BRITISH STANDARD

BS 5306-6.2: 1989

Fire extinguishing installations and equipment on premises —

Part 6: Foam systems —

Section 6.2 Specification for medium and high expansion foam systems

UDC 614.842.6:614.844.5

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/13, upon which the following bodies were represented:

Association of Metropolitan Authorities
British Automatic Sprinkler Association
British Fire Protection Systems Association Ltd.
British Fire Services' Association
British Gas plc
British Nuclear Fuels Limited
Chief and Assistant Chief Fire Officers' Association
Confederation of British Industry
Convention of Scottish Local Authorities
Department of Health and Social Security
Department of the Environment, Building Research Establishment (Fire Research Station)
Department of the Environment (Property Services Agency)
Department of Transport (Marine Directorate)
Electricity Supply Industry in England and Wales
Engineering Equipment and Materials Users' Association
Fire Brigades Union
Fire Extinguishing Trades Association
Health and Safety Executive
Hevac Association
Home Office
Incorporated Association of Architects and Surveyors
Institution of Fire Engineers
Institution of Gas Engineers
Loss Prevention Council
Ministry of Defence
Royal Institute of British Architects
Society of Fire Protection Engineers
Society of Motor Manufacturers and Traders Limited
United Kingdom Atomic Energy Authority

This British Standard, having been prepared under the direction of the Fire Standards Policy Committee, was published under the authority of the Board of BSI and comes into effect on 31 January 1989

The following BSI references relate to the work on this standard:
Committee reference FSM/13
Draft for comment 87/44827 DC

ISBN 0 580 17018 7

Amendments issued since publication

Amd. No.	Date of issue	Comments

Contents

Foreword

This Section of BS 5306 has been prepared under the direction of the Fire Standards Policy Committee.

The other Parts of BS 5306 in preparation or published are as follows:

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

— *Part 1: Hydrant systems, hose reels and foam inlets;*

— *Part 2: 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 5.1: Halon 1301 total flooding systems;*

— *Section 5.2: Halon 1211 total flooding systems;*

— *Part 6: Foam systems;*

— *Section 6.1: Specification for low expansion foam systems;*

— *Part 7: Specification for powder systems.*

Medium and high expansion foam systems are designed to provide a supply of foam for the extinction of fire.

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 these recommendations.

To comply with this standard, 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 reason for doing so.

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 foam systems and equipment, for whose guidance it has been prepared.

A classification of foam concentrates is given in Appendix A.

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 and ii, pages 1 to 22, 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. Foam systems can form only a part, though an important part, of the available facilities, but it should not be assumed that their provision necessarily removes the need to consider other 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.

Foams have for many years been recognized effective media for the extinction of fires. In particular, medium expansion foams have been developed for the extinction of both flammable liquid and solid fuel fires, and high expansion foam for use against solid fuel fires and to a lesser extent flammable liquid fires. In the planning of a comprehensive fire protection scheme, it should not be forgotten that there may be hazards for which foams are *not* suitable or there may be dangers in their use which require 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 to BS 5306-0 and as necessary to other Parts of this standard.

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 Section of BS 5306 specifies requirements and gives recommendations for the design, installation and maintenance of fixed and semi-fixed systems; ancillary portable or transportable equipment provided as part of a pre-planned scheme for applying medium and high expansion foam to fires in buildings, industrial plant and storage facilities.

Application rates are specified for medium expansion foam to flammable liquid fires, and for high expansion foam to flammable liquid fires and combustible solid fires.

NOTE 1 Unless otherwise specified in this standard all pressures are gauge pressures and are expressed in bars
$1 \text{ bar} = 10^5 \text{ N/m}^2 = 10^2 \text{ kPa}$.

NOTE 2 The titles of the publications referred to in this standard are listed on the 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
competent person

a person capable of carrying out the inspection and maintenance procedures of clause **11**, by reason of experience and access to the requisite information, tools and equipment

2.2
concentration

the ratio of foam concentrate in the foam solution usually expressed as a percentage by volume

2.3
expansion (expansion ratio)

the ratio of the volume of aerated foam to the volume of foam solution from which it was made

2.4
high expansion foam generator

a foam-making component in which air is forced through a gauze screen that is sprayed with foam solution to make the foam

2.5
medium expansion foam branchpipe

a hand-held self-aspirating foam-making component that produces foam with an expansion in the range 21 to 200

2.6
medium expansion foam monitor

a self-aspirating foam-making component that produces foam with an expansion in the range 21 to 200, at a rate of substantially greater than that of a hand-held branchpipe

NOTE A monitor is usually supported on a swivel mounting which is either connected to fixed pipework or may be mounted on a mobile wheeled or skid unit.

2.7
self-aspirating foam-making component

foam-making component in which air is induced by the discharge of foam solution from a nozzle or nozzles within the equipment. The induced air is mixed intimately with the foam solution within the equipment to produce the foam

2.8
user

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

3 Characteristics of medium and high expansion foam

3.1 General

Foam systems shall produce foam as an aggregate of gas filled bubbles from an aqueous solution of a foam concentrate.

COMMENTARY AND RECOMMENDATIONS ON **3.1**. *The gas is usually air.*

3.2 Uses

The requirements of this standard apply to medium and high expansion foams suitable for extinguishing fires in combustible solids, flammable liquids, or combinations of both.

COMMENTARY AND RECOMMENDATIONS ON **3.2**. *Medium expansion foam may be used on combustible solids up to a height of about* 3 m, *either by direct application to the solid surfaces or by total submersion. It operates by excluding air from the combustibles, and by wetting down the burning surfaces. It is useful in outdoor conditions, for example on bund fires, provided the wind speed is not greater than about* 10 m/s *and is not gusty. The foam may be laid gently upon the surface of a fire, or can be projected as a stream, according to the design of the application equipment.*

Medium expansion foam is effective on hydrocarbon liquid fires but, except for the alcohol resistant type, is generally not suitable for use on foam destructive liquids which cause rapid breakdown of the foam.

High expansion foam is used most effectively in indoor spaces where it can be used to submerge a combustible solid or flammable liquid fire and exclude the air needed for combustion. Because it has a relatively low water content per unit volume it does not have a great cooling effect, e.g. on solid surfaces, and the extinction process therefore depends mostly on smothering the fire. It is capable of extinguishing fires of considerable vertical extent, e.g. in high-racked storages up to at least 10 m, *provided that the foam can be applied from above the fire site and horizontal transit to the site is minimized. Some destruction of the foam by the fire will occur which can be compensated by an increased application rate. A solid fuel fire submerged in high expansion foam is not necessarily extinguished quickly, but can smoulder beneath the foam surface for a considerable time until the drainage of water from the foam cools the combustible surfaces to below ignition temperature. High expansion foam is most valuable in total flooding of places where it is inadvisable for personnel to go during firefighting, e.g. in underground storage facilities or basements.*

3.3 Expansion

3.3.1 *Medium expansion foam.* Medium expansion foam shall have an expansion between 21 and 200.

3.3.2 *High expansion foam.* High expansion foam shall have an expansion between 201 and 1 000.

COMMENTARY AND RECOMMENDATIONS ON **3.3**. *Foams are arbitrarily subdivided into three ranges of expansion.*

Low expansion foam (LX): expansion up to 20

Medium expansion foam (MX): expansion 21 to 200

High expansion foam (HX): expansion 201 to 1 000

3.4 Application method

3.4.1 *Medium expansion.* Medium expansion foams shall be applied:

a) gently to the surface of a flammable liquid or solid combustible fire; or

b) by means of a medium expansion foam branchpipe or monitor.

COMMENTARY AND RECOMMENDATIONS ON **3.4.1**. *The first method is suitable for fixed systems where the location, size and shape of the hazard is known, and the system can be designed to meet this requirement. The second method is more appropriate where the size and location of the hazard may vary with circumstance, and needs to be dealt with by a more flexible approach.*

3.4.2 *High expansion.* High expansion foams shall be applied:

a) by filling the volume in which the fire occurs; or

b) by guiding a wall of foam in the direction of a localized fire, in order to submerge and suppress it.

The foam may be introduced directly, or through flexible ducting.

COMMENTARY AND RECOMMENDATIONS ON **3.4.2**. *High expansion foam, by its nature, can only be applied gently to fires. Method a) is generally preferable as the water content of the foam needs to be retained as far as possible to ensure heat resistance at the fire. Horizontal movement at floor level promotes water drainage and degrades the foam quality. To make high expansion foam effective in large compartments and up to heights of* 10 m, *flexible barriers may be used to retain the foam in the required area and to permit its fast build up to the required height. Wherever possible foam should be applied at a high level, i.e. above the level of foam in the fire space.*

3.5 Potential hazards

Foam systems shall include provision to minimize the danger when foam is applied to liquids above 100 °C, energized electrical equipment or reactive materials.

