be used effectively on solid fuel fires, or "mixed" fires of solid and liquid combustibles. Typical examples would be on a fire in a gas turbine driven generating set, a fuel fire in the engine room of a ship, heat-treatment baths, or places where fuel spillages can occur, e.g. in pit areas, in garages or in overhaul shops.

High expansion foams are similar in action to medium expansion foams, but they require generators in which air is supplied by a fan, in order to achieve the rate of flow necessary for their production. They work by blanketing or smothering a fire, but the degree of cooling available is much less than for medium expansion foams, due to their lower water content. They can, however, produce much greater foam depths of at least 10 m, and can therefore smother a fire in goods stored on high racks. For this, the depth of the foam needs to increase rapidly in order to match, or overtake, the upward rate of development of the fire.

10 Powders

Powders are finely divided chemicals with a controlled range of particle size, which are used in the extinction of fires in flammable liquids, gases and solids. They are manufactured in four main types.

- a) BC powders for flammable liquids and flammable gases only.
- b) BC (foam compatible) powders as in a) but suitable for use in conjunction with fire-fighting foams without adverse effects on the foam.
- c) ABC powders suitable for use generally on flammable liquids, gases and solids (excepting flammable metals).
- d) D powders suitable for use on flammable metals. These powders may be subdivided into those suitable for radioactive metals (and hence acceptable to the Atomic Energy Authority), and those for use on general industrial metals.

BC powders are usually the bicarbonates of sodium or potassium, with a siliconized additive to promote flow and non-caking qualities. There is also a proprietary powder based upon an intimate mixture of potassium bicarbonate and other materials that decrepitates in the fire zone and produces a fine powder of high performance.

A flammable liquid fire will reflash when application of powder ceases if an ignition source is present.

ABC powders are based on ammonium phosphates with a siliconized additive. On impact with the surface of a burning solid, the powder melts and forms a coating that inhibits further combustion. Solid fuel fires against which ABC powder is used will re-ignite slowly if application stops before extinction.

D powders are usually formulated with a specific range of metals in mind, and hence they vary widely in their characteristics. For use on industrial metals, e.g. aluminium, magnesium and its alloys, a powder based on boron trioxide has been used very successfully.

Section 4. Effects of extinguishing media on people and materials

11 General

This section reviews the problems and dangers that can arise in the use of the various extinguishing media in systems. These effects are summarized as follows.

- a) Factors affecting people:
 - 1) toxicity;
 - 2) dangers to respiration;
 - 3) electric shock hazard;
 - 4) loss of vision, hearing or orientation.
- b) Factors affecting equipment:
 - 1) corrosion problems;
 - 2) cold shock on delicate equipment;
 - 3) other problems.

12 Water

12.1 Effects on people

Water is non-toxic to humans unless it has been contaminated by toxic substances, e.g. radioactive or toxic chemicals wrongfully disposed of, brackish or other sediments and sewage. The source of water supplies should be tested periodically to ensure that the water used does not present a toxic hazard.

Water is not normally a danger to respiration unless it is discharged directly at the face at a rate of discharge sufficient to render breathing difficult. The danger is fairly readily avoided, however.

Water supplies, with their dissolved natural salts, conduct electricity to a degree dependent upon the specific conductance of the solution. Safe distances for hose streams of various jet diameters, and for water sprays, are given in Fire Research Station Technical Paper No. 13³⁾ for various applied voltages. Water sprays are, in general, much safer than water jets, but it is better to avoid danger by not using water against electrical equipment except where special devices are installed, or precautions are taken, to switch off the electrical supply before application. However, care should always be exercised when water is used against electrical equipment particularly where manual methods of application are used. A further danger exists if the surrounding surfaces are wetted, when they may provide a conductive path to earth, and personnel in the vicinity could be electrocuted by the resulting discharge.

12.2 Effects on materials

Water with its dissolved salts can be corrosive, particularly to iron and steel, although other metals, such as brass, bronze and aluminium are not affected, especially if dried off after exposure. Goods likely to be adversely affected by water, e.g. paper, cloth and foodstuffs, should be wrapped and stored so as to protect them. If wetted, they should be dried and repacked as soon as possible. Items like wallpapers, clothing, etc., while not adversely affected if salvaged quickly, may nevertheless be considered unsaleable due to staining or marking.

Water jets or sprays may give a cold shock to warm electrical or electronic equipment. It is desirable that the water discharge should not come into direct contact with the sensitive equipment.

13 Gaseous extinguishing media

13.1 Effects on people

13.1.1 General. The precautions necessary in using the gaseous extinguishing media are considered in the appropriate Parts of BS 5306 and in the Health and Safety Executive Guidance Note GS16³⁾.

The gaseous extinguishing media do not conduct electricity to any extent and do not present a danger of shock if they are discharged against high voltage equipment, provided that the recommended system component clearance gaps are observed. Discharge of these media may be accompanied by noise and misting of the atmosphere.

13.1.2 Carbon dioxide. Carbon dioxide is a colourless, odourless gas normally present in the atmosphere at a concentration of 0.03 % (V/V). At concentrations in the range 5 % (V/V) to 10 % (V/V), breathing becomes increasingly more difficult, and a 10 % (V/V) concentration may be regarded as the danger level for most people, though some people are more tolerant to carbon dioxide than others. A concentration of 10 % (V/V) is sufficient to cause unconsciousness if breathed for some minutes (about 10 min), and if not removed the subject could die.

Removal to fresh air will usually result in full recovery. Fire extinguishing concentrations of 30 % (V/V) or more carry the risk of almost immediate asphyxiation.