COMMENTARY AND RECOMMENDATIONS ON **3.5**. *Since all foams are aqueous solutions, their application to burning flammable liquids in depth, where the temperature of the liquid exceeds* 100 °C, *may be accompanied by the danger of frothing or slop-over of the burning liquid, due to the boiling of the water draining from the foam, as it passes through the hot layers of liquid. This danger will apply to medium expansion foam as well as to low expansion foam (see BS 5306-6.1), but is is probable that in these circumstances, the lower water content of the medium expansion foam may be largely evaporated on contact with the flammable liquid surface, reducing the danger significantly. High expansion foam is not used in this type of application.*

Because foams are made from aqueous solutions, they may be dangerous to use on materials which react violently with water, such as sodium or potassium, and should not be used when these are present. A similar danger is presented by other metals, such as zirconium or magnesium, only when they are burning.

Medium and high expansion foams are electrically conductive, and should not be used on energized electrical equipment, where this would be a danger to personnel (see ***19.6****).*

Personnel should not enter spaces filled with high expansion foam see ***19.6****).*

3.6 Compatibility with other extinguishing media

The foam produced by the system shall be compatible with any media provided for application at or about the same time as foam.

COMMENTARY AND RECOMMENDATIONS ON **3.6**. *Certain wetting agents and some extinguishing powders may be incompatible with foams, causing a rapid breakdown of the latter. Only media that are substantially compatible with a particular foam should be used in conjunction with it.*

Water jets or sprays may adversely affect a foam blanket, but the simultaneous application of water from sprinklers can be beneficial provided that allowance is made for the increased breakdown of foam (see commentary and recommendations on ***19.4****).*

3.7 Compatibility of foam concentrates

Foam concentrate (or solution) added or put into a system shall be suitable for use and compatible with any concentrate (or solution) already present in the system.

COMMENTARY AND RECOMMENDATIONS ON **3.7**. *Foam concentrates, and foam solutions, even of the same class, are not necessarily compatible, and it is essential that compatibility be checked before mixing two concentrates or premixed solutions.*

4 Classification of flammable liquids

4.1 Flashpoint

For the purposes of this standard flammable hydrocarbon liquids are classified into those with:

a) flash points up to and including 40 °C;

b) flash points above 40 °C.

when determined in accordance with BS 2000-34.

COMMENTARY AND RECOMMENDATIONS ON **4.1**. *It is important to note that other classifications may use different methods of flash point determination and divide the classes at other temperatures.*

Tanks containing liquids with flash points much above 60 °C *are not normally protected by fixed foam systems unless these liquids are heated above ambient temperature.*

4.2 Foam destructiveness

For the purposes of this standard when considering foam destructiveness, flammable liquids are considered as falling into two groups:

a) hydrocarbons, and those non-hydrocarbon liquids which are not more foam destructive than hydrocarbons;

b) foam destructive liquids, which are generally water soluble and which are much more foam destructive than hydrocarbons.

COMMENTARY AND RECOMMENDATIONS ON **4.2**. *Special types of concentrate are used for foam destructive liquids. Higher rates of application are specified for foam destructive liquids than for hydrocarbons and it is usually essential to use gentle application methods.*

The degree of foam destructiveness varies however, and isopropyl alcohol, butyl alcohol and isobutyl methyl ketone, methyl methacrylate monomer and mixtures of water-miscible liquids in general may require higher application rates.[1]*Protection of products such as amines and anhydrides which are particularly foam destructive require special consideration.*

[1] The preferred names for isopropyl alcohol, butyl alcohol and isobutyl methyl ketone are propan-2-ol, butan-1-ol and 4-methylpentane-2-one respectively.

5 Types of system

5.1 General

For the purposes of this standard foam systems are considered as being of the fixed, semi-fixed, portable or transportable type and shall comply with **5.2** to **5.5** as appropriate.

COMMENTARY AND RECOMMENDATIONS ON **5.1**. *A foam system consists of a water supply, a supply of foam liquid concentrate, a device to proportion correctly the water and foam concentrate, and pipework or hose connected to equipment to make and to distribute foam over the hazard.*

Self-contained systems are those in which all components and water and foam concentrate, separately or as premixed solution, are contained within the system. Such systems usually use compressed gas to provide pressurization at the time of operation.

5.2 Fixed systems

Fixed systems shall have permanent pipework connecting the water supply via the fire water pump (if fitted) and foam liquid proportioning device to the foam maker(s) which protect the hazard.

5.3 Semi-fixed systems

Semi-fixed systems shall have permanent pipework from the foam maker(s) which protect the hazard to an area, adjacent to the hazard, where it is considered safe for personnel to conduct fire fighting operations.

COMMENTARY AND RECOMMENDATIONS ON **5.3**. *This pipework may include the proportioning device. The water supply to the pipework is via hoses and is usually pumped by mobile fire appliances. The area adjacent to the hazard should be outside any bunded area and at least one tank diameter or* 15 m, *whichever is the greater, from any tank. The inlet to the fixed pipework should be fitted with corrosion resistant metal connections provided with plugs or caps and should be marked by a notice reading "Foam inlet — for firefighting use only".*

5.4 Portable systems

Portable systems shall have foam producing equipment that can be carried by one or more men and connected via fire hose to a pressurized water or premixed solution supply.

5.5 Transportable systems

Transportable systems shall have foam producing equipment mounted on wheels or skids.

COMMENTARY AND RECOMMENDATIONS ON **5.5**. *These may be self-propelled, towed by a vehicle or pushed by hand. These units are for connection via hoses to a water or foam solution supply.*

6 Planning

Where a foam extinguishing system is being considered for new or existing buildings or plant the following shall be consulted:

a) the fire authority;

b) other appropriate public authorities;

c) the insurers.

COMMENTARY AND RECOMMENDATIONS ON CLAUSE **6**. *The authorities mentioned above should be informed as early as possible of the type of foam 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 which should be co-ordinated in the planning stages of the contract.*

Section 2. Contract arrangements

7 Contract drawings

Prior to installation, contract drawings and specifications shall be prepared and submitted to the relevant authority for approval. 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 present, 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 following details of the proposed system shall be included on the contract drawings:

a) the purpose and function of the system;

b) the application rate and the duration of discharge of the system, and the appropriate minimum values of this standard;

c) hydraulic calculations;

d) the pipework including support details;

e) the detection system layout (if specified) and method of operation;

f) the type, location and spacing of foam discharge devices;

g) the type and location of foam proportioning devices;

h) the source of water and quantity needed;

i) the quantity and type of foam concentrate, its design concentration, the method of storage and the quantity to be held in reserve.

8 Extensions and alterations

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

COMMENTARY AND RECOMMENDATIONS ON CLAUSE **8**.
Any extension or alteration to the foam installation should be carried out by the installer or his agent. The organization that services the system and the relevant authorities should be notified promptly of any alteration.

The effect on available water supply and minimum required quantity of foam concentrate should be considered at the design stage of extension or alteration to a system, and full hydraulic calculations should be carried out on the new system layout prior to commissioning.

9 Commissioning and acceptance tests

9.1 General

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.

9.2 Inspection

A visual inspection shall be conducted to ensure that the system has been installed correctly. All normally dry horizontal pipework shall be inspected for drainage pitch (see **16.2.4**).

COMMENTARY AND RECOMMENDATIONS ON **9.2**.
Inspection should check for conformity with design drawings and specifications, continuity of pipework, removal of temporary blinds, accessibility of valves, controls and gauges and proper installation of foam makers, vapour seals and proportioning devices. All equipment should be checked for correct identification and operating instructions.

Water supply pipework, both underground and above ground, should be flushed thoroughly at the maximum practicable rate of flow, before connection is made to system piping, in order to remove foreign materials which may have entered during installation or which may have accumulated in the mains systems at lower rates of flow. The minimum rate of flow for flushing should be not less than the water demand rate of the system.

Foam concentrates have a lower surface tension than water, and they may cause internal pipe scale or sediment to loosen with the risk of blockage of sprayers, proportioning equipment, etc. Pipes and fittings should be carefully cleaned before assembly and any loose jointing material should be removed.

All foam system piping should be flushed after installation, using its normal water supply without foam concentrate or solution, unless the hazard cannot be subjected to water flow. The flow should be continued for a sufficient time to ensure thorough cleaning. Flushing water should be disposed of outside the system. Where flushing cannot be accomplished, pipe interiors should be carefully examined for cleanliness during installation.

9.3 Pressure tests

Except where the user agrees otherwise, all pipework shall be subjected to a hydrostatic pressure test at 1.5 times the maximum pressure anticipated for a period of 1 h. There shall be no permanent distortion or rupture.

COMMENTARY AND RECOMMENDATIONS ON **9.3**. *There should be no substantial leakage during this test.*

9.4 Discharge tests

If requested by the user, a full scale discharge test shall be conducted to ensure that the system discharges at the design rate, functions in accordance with all other design requirements, and produces and maintains an even foam blanket over the surfaces to be protected, or within the volume to be filled.

COMMENTARY AND RECOMMENDATIONS ON **9.4**. *The tests should be carried out by competent persons.*

Discharge tests should be carried out wherever possible. Wind, and obstructions such as pipework, pumps, motors, vessels, may hinder the development of an even foam blanket. Particular checks should be made during the discharge tests to ensure that these factors have been taken properly into account.

Water may be used instead of foam solution for some tests to avoid the need of extensive cleaning of the system after tests.

The inspections and tests should cover:

a) *rate of application of foam solution;*

b) *foam expansion;*

c) *foam distribution;*

d) *running pressures;*

e) *concentration of the foam solution;*

f) *manpower requirements;*

g) *rate of foam production [by calculation from a) and b)].*

9.5 System restoration

After completion of the acceptance tests, the pipework shall be flushed, strainers and foam making gauzes inspected and cleaned and the system restored to operational condition.

9.6 Completion certificate

The installer shall provide to the user a completion certificate stating that the system complies with all the appropriate requirements of this standard, and giving details of any departure from appropriate recommendations.

Section 3. Periodic inspection, testing and maintenance

10 Inspection

10.1 General

The user shall carry out a programme of inspection and arrange a service and maintenance schedule, and keep records of the inspections, servicing and testing, and personnel training.

COMMENTARY AND RECOMMENDATIONS ON **10.1**. *The continued capability for effective performance of foam systems depends on fully adequate maintenance procedures with, where possible, periodic testing. The many variations in system design and equipment applications make it impossible to recommend anything other than general purpose procedures for periodic inspection.*

The installer should provide to the user a logbook in which records can be entered.

10.2 User's programme of inspection

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

COMMENTARY AND RECOMMENDATIONS ON **10.2**. *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. Carry out a visual check that there are no leaks or obvious damage to pipework; all operating controls and components are properly set and undamaged; the water supply is available and at the right pressure.*

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.*

11 Service and maintenance schedule

The schedule shall be carried out by a competent person who shall provide to the user a signed, dated report of the inspection and advising any rectification carried out or needed.

COMMENTARY AND RECOMMENDATIONS ON CLAUSE **11**. *A suitable schedule is as follows.*

a) *Every three months. Test and service all electrical detection and alarm systems as recommended in BS 5839-1.*

b) *Every six months*

1) *Foam producing equipment. Inspect proportioning devices, their accessory equipment and foam makers for mechanical damage, corrosion, blockage of air inlets and correct manual function of all valves. This may necessitate the temporary isolation of the water main.*

2) *Pipework. Examine externally above ground pipework to determine its condition and that proper drainage pitch is maintained. Hydraulically pressure test normally dry pipework when visual inspection indicates questionable strength due to corrosion or mechanical damage.*

3) *Strainers and foam making gauzes. Inspect and clean strainers and foam making gauzes. This is essential after use of the system and after any flow test.*

4) *Valves. Check all control valves for correct manual function and automatic valves additionally for correct automatic operation.*

5) *Tanks. Visually inspect all foam concentrate and foam solution tanks, without draining; check shipping containers of concentrate for evidence of deterioration.*

c) *Every twelve months. Test the foam concentrate or solution for changes in constitution or characteristics and the formation of sediment or precipitate. Correct any deterioration according to the manufacturers' recommendations.*

d) *As required by statutory regulations but otherwise as and when convenient. Internally inspect all tanks.*

Section 4. System design

12 General

The system shall be designed to suit the particular hazard, and the following shall be considered when preparing the design:

a) full details of the solid combustibles and/or flammable liquids, their methods of storage and packaging, handling and location;

b) the most suitable class of foam concentrate, concentration and solution application rate;

c) the most suitable method of application of the foam, and the most suitable equipment to provide this method, including the method of proportioning;

d) the quantity of foam concentrate required for extinction, including back-up supplies where extended application is necessary for concealed or prolonged fires;

e) the required system operation time taking into account item d);

f) the quantity of foam concentrate to be held in reserve;

g) water supply quantity, quality and pressure;

h) pipework sizes and pressure losses;

j) method of system operation, and any fire or gas detection equipment required; need for a manual override where personnel may be present;

k) any special considerations, e.g. the need to use flameproof electrical equipment where flammable vapours may be present;

l) drainage and bunds;

m) environmental conditions.

13 Foam quality

The expansion values of foam produced by a system shall be within the appropriate limits of **3.3.1** or **3.3.2** when tested in accordance with Appendix C.

14 Water supplies, pumps and drainage

14.1 Quantity, pressure and flow rate

The water supply shall provide the total quantity, flow rate and supply pressure specified for the foam system and for any other fire protection systems which may be used simultaneously with it, for the specified discharge times.

COMMENTARY AND RECOMMENDATIONS ON **14.1**. *The supply may be reduced by drought or by freezing, or where process water is used to maintain normal working conditions, e.g. for cooling reactors.*

Where the primary source is not capable of meeting the system design requirements at all times, storage facilities should be used to meet the shortfall. Consideration should be given to duplication of the water supply pipework, or the use of a ring main system so that the effects of interruptions in the main supply are minimized.

14.2 Quality

The selected source of water shall be suitable for use with the system and foam concentrate.

COMMENTARY AND RECOMMENDATIONS ON **14.2**. *Suitable sources are public or town mains, rivers, lakes, the sea, wells, canals, storage tanks, water impounded by dams and process water. A pump may be necessary for the use of any of these sources and in the case of sea water, special precautions will be necessary to combat corrosion and the development of marine life, especially at the intakes. In the case of tidal waters, particular provision should be made for the variation in level, and the need to avoid cavitation.*

Sea water, or chemical treatment and other contaminants of the water supply, can affect foam quality. If non-potable water is to be used the foam concentrate supplier should be consulted.

The recommended range of water temperature is between 5 °C *and* 38 °C. *Outside this temperature range foam performance may be impaired.*

Precautions should be taken to prevent freezing, taking into account the combined effect of low temperature and high wind.

Where solids of sufficient size to obstruct openings in the foam equipment may be present, strainers should be provided.

14.3 Water pumps

The pump shall supply water to the inlet of the foam system within the range of flow and pressure for which the system is designed.

Switches on the electricity supply circuit to the motor shall be clearly labelled with the following words on a sign complying with BS 5499-1:

> "Fire equipment — pump motor supply — not to be switched off."

The lettering shall be white on a red background and lower case except for the initial letter "F". The letter height shall be not less than 15 mm.

The electricity supply circuit shall have means of short circuit protection.

COMMENTARY AND RECOMMENDATIONS ON **14.3**. *Pumps providing a water supply to foam equipment should be correctly sized, so that at maximum demand they operate below their overload characteristic. They should be capable of operating satisfactorily following long periods of inactivity.*

Where an alternative water supply is available a single pump may be used, otherwise multiple pump arrangements are preferred to improve reliability.

Diesel engines are preferred to electric motors for driving pumps. The use of one diesel driven and one electrically driven pump of appropriate size is an acceptable arrangement.

The electric power supply to a pump should be a separately switched circuit; where only electric pumps are used an alternative independent supply of electric power should be provided.

Means should be provided for starting the pumps manually, in addition to any automatic means of starting. For electric pumps this should be a manual switch and for diesel engined pumps an electric starter with manual switch or a manually operated mechanical starter.

14.4 Drainage of bunds

Drains and interceptors in bunded areas shall be of adequate capacity to carry the anticipated drainage of water used in fire fighting.

15 Foam concentrate and solution

15.1 General

Foam concentrate used in the system shall be classified as described in Appendix A. The nominal concentration of use shall be not less than that recommended by the manufacturer, and when the system is operating at the design application rate the actual concentration, when determined in accordance with Appendix D_1 shall be:

a) for a nominal percentage concentration equal to or greater than 5 %, within one percentage point of the nominal concentration, i.e. $C \pm 1$.

b) for a nominal percentage concentration less than 5 %, but not less than 3 %, within one percentage point of, and no less than, the nominal concentration, i.e. C^{+1}_{-0}.

c) for a nominal percentage concentration less than 3 %, within 0.25 of a percentage point of, and no less than, the nominal concentration, i.e. $C^{+0.25}_{-0}$.

Premixed foam solution used in the system shall have a concentration within the range 0.9 to 1.1 times the value specified by the manufacturer when determined in accordance with Appendix D.

The nominal concentration of use of mixtures of foam concentrates shall be not less than the higher or highest value recommended by the manufacturer or manufacturers.

15.2 Storage

15.2.1 Foam concentrate or premixed solution shall be stored at an accessible location not exposed to the hazard it protects. The material of construction of any building shall be non-combustible when tested in accordance with BS 476-4.

COMMENTARY AND RECOMMENDATIONS ON **15.2.1**. *Foam concentrate in shipping containers and in storage tanks should be stored in accordance with the manufacturer's recommendations. Exposure to extreme heat, cold, contamination, or mixing with other materials should be avoided.*

Storage containers should be sited where they will be readily accessible for inspection, testing, recharging or maintenance with the minimum of interruption of protection.