³⁾ Available from HMSO.

13.1.3 Halon 1211. The vapour of Halon 1211 has no smell and gives no warning of its presence in the unpyrolized state. Animal and human experiments have suggested that the maximum concentration of Halon 1211 to which people can be exposed without ill effect is approximately 4 % (V/V) to 5 % (V/V) for 1 min. At higher concentrations or for longer exposures, narcotic effects can occur such as dizziness, impaired coordination and reduced mental activity, with a risk of irregular heart action, particularly in cases where the adrenalin level is raised. People should never be exposed to the design extinguishing concentrations of 5 % (V/V) to 8 % (V/V).

The thermal decomposition products of Halon 1211 are considerably more hazardous than the undecomposed gas. If detection and extinction of a fire is rapid, as it is intended to be, the concentration of such products will be low of the order of a few p.p.m., and the hazard will not be great. Great care should be taken to avoid exposure to these decomposition products after extended fire-fighting operations against a deep-seated fire where their concentration could be much greater. The decomposition products have a characteristic sharp, acrid odour even in minute concentration which provides a built-in warning system, but at the same time creates a noxious, irritating atmosphere for those who have to enter the hazardous area following a fire.

13.1.4 Halon 1301. The vapour of Halon 1301 has no smell and gives no warning of its presence in the unpyrolized state. Current knowledge suggests that exposure to 5 % (V/V) to 7 % (V/V) concentration of Halon 1301 for up to 10 min gives no ill effects. At higher concentrations or for longer exposures, narcotic effects can occur, such as dizziness, impaired coordination and reduced mental activity, with a risk of irregular heart action, particularly in cases where the adrenalin level is raised. The recommended minimum design concentrations for flame extinction range from 5 % (V/V) to 8 % (V/V), and for inerting up to 10.7 % (V/V). It is recommended that where concentrations greater than 6 % (V/V) are to be applied, the protected volume should be evacuated.

The decomposition products of Halon 1301 on a fire create similar hazards to those of Halon 1211 and the precautions recommended in **13.1.3** should be taken.

13.1.5 Nitrogen. Nitrogen is a colourless, odourless gas which does not support life, and which comprises some 79 % (V/V) of the air, the remaining 21% (V/V) being mainly oxygen. To reduce this 21% (V/V) to the 14 % (V/V) necessary to subdue flaming combustion requires an addition of nitrogen equal to about 50 % (V/V) of the total air present, assuming complete mixing, giving a final proportion of 86 % (V/V) nitrogen, which is sufficient to cause asphyxiation in humans. It follows that the use of nitrogen as an extinguishing or inerting gas in an enclosure makes it imperative that no persons are present at the time of discharge.

13.2 Effects on materials

The gaseous media do not adversely affect materials provided they are discharged in a manner that does not cause sudden cooling of sensitive electronic and other equipment. They are all "clean" and do not leave any residual deposits that require cleaning up after extinction, nor do they cause subsequent corrosion of the affected materials.

14 Foams

14.1 Effects on people

The accepted foaming solutions are not toxic to humans, neither are they likely to be a danger to respiration when applied as a surface layer or foam spray.

There is one situation, however, where medium or high expansion foams can be a danger. This occurs where the foam is being applied to fill an enclosure or volume, so as to provide an extinguishing facility over a substantial depth, i.e. more than 1 m, and particularly where the full depth is greater than 2 m. In such circumstances, personnel can strike hidden objects when moving towards exits and, where the depth is above their heads, can lose vision and hearing and become disorientated. Where the foam layer is substantially, i.e. 0.5 m or more, above the head, it is difficult to prevent foam entering the lungs and causing asphyxia. It is imperative, therefore, that in total flooding systems, warning is given to personnel to evacuate an enclosure before discharge occurs, and that adequate time is given for them to do so.

Foam solutions conduct electricity in just the same way as water supplies with dissolved salts will do. The specific resistance of the solution should be checked to determine the degree of risk. Aerated foam is less conductive than the foam solution, the specific resistance increasing linearly with the expansion.

14.2 Effects on materials

Most foam solutions can cause corrosion, even if only by removing the grease layer from a metal. Some of the low expansion foam concentrates are corrosive to specific materials. It is therefore necessary to establish that the foam concentrate selected does not have an adverse effect on the system in which it is used. This is best achieved by reference to the foam manufacturer, who can do check tests where necessary. Valuable equipment wetted by foam in the course of fire-fighting should be carefully cleaned afterwards, particularly if its subsequent corrosion is likely to affect its life or operation.

15 Powders

15.1 Effects on people

Most of the extinguishing powders commonly used against class A, B or C fires are not toxic to humans. When powders are discharged from a total flooding system, it is desirable that the personnel present should either leave the enclosure or take precautions against inhalation of the powder. Powder discharge will markedly reduce visibility, so that evacuation should be before discharge of the powder.

Powders specifically designed to be used against class D fires (particularly those for the radioactive metals) are intended to be used under controlled conditions where they will not be inhaled. Some of them are toxic, and all should be treated with caution. It is strongly recommended that personnel in affected areas wear appropriate respiratory protection.

15.2 Effects on materials

Extinguishing powders discharged on to equipment will cling to metal and painted surfaces, grease films, etc. and in combining with the moisture of the atmosphere will become mildly corrosive. Many powders have the effect of removing painted layers. ABC powders melt on to hot surfaces and after cooling the hardened coating may be difficult to remove. Equipment contaminated with powder should be cleaned as soon as possible.