15.2.2 Means shall be provided to ensure that the concentrate or premixed solution is kept within its design operating temperature range.

15.2.3 Storage vessels shall be clearly marked with the class of concentrate and its grade (concentration in the foam solution).

15.2.4 Storage tanks shall have sufficient ullage to accommodate thermal expansion of the concentrate or solution.

15.2.5 Only suitable concentrates shall be stored as premixed solutions.

COMMENTARY AND RECOMMENDATIONS ON **15.2.5**. *Not all foam concentrates are suitable for storage as a premixed solution and the manufacturer's advice should be sought and followed. High storage temperatures tend to accelerate any deterioration due to ageing of the solution.*

For smaller risks a pressure tank is usually used to provide a quick acting automatic system. Nitrogen, carbon dioxide or water is used to expel the contents.

15.3 Supply of foam concentrate for recommissioning after use

A reserve supply of foam concentrate shall be available to enable the system or systems to be put back into service within 24 h of operation.

COMMENTARY AND RECOMMENDATIONS ON **15.3**. *This supply may be stored in separate tanks, in drums or cans on the premises, or be available from an outside source.*

Adequate loading and transportation facilities should be assured at all times.

Other equipment which may be necessary to recommission the system, such as bottles of nitrogen or carbon dioxide for premix systems, should also be readily available.

15.4 Foam concentrate pumps

Pumps for foam concentrate shall be self-priming or flooded-suction pumps, driven by a suitable prime mover which is constantly available.

Pumps shall have adequate capacity to meet the maximum system requirements. To ensure positive injection, the discharge pressure rating at design discharge capacity shall be sufficiently in excess of the maximum water pressure under any condition at the point of injection of the concentrate.

Pumps shall be provided with adequate means of pressure and flow relief from the discharge to the suction side of the circuit to prevent excessive pressure and temperature.

Pumps that stand dry shall have means provided for flushing with clean water after use. They shall be provided with a draindown valve.

COMMENTARY AND RECOMMENDATIONS ON **15.4**. *Gaskets and seals should be resistant to the foam concentrate.*

Materials of construction should be suitable for use with the type and grade of foam concentrate without risk of corrosion, foaming or sticking.

16 Components and pipework

16.1 Components

System components shall be installed as recommended by the manufacturer.

COMMENTARY AND RECOMMENDATIONS ON **16.1**. *Account should be taken of the manufacturer's recommendations regarding associated components and equipment, so that only compatible components are used in the system.*

16.2 Pipes, connections and valves

16.2.1 *Protection from fire damage*

16.2.1.1 *General.* Valves and connections in the pipework to the hazard shall be located outside the hazard area or shall comply with **16.2.1.3**.

16.2.1.2 *Outside the hazard area.* Pipes, connections and valves shall be suitable for hydraulic or compressed gas use as appropriate at the maximum operating pressure.

16.2.1.3 *Inside the hazard area.* Pipe shall be of metal suitable for the pressure and temperature involved. Connections shall be welded, flanged or screwed with a taper thread. Where gaskets are required, they shall be fabricated from a material which is non-combustible when tested in accordance with BS 476-4.

COMMENTARY AND RECOMMENDATIONS ON **16.2.1**. *In locations where pipework may be exposed to fire or explosion, it should be routed to afford the best protection against damage. This can be accomplished by running it close to major structural members. In such locations, special consideration should be given to the spacing and type of pipe supports used.*

16.2.2 *Condition.* Pipework systems shall be either fully charged with liquid or dry.

COMMENTARY AND RECOMMENDATIONS ON **16.2.2**. *This is to minimize situations when there may be an air/liquid interface in a line or valve.*

16.2.3 *Pipe size.* The pipework shall be sized to ensure that pressure losses are kept within design limits and that a reasonably uniform distribution is obtained from foam outlets.

16.2.4 *Drainage.* All piping which is normally dry shall be arranged to drain and shall have a minimum pitch towards the drain of 1 in 120.

Drain valves shall be provided for premixed solution or foam pipework at low points, whether below or above ground.

COMMENTARY AND RECOMMENDATIONS ON **16.2.4**. *Systems installed to apply foam to hazards where the application of water would cause adverse effects should be provided with a pipe with means to drain away any initial discharge of water or incompletely formed foam.*

16.2.5 *Corrosion protection for foam pipework*

16.2.5.1 *Internal protection.* Pipework shall be of a material, or have a protective lining, which is compatible with the concentrate or premixed solution being used.

COMMENTARY AND RECOMMENDATIONS ON **16.2.5.1**. *Normally dry pipework may be galvanized providing that it is well flushed through after use (see **16.6**).*

Normally wet pipework should not be galvanized as there may be a reaction with the foam concentrate or premix solution. Corrosion resistant material such as a suitable plastics or stainless steel may be used, or the pipework may be protected with a suitable coating. Unlined steel or cast-iron pipework may not be suitable for wet use unless flushed periodically.

16.2.5.2 *External protection.* Pipework shall be of a material suitable for exterior use in the prevailing atmosphere of the hazard, or shall be given a suitable protective coating.

COMMENTARY AND RECOMMENDATIONS ON **16.2.5.2**. *Steel pipework should be protected by painting with red oxide primer, undercoat and two topcoats, or equivalent.*

The use of dissimilar metals should be avoided to limit electrolytic action and non-conducting separating means should be used in the joint between any which are used.

16.3 Valves

Valves shall comply with BS 5153, BS 5155, BS 5160 or BS 5163.

16.4 Pipe and pipe fittings

Pipework shall be able to withstand the expected pressures and temperatures without damage. Fittings shall be screwed or welded.

COMMENTARY AND RECOMMENDATIONS ON **16.4**. *Pipe complying with BS 1387, BS 3601, API 5L, ASTM A53-84, ASTM A120-84 or ASTM 135-84 is suitable.*

Fittings complying with BS 143 and BS 1256, BS 1560, BS 1640, BS 1740 or BS 3799 are suitable.

16.5 Colour coding of pipework

The pipes shall be colour coded in accordance with any scheme for pipework that may be in use on the premises.

COMMENTARY AND RECOMMENDATIONS ON **16.5**. *Where possible the pipes should be signal red (reference 537 of BS 381C equivalent to 04E53 of BS 5252) or colour coded in accordance with BS 1710.*

16.6 Flushing

Provision shall be made for flushing with clean water any lines that are normally empty but that have contained foam concentrate, premix solution or foam after use or test of the system.

16.7 Strainers

A strainer shall be fitted where a 9.5 mm sphere will not pass through the waterways.

COMMENTARY AND RECOMMENDATIONS ON **16.7**. *Strainers should be provided in the line upstream of foam-making equipment where this appears desirable.*

16.8 Low temperature

Pipes that are normally wet shall be protected against freezing of their contents where ambient temperatures below 5 °C may be experienced.

17 Operation

17.1 Method

Foam systems shall be manually or automatically/manually operated. All systems shall give an audible alarm on operation, and where the building is provided with a main fire alarm system shall operate that alarm system.

COMMENTARY AND RECOMMENDATIONS ON **17.1**. *The choice of method of operation will be governed by the potential rate of fire development, the likelihood of spread to other risks, and the degree of life hazard.*

Automatic operation is to be preferred where rapid escalation or spread of fire is likely, especially for indoor hazards where heat and products of combustion will not disperse as readily as outdoors.

All operating devices whether manual or automatic should be suitable for the service conditions they will encounter. They should not be readily rendered inoperative, nor be susceptible to inadvertent operation, as a result of relevant environmental factors such as high or low temperature, atmospheric pollution, humidity, or marine environments.

A visual alarm should also be provided where sounding of the audible alarm might not be apparent.

17.2 Operating instructions and training

Operating instructions for the system shall be provided at

a) the control equipment; and

b) the plant or fire control centre.

COMMENTARY AND RECOMMENDATIONS ON **17.2**. *All persons who are authorized to operate the system should be thoroughly trained in its function and method of operation.*

17.3 Manual controls

The location and purposes of the controls shall be plainly indicated, and shall be related to the operating instructions.

COMMENTARY AND RECOMMENDATIONS ON **17.3**. *It is recommended that the sign shown in Figure 1 be used to indicate the location of manual controls.*

Manual controls for systems should be located in an accessible place sufficiently removed from the hazard to permit them to be safely operated in emergency, yet close enough for the operator to be aware of conditions at the hazard.

17.4 Automatically operated systems

Automatic systems shall incorporate a manually operated lock-off device which will prevent discharge of the system, but will not prevent the giving of the alarm signal. Operation of the lock-off device shall be indicated at the plant or fire control centre.

COMMENTARY AND RECOMMENDATIONS ON **17.4**. *The lock-off device is for use when maintenance personnel are working on the system.*

To allow personnel to evacuate from the protected area prior to discharge of foam 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 60 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 will prevent foam discharge until release of the switch.

17.5 Detection and alarm equipment

Automatic detection and control equipment shall give a positive warning of any fault or abnormality, e.g. loss of power or pressure which may render the detection and control system inoperative.

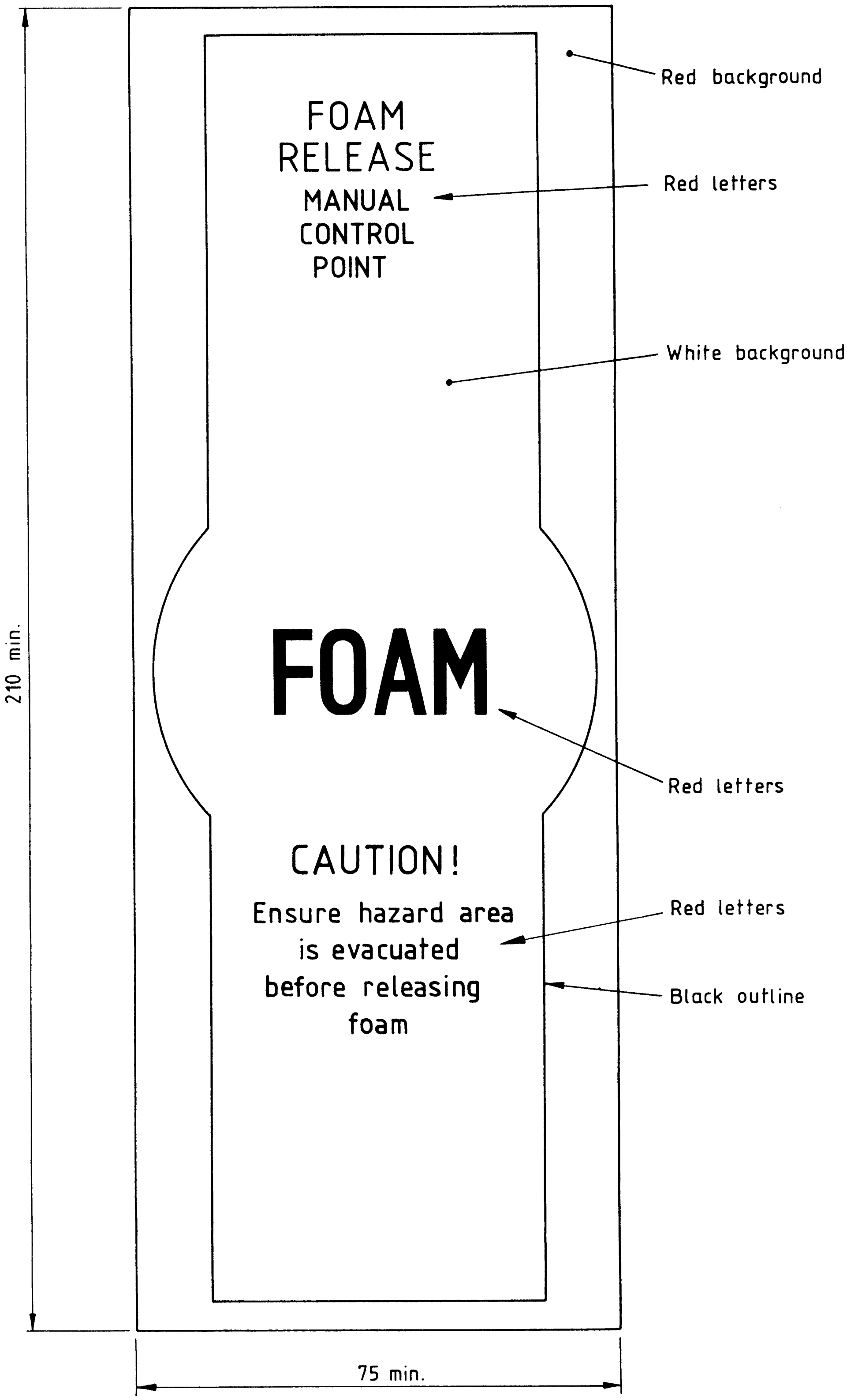
Automatic detection equipment shall provide a local alarm at the control point of each automatic system, as well as at the plant or central control point.

COMMENTARY AND RECOMMENDATIONS ON **17.5**. *Automatic systems should include a facility for coincidental shutdown of any heat source or potential means of ignition or reignition in the vicinity of the hazard. Detection and alarm equipment may be electrical, pneumatic, hydraulic or mechanical, e.g. link line type. Automatic detection and control equipment should comply with the appropriate recommendations of BS 5839-1.*

Detectors should comply with the requirements of the appropriate Part of BS 5445 or BS 5839.

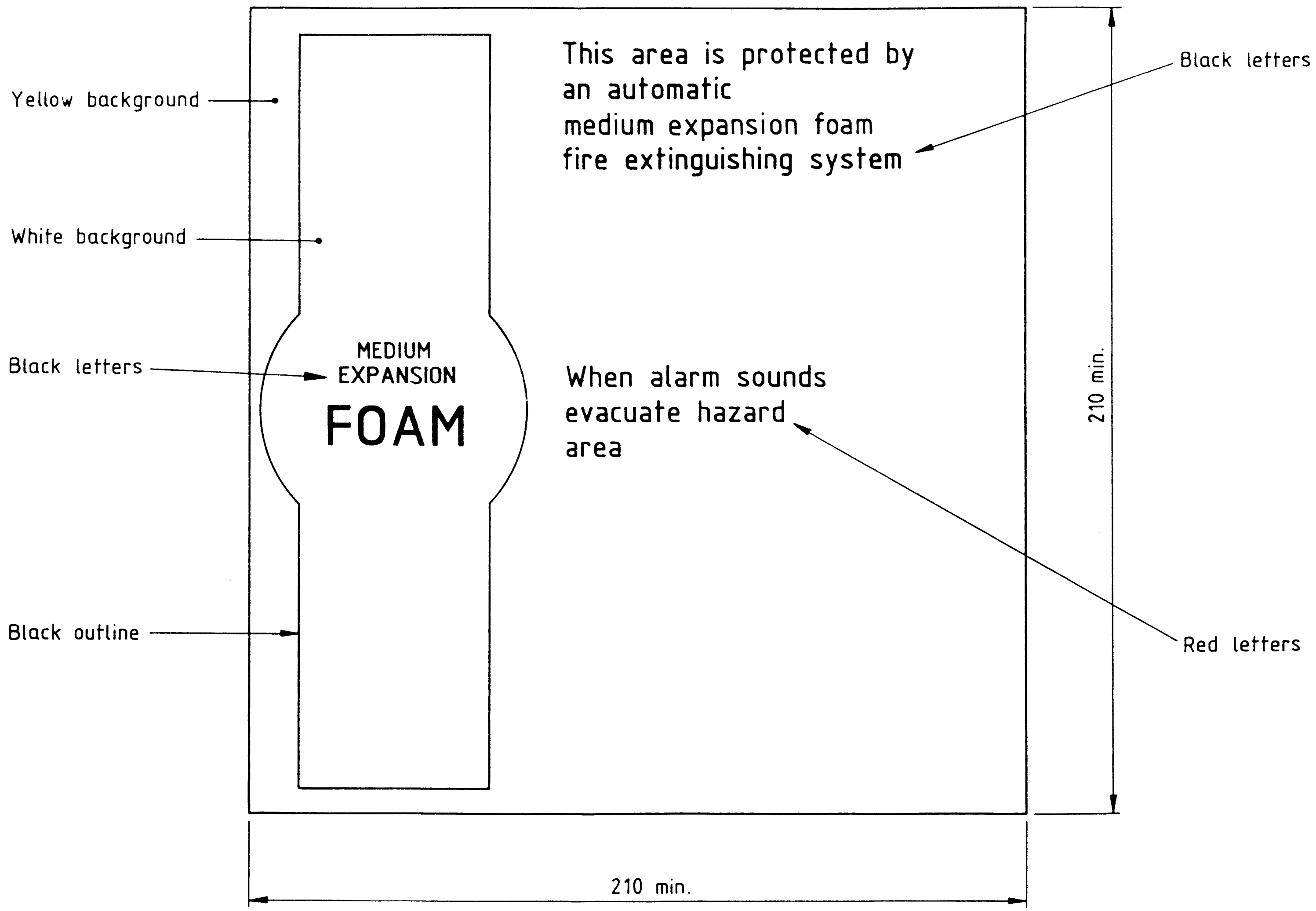
17.6 Warning signs

The warning sign shown in Figure 2(a) or Figure 2(b) as appropriate shall be displayed at the entrances to enclosed areas or compartments protected by an automatic medium or high expansion foam system.



All dimensions are in millimetres.

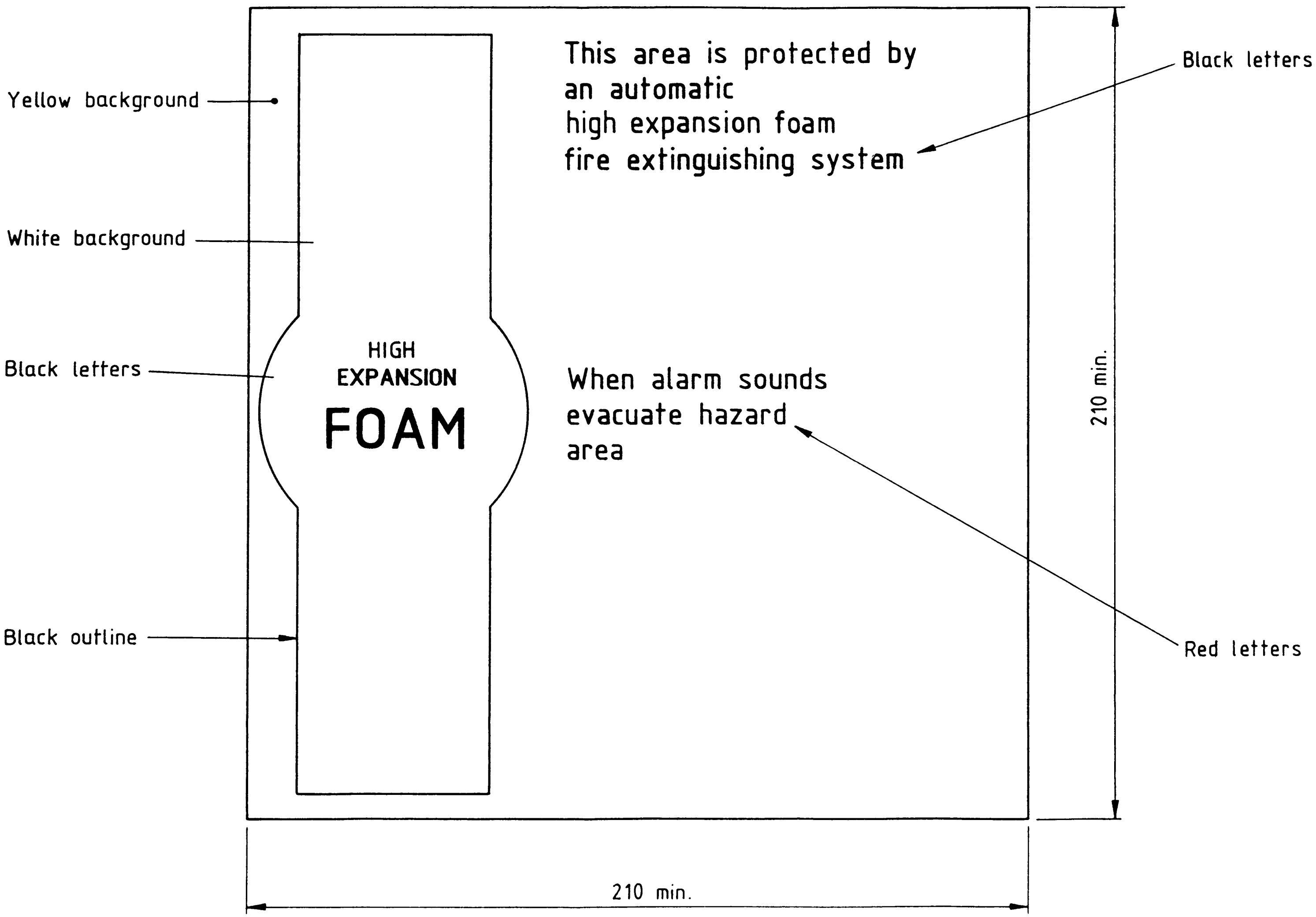
Figure 1 — Sign for display at manual control



(a) Medium expansion

All dimensions are in millimetres.

Figure 2 — Signs for display at entrances to hazard



(b) High expansion

All dimensions are in millimetres.

Figure 2 — Signs for display at entrances to hazard *(concluded)*

Section 5. Specific types of system

18 Medium expansion foam systems

18.1 General

Medium expansion foam systems shall comply with **18.2** to **18.4**. The requirements are applicable to systems for protection against fires in

a) flammable liquid as spills of average depth not more than 25 mm; or

b) flammable liquids in defined areas such as bunds and heat treatment baths; or

c) combustible solids where up to about 3 m foam build-up is necessary to cover the hazard, e.g. engine test cells and generating sets.

COMMENTARY AND RECOMMENDATIONS ON **18.1**. *The following features should be considered in the design of systems.*

a) *Because of the low density of the foam it can be applied gently to flammable liquids.*

b) *A high rate of foam build-up is possible and it is particularly of advantage with combustible solids.*

c) *Medium expansion foam may have a relatively low stability and burn back resistance, and it achieves its results by rapid application. It is essential that the application rate is adequate to meet any likely contingency.*

d) *Foam distribution may be adversely affected by wind. In outdoor hazards, the foam should be applied, wherever possible, to protected areas, and allowance should always be made for likely losses due to wind speeds above* 10 m/s.

e) *Medium expansion foam should not be used to protect hazards involving unenclosed energized electrical equipment, unless the equipment can be switched off before actuation of the system.*

f) *It may be necessary to screen foam-makers to prevent obstruction, including obstruction by birds or animals.*

18.2 Application rate

18.2.1 *Flammable liquids.* The application rate, determined in accordance with Appendix B, shall be not less than:

a) the rate, agreed with the user, shown to be effective by tests; or

b) if test data is not available:

4 L/m^2 for hydrocarbon liquids, or

6.5 L/m^2 per minute for foam destructive liquids.

18.2.2 *Combustible solids.* The application rate, determined in accordance with Appendix B, shall be not less than the rate agreed with the user.

18.3 Duration of discharge

The minimum duration of discharge of systems discharging at the minimum rate specified in **18.2** shall be as given in Table 1. The minimum duration of systems discharging at higher than the minimum rate may be reduced in proportion but shall be not less than 70 % of the time given in Table 1.

Table 1 — Minimum discharge times for medium expansion foam systems discharging at the minimum rate

Hazard	Minimum discharge time
	min
Indoor and outdoor spill up to 100 m^2	10
Other indoor hazards and outdoor protection	15

18.4 Quantity of foam concentrate

18.4.1 The quantity of foam concentrate or premix available for immediate use in the system shall be not less than:

$$V = \frac{A \times R \times C \times T}{100}$$

or

$$V_1 = A \times R \times T$$

where

V_1 is the minimum quantity of premix (in L);

V is the minimum quantity of foam concentrate (in L);

A is the area of application (in m^2);

R is the rate of application of foam solution (in L/m^2 per minute);

C is the concentration (in %);

T is the duration of application (in min);

plus a quantity not less than the allowance specified in **18.4.3**.

18.4.2 The hazard requiring the greatest quantity of foam concentrate shall be used to determine the quantity available for immediate use.

18.4.3 Allowance shall be made for the quantity of foam concentrate needed to fill the feed lines installed between the source and the most remote monitor or branchpipe.

19 High expansion foam systems

19.1 General

High expansion foam systems shall comply with **19.2** to **19.7**. The requirements are applicable to total flooding systems, local application systems and portable or mobile units used as adjuncts to fixed systems, and fed from them.

COMMENTARY AND RECOMMENDATIONS ON **19.1**. *High expansion foam systems are used for the total flooding of warehouses, aircraft hangars, furniture depositories and other similar large volumes. This type of system can also be used in situations where it would be hazardous to send personnel, for example, into underground enclosures such as refrigerated rooms, mine shafts or cable tunnels, where smoke logging could occur and in consequence exit routes might be difficult to find.*

Local application systems are used for smaller enclosures within larger areas, e.g. pits, basements, under-floor cavities, engine test cells and enclosed generating sets, where volume filling would be an effective means of dealing with an inaccessible fire situation. Local application systems may be used both indoors and outdoors provided there is a means of containing the foam and shielding it from the effects of wind on the foam-making devices and on the foam distribution.

Portable or mobile units are used as an adjunct to a fixed system where the nature of the hazard is variable, or some of it falls outside the main protected area.

The following features should be considered in the design of systems.

a) *High expansion foam is suitable for a wide range of solid and liquid fires although the expansion used may have some effect on the efficiency of the foam in extinguishing any particular fire.*

b) *It is effective on flammable liquid fires involving hydrocarbon liquids, including cryogenic liquids.*

c) *The smothering effect of high expansion foam retains the combustion gases in close proximity to the fire and restricts the ingress of air.*

d) *The production of steam from the expanded foam dilutes the oxygen concentration in the area of the fire and also extracts latent heat which helps to cool the fire.*

e) *The breakdown of the foam solution can also produce a damping-down of combustible solids, and cooling or dilution of the surface layers of some flammable liquids below their fire point.*

f) *Air for making foam should be clean and it is essential that it is not contaminated by combustion products, which can cause rapid breakdown of the foam. In general air from outside the protected enclosure should be used to make foam; this will reduce the possibility of contamination.*

g) *It is essential to make allowance for the limits to the distance that foam can be made to travel, when deciding the number and position of high expansion foam generators.*

h) *In outdoor locations, foam distribution may be adversely affected by wind. Allowance for this has to be made in calculation of foam application rates and quantities.*

i) *Deep-seated fires in combustible solids may not be extinguished immediately, and cooling may require the maintenance of foam cover for considerable periods of time.*

j) *High expansion foam should not be used on chemicals which release sufficient oxygen to sustain combustion, e.g. cellulose nitrate.*

19.2 Venting

19.2.1 *General.* Where air from outside the protected enclosure is used to make the foam, provision shall be made for the venting of air and/or products of combustion displaced from the enclosure by the discharged foam.

19.2.2 *Vent design.* The vent(s) shall be positioned at the most remote point(s) from the foam inlet(s), and shall be to the open air. The vent(s) shall be of open design, or it normally closed shall open automatically on actuation of the system.

COMMENTARY AND RECOMMENDATIONS ON **19.2**. *Correct positioning of the vent(s) is necessary to ensure that the submergence depth is achieved throughout the protected area. Venting is to the outside air to allow the safe dispersal of smoke and combustion products.*

The area of the vent(s) should be sufficient to limit the venting velocity to not more than 300 m/min.

This will be achieved if the vent area (in m^2*) is not less than F/300, where F is the foam discharge rate in* m^3/min.

Venting is not usually necessary where air from within the enclosure is used to make the foam.

19.3 Submergence depth

The system shall produce, throughout the protected area, a depth of foam sufficient to cover and extinguish the highest hazard.

COMMENTARY AND RECOMMENDATIONS ON **19.3**. *In unsprinklered enclosures of combustible construction the submergence depth should be sufficient to fill the enclosure.*

For combustible solids, in enclosures which are sprinklered or are of non-combustible construction the submergence depth should be sufficient to cover the highest hazard with

1 m, *or*

0.1 times the height of the highest hazard, in metres,

whichever is the greater, of foam.

For flammable liquids the submergence depth should be determined by test, and may be considerably more than for combustible solids.

19.4 Submergence time

The system shall produce throughout the protected area a depth of foam not less than the submergence depth in not more than the appropriate maximum time given in Table 2.

COMMENTARY AND RECOMMENDATIONS ON **19.4**. *The principle involved is that the enclosure to be protected should be filled to the submergence depth with high expansion foam, before an unacceptable degree of fire damage occurs. Allowance should be made for uneven depth across the protected area since the foam is stiff and does not flow readily. In general, the depth will be least at the furthest distance from the generator, but this will be modified by the presence of obstructions, vents and leakages, and by the interaction of a number of generators filling the protected enclosure. Where sprinkler protection is used a longer submergence time applies (see Table 2) but some additional breakdown of foam will result.*

In calculating the foam application rate, the volume of vessels, machinery or other permanently located equipment may be deducted from the total volume to be protected. Volumes occupied by stored materials are not deducted from the volume of the area to be protected, since the quantity may vary with time.

*Provided appropriate attention is given to distribution [see **19.1** g)], the requirements for submergence time will be met if the discharge rate of the system is not less than:*

$$F = C_N \times C_L \times \left[F_S + \frac{(D \times A) - V_{eq}}{T} \right]$$

where

D is the submergence depth (in m);

F is the foam discharge rate (in m^3/min);

T is the submergence time (in min);

A is the floor area of the protected space (in m^2);

V_{eq} is the volume of any permanently installed equipment, vessels or machinery, excluding the volume of any removable stored material or equipment (in m^3).

C_N = 1.20, an empirical factor based on the average reduction in foam quantity due to solution drainage, fire, wetting of dry surfaces, etc.

C_L = 1.1 an empirical factor compensating for the loss of foam due to leakage around doors and windows where these are closed but not sealed.

F_s is the rate of foam breakdown by sprinkler discharge (in m^3/min). The factor should be determined either by test or, in the absence of specific test data by the following formula:

$$F_s = 0.075 \times Q$$

where

Q is the estimated total discharge from the maximum number of sprinklers expected to operate (in L/min).

19.5 Quantity of foam concentrate

The quantity of foam concentrate (in litres) available for immediate use in the system shall be not less than:

a) for fire involving combustible solids:

$$250 \times \frac{FC}{E}\text{ ; or}$$

b) for fires involving flammable liquids:

$$150 \times \frac{FC}{E}$$

where

F is the foam discharge rate (in m^3/min) (see commentary and recommendations on **19.4**);

C is the concentration (in %);

E is the expansion.

COMMENTARY AND RECOMMENDATIONS ON **19.5**. *The quantities specified allow system running times (whether continuously or intermittently) of* 25 min *for combustible solids and* 15 min *for flammable liquids. For flammable liquids it is usual for the system to run continuously but for systems protecting combustible solids once submergence is achieved it is usual to run the system intermittently, in effect discharging foam at a rate equivalent to the breakdown rate, to maintain the submergence depth for the maximum time possible.*

19.6 Personnel safety

Unenclosed electrical apparatus shall be switched off when the foam system is activated. Total immersion of personnel in the foam shall be avoided where possible.

Table 2 — Maximum submergence times for high expansion foam systems

Hazards	Maximum submergence times	
	High expansion foam only	High expansion foam with supporting water sprinklers
	min	min
Flammable liquids with flash points not above 40 °C	2	3
Flammable liquids with flash points above 40 °C	3	4
Low density combustible solids, e.g. foam rubber, foam plastics, rolled tissue or crepe paper	3	4
High density combustible solids, e.g. rolled paper, rubber tyres	5	7

COMMENTARY AND RECOMMENDATIONS ON **19.6**. *Since total immersion in high expansion foam presents a considerable hazard to life, personnel working in areas covered by the system should be given adequate warning to allow them to evacuate the area before flooding with foam commences (see **17.4** and **17.6**).*

Instructions should be given that should anyone inadvertently become immersed in high expansion foam the nose and mouth should be covered with the hand or preferably a cloth, e.g. a handkerchief, to minimize the discomfort in breathing. It should be emphasized that where a considerable depth of foam exists, the foregoing may not be sufficient to ensure that foam does not enter the nose and mouth. Immersion in foam can cause irritation to eyes and breathing passages, make it impossible to see or hear and produce a stifling feeling because of the insulation effect. It could readily result in claustrophobia and panic.

Where trained personnel need to enter the foam for rescue or firefighting, self-contained breathing apparatus should be used in conjunction with a life line. Canister-type gas masks react with the water and foam and it is therefore essential that these should not be used.

19.7 Clearance of high expansion foam

Provision shall be made for the clearance of foam from the hazard area.

COMMENTARY AND RECOMMENDATIONS ON **19.7**. *After fire extinction, foam may be cleared from a building by encouraging as much ventilation as possible with forced draughts or the use of all openings. A water spray may be used to cut a path through the foam and this is most effective when employed an hour or more after foam application. Dry powders and special defoaming chemicals are also effective in destroying high expansion foam.*

Appendix A Classification of foam concentrates

NOTE Foam concentrates are liquids, usually aqueous solutions, which are mixed with water to produce the foam solution used to make foam.

Foam concentrates are generally classified by composition, and for the purposes of this standard as described in this appendix (see **15.1**).

A.1 Protein

Protein (P) foam concentrates are aqueous solutions of hydrolized protein and are generally used at 3 % and 6 % concentration.

A.2 Fluoroprotein

Fluoroprotein (FP) foam concentrates are protein foam concentrates with added fluorinated surface active agents. The foam is generally more fluid than protein foam, gives faster control and extinction of the fire, and has a greater ability to reseal if the foam blanket is disturbed. Fluoroprotein foam is more resistant than protein foam to contamination by hydrocarbon liquids and is generally used at 3 % or 6 % concentration.

A.3 Film-forming fluoroprotein

Film-forming fluoroprotein (FFFP) foam concentrates are protein foam concentrates with added fluorinated surface active agents. The foam is more fluid than both protein and standard fluoroprotein foams. The foam is resistant to contamination by hydrocarbon liquids. The solution is film-forming on some liquid hydrocarbon fuel surfaces and is generally used at 3 % or 6 % concentration.

A.4 Synthetic

Synthetic (S) foam concentrates are solutions of hydrocarbon surface active agents. Fluorinated surface active agents if present are present in amounts which do not lead to film-forming on hydrocarbon liquids. Synthetic foam concentrates are generally used at a concentration between 1 % and 6 %.

A.5 Aqueous film-forming

Aqueous film-forming (AFFF) foam concentrates are generally based upon mixtures of hydrocarbon and fluorinated hydrocarbon surface active agents. Foam solutions made from fluorochemical concentrates are film forming on some liquid hydrocarbon fuel surfaces and are generally used at 1 %, 3 % or 6 % concentration.

A.6 Alcohol resistant

Alcohol resistant (AR) foam concentrates are formulated for use on foam destructive liquids; the foams produced are more resistant than ordinary foams to breakdown by the liquid. They may be of any of the classes given in **A.1** to **A.5** and may be used on fires of hydrocarbon liquids with a fire performance generally corresponding to that of the parent type. Film-forming foams do not form films on water miscible liquids. Alcohol resistant foam concentrates are generally used at 6 % concentration on water miscible fuels.

Appendix B Determination of application rate (medium expansion) and foam discharge rate (high expansion)

NOTE See **18.2** and **19.4**.

B.1 Apparatus

B.1.1 *Pressure gauge,* installed adjacent to the discharge point in the hydraulically most remote location, with respect to the main foam solution supply line to the system.

B.2 Procedure

Discharge the system and record the steady state discharge pressure (P) at the nozzle. Visually examine all discharge points to see that they are operating satisfactorily. Sample the foam from the most remote nozzle to measure expansion and drainage in accordance with Appendix C.

B.3 Calculation

B.3.1 ***Medium expansion foam***

Calculate the overall foam solution flow rate (Q) (in L/min) where only one type of nozzle is used from the equation:

$$Q = N \times K \times P^{0.5}$$

where

Q is the foam solution flow rate (in L/min);

K is the nozzle discharge coefficient;

N is the number of nozzles fitted;

P is the steady state nozzle pressure (in bar);

or where more than one type of nozzle is fitted, from the sum of the overall rates for each type of nozzle, given by the equation:

$$Q = \sum^{n} N \times K \times P^{0.5}$$

where

n is the number of types of nozzle.

Calculate the application rate R (in L/m^2 per minute) from the equation:

$$R = \frac{Q}{A}$$

where

A is the area covered by the system (in mm^2).

NOTE The discharge coefficients are determined by separate tests of the nozzles concerned measuring flow rates over the pressure range involved.

B.3.2 ***High expansion foam***

Calculate the foam solution flow rate in accordance with **B.3.1**.

Calculate the foam discharge rate (in m^3) from:

$F = Q \times E$

where

E is the expansion, determined in accordance with Appendix C.

Appendix C Determination of expansion

NOTE See clause **13**.

C.1 Apparatus

C.1.1 *Cylindrical aluminium container,* of volume 166.25 L, internal diameter 500 mm and height 847 mm.

C.1.2 *Balance,* preferably with digital readout.

C.1.3 *Stand,* to support the container vertically.

C.2 Procedure

Carry out the procedure as follows.

a) Weigh the empty pan (W_1).

b) Collect a sample of foam, directly into the container. Collect the sample either from the foam outlet and as close as possible to the point at which the foam would be applied to the fuel or from a foam sampling point in the system as close as possible to the outlet.

c) As soon as the container is full skim the foam from above the level of the rim and remove any foam adhering to the outside.

d) Weigh with the contained liquid and foam (W_2).

C.3 Calculation

Calculate the foam expansion E from the equation:

$$E = \frac{166.25}{W_2 - W_1}$$

where

W_1 is the mass of the empty pan (in kg);

W_2 is the mass of the full pan (in kg).

The volume of foam is the volume of the pan, 166.25 L, and $W_2 - W_1$ is the volume of water (equal to the mass of the foam) contained in it.

Appendix D Determination of percentage concentration

NOTE See **15.1**.

D.1 Method 1

D.1.1 ***Apparatus***

D.1.1.1 *Three graduated cylinders,* of 100 mL capacity.

D.1.1.2 *Measuring pipette,* of 10 mL capacity.

D.1.1.3 *Beaker,* of 100 mL capacity.

D.1.1.4 *Beaker,* of 500 mL capacity.

D.1.1.5 *Refractometer,* having a measuring range of 1.3330 to 1.3723 index of refraction (equivalent to 0 % to 25 % sugar content in water).

D.1.2 ***Procedure***

Prepare a calibration curve of refractive index against foam concentrate content (V/V), using the specified concentrate and typical sample of the water to be used in the system.

NOTE The concentrations used should cover a range from about 0.5 times to 2 times the specified concentration. For example, to prepare a calibration curve for a 6 % solution, place three measured volumes of about 3 mL, 6 mL and 9 mL in each of the 100 mL graduated cylinders and make up to 100 mL by filling gently with the actual supply water.
After gentle but thorough stirring, take a refractive index measurement for each sample and prepare a calibration curve. Samples of the foam drained out in the drainage test should now be used to estimate the refractive index and from this, the concentration.

D.2 Method 2

Determine the percentage concentration directly by measuring the rate of withdrawal of foam concentrate from the tank (e.g. by rate of reduction of level) and the rate of flow of water at a suitable point, either by pressure loss across an orifice plate or by a direct reading flowmeter.

NOTE In field determinations the choice of method of measuring the foam induced and the water flow will depend upon the design of the system and the available measuring points. This test method will need to be decided at the design stage and allowed for in the equipment and fittings supplied to the installation.

blank

Publications referred to

BS 143 and 1256, *Specification for malleable cast iron and cast copper alloy threaded pipe fittings.*
BS 381C, *Specification for colours for identification, coding and special purposes.*
BS 476, *Fire tests on building materials and structures.*
BS 476-4, *Non-combustibility test for materials.*
BS 1387, *Specification for screwed and socketed steel tubes and tubulars and for plain end steel tubes suitable for welding or for screwing to BS 21 pipe threads.*
BS 1560, *Specification for steel pipe flanges and flanged fittings (nominal sizes ½ in to 24 in) for the petroleum industry.*
BS 1640, *Specification for steel butt-welding pipe fittings for the petroleum industry.*
BS 1710, *Specification for identification of pipelines and services.*
BS 1740, *Specification for wrought steel pipe fittings (screwed BS 21R-series thread).*
BS 1740-1, *Metric units.*
BS 2000, *Methods of test for petroleum and its products.*
BS 2000-34, *Flash point by Pensky-Martens closed tester.*
BS 3601, *Specification for carbon steel pipes and tubes with specified room temperature properties for pressure purposes.*
BS 3799, *Specification for steel pipe fittings, screwed and socket-welding for the petroleum industry.*
BS 4422, *Glossary of terms associated with fire.*
BS 4422-4, *Fire protection equipment.*
BS 5153, *Specification for cast iron check valves for general purposes.*
BS 5155, *Specification for butterfly valves.*
BS 5160, *Specification for flanged steel globe valves, globe stop and check valves and lift type check valves for general purposes.*
BS 5163, *Specification for predominately key-operated cast iron gate valves for waterworks purposes.*
BS 5252, *Framework for colour co-ordination for building purposes.*
BS 5306, *Fire extinguishing installations and equipment on premises.*
BS 5306-0, *Guide for the selection of installed systems and other fire equipment.*
BS 5306-6, *Foam systems.*
BS 5306-6.1, *Specification for low expansion foam systems.*
BS 5445, *Components of automatic fire detection systems.*
BS 5499, *Fire safety signs, notices and graphic symbols.*
BS 5499-1, *Specification for fire safety signs.*
BS 5839, *Fire detection and alarm systems for buildings.*
BS 5839-1, *Code of practice for system design, installation and servicing.*
API 5L, *Specification for pipe lines.*
ASTM A53-84, *Specification for pipe, steel, black and hot-dipped zinc coated, welded and seamless.*
ASTM A 120-84, *Specification for pipe steel, black and hot-dipped zinc coated (galvanized), welded and seamless, for ordinary uses.*
ASTM A 135-84, *Specification for electric-resistance welded steel pipe.*

BSI — British Standards Institution

BSI is the independent national body responsible for preparing British Standards. It presents the UK view on standards in Europe and at the international level. It is incorporated by Royal Charter.

Revisions

British Standards are updated by amendment or revision. Users of British Standards should make sure that they possess the latest amendments or editions.

It is the constant aim of BSI to improve the quality of our products and services. We would be grateful if anyone finding an inaccuracy or ambiguity while using this British Standard would inform the Secretary of the technical committee responsible, the identity of which can be found on the inside front cover. Tel: 020 8996 9000. Fax: 020 8996 7400.

BSI offers members an individual updating service called PLUS which ensures that subscribers automatically receive the latest editions of standards.

Buying standards

Orders for all BSI, international and foreign standards publications should be addressed to Customer Services. Tel: 020 8996 9001. Fax: 020 8996 7001.

In response to orders for international standards, it is BSI policy to supply the BSI implementation of those that have been published as British Standards, unless otherwise requested.

Information on standards

BSI provides a wide range of information on national, European and international standards through its Library and its Technical Help to Exporters Service. Various BSI electronic information services are also available which give details on all its products and services. Contact the Information Centre. Tel: 020 8996 7111. Fax: 020 8996 7048.

Subscribing members of BSI are kept up to date with standards developments and receive substantial discounts on the purchase price of standards. For details of these and other benefits contact Membership Administration. Tel: 020 8996 7002. Fax: 020 8996 7001.

Copyright

BSI
389 Chiswick High Road
London
W4 4AL