BRITISH STANDARD

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Incorporating Amendments Nos. 1 and 2

Fire extinguishing installations and equipment on premises —

Part 6: Foam systems —

Section 6.1 Specification for low expansion foam systems

ICS 13.220.10

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Fire Standards 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
Fire Insurers Research and Testing Organisation (FIRTO)
Fire Offices Committee
Fire Protection Association
Health and Safety Executive
Hevac Association
Home Office
Incorporated Association of Architects and Surveyors
Institution of Fire Engineers
Institution of Gas Engineers
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

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9808	January 1998	Indicated by a sideline in the margin
9945	February 1998	BS number on front cover changed from '5036' to '5306'

Contents

Foreword

This Section of BS 5306 has been prepared under the direction of the Fire Standards 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 6.2: Specification for medium and high expansion foam systems*[1)];

— *Part 7: Extinguishing powder systems*[1)].

Low 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 to iv, pages 1 to 32, 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.

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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.

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

Advice on these matters can be obtained from the appropriate fire authority, the Health and Safety Executive or other enforcing authority under the Health and Safety at Work etc. Act 1974, and the insurers. In addition, reference should be made 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 low expansion foam to fires in buildings, industrial plant and storage facilities.

Application rates are specified for foams made from four classes, protein (P), fluoroprotein (FP), film-forming fluoroprotein (FFFP) and aqueous film forming (AFFF), of foam concentrate for use on fires of hydrocarbon liquids, and for alcohol resistant (AR) foam concentrates for use on fires of foam destructive liquids.

This standard is not applicable to low expansion foam systems using synthetic (S) foam concentrates as such systems are not in common use in the UK.

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

1 bar – 10^5 N/m^2 – 10^2 kPa.

NOTE 2 The titles of 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
self-aspirating foam-making equipment

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

2.2
concentration

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

2.3
drainage time

the time for a defined percentage, usually 25 %, of the liquid content of a foam to drain out under specified conditions

2.4
expansion (expansion ratio)

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

2.5
film forming

the characteristic of a foam or foam solution forming an aqueous film on some hydrocarbon liquids

NOTE The term may be applied to foam and foam concentrates and foam solutions.

2.6
hydrant

a fixed outlet from which water or foam solution may be dispensed from the mains supply

2.7
preburn time

the period of time between ignition of a fire and the commencement of foam application

2.8
spill fire

a flammable liquid fire having an average depth of not more than 25 mm

2.9
user

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

2.10
aspirated foam

foam produced, by the intimate mixing of air and foam solution, within the equipment

2.11
non-aspirated foam

foam produced, by the mixing of air and a spray of foam solution, outside the equipment

3 Characteristics and use of low expansion foam

3.1 General

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

COMMENTARY AND RECOMMENDATIONS ON **3.1**. *The gas is usually air. Foam was sometimes formerly referred to as air-foam or mechanical foam to distinguish it from chemical foam made by chemical reaction of two solutions.*

3.2 Uses

The requirements of this standard apply to low expansion foam and foam systems suitable for extinguishing fires on a generally horizontal flammable liquid surface.

COMMENTARY AND RECOMMENDATIONS ON **3.2**. *Extinction is achieved by the formation of a blanket of foam over the surface of the burning liquid. This provides a barrier between the fuel and air, reducing the rate of emission of flammable vapours to the combustion zone, and cooling the liquid.*

Low expansion foam is not generally suitable for the extinction of running fuel fires, e.g. fuel running from a leaking container or from damaged pipework or pipe joints. However, low expansion foam can control any pool fire beneath the running fire which may then be extinguished by other means.

Low expansion foam, except for the alcohol resistant type, is generally not suitable for use on foam destructive liquids which cause rapid breakdown of the foam.

Low expansion foam is not suitable for use on fires involving gases or liquefiable gases with boiling points below 0 °C, *or cryogenic liquids. The advice of the manufacturer should, therefore, be sought for this application.*

3.3 Expansion

Low expansion foam shall have an expansion not exceeding 20.

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

Low expansion foams shall be applied:

a) gently to the surface of the burning liquid (as pourer or semi-subsurface systems); or

b) forcefully to the surface of the burning liquid (as in monitor and branchpipe systems); or

c) below the surface so that they float to the surface under their own buoyance (as in subsurface systems).

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, where liquid fuel temperatures exceed* 100 °C *they may be ineffective and, particularly where the fuel depth is considerable (e.g. tanks) may be dangerous in use. The foam and drainage of the water from the foam can cool the flammable liquid but boiling of this water may cause frothing or slop-over of the burning liquid. Boil-over, which may occur even where foam is not applied, is a more severe and hazardous event. Large scale expulsion of the burning contents of a tank is caused by the sudden and rapid boiling of water in the base of the tank or suspended in the fuel. It is caused by the eventual contact of the upper layer of liquid fuel in the tank, heated to above* 100 °C *by the fire, with the water layer. Particular care should be taken when applying foam to high viscosity liquids, such as burning asphalt or heavy oil, above* 100 °C.

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 where they are present. A similar danger is presented by some other metals, such as zirconium or magnesium, only when they are burning.

Low expansion foam is a conductor and should not be used on energized electrical equipment, in situations where this would be a danger to personnel.

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.*

Use of water jets or sprays may adversely affect a foam blanket. They should not be used in conjunction with foam unless account is taken of any such effects.

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 or 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 Flash point

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, isobutyl methyl ketone, methyl methacrylate monomer and mixtures of water-miscible liquids in general may require higher application rates[2)]*. Protection of products such as amines and anhydrides which are particularly foam destructive requires special consideration.*

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 steel 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 steel 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.

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

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 hazard 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 given in 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;

j) 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 system 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 requests otherwise, all pipework, except that carrying foam for surface application or semi-subsurface application systems, 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.

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 properties;*

c) *foam distribution;*

d) *running pressures;*

e) *concentration of the foam solution;*

f) *manpower requirements.*

9.5 System restoration

After completion of the acceptance tests, the pipework shall be flushed, strainers 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 and servicing.

COMMENTARY AND RECOMMENDATIONS ON **10.1**. *The continued capability for effective performance of foam equipment 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.*

Installers 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. Inspect and clean strainers. 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 manufacturer's 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.

COMMENTARY AND RECOMMENDATIONS ON CLAUSE **12**. *The following should be considered:*

a) *full details of the flammable liquid, its storage, handling and location;*

b) *the most suitable class of foam concentrate and concentration;*

c) *the most suitable solution application rate;*

d) *the most suitable equipment for making and delivering foam;*

e) *required system operation time;*

f) *quantity of foam concentrate required for extinction;*

g) *the most suitable proportioning method(s);*

h) *pipework sizes and pressure losses;*

j) *water supply quantity, quality and pressure;*

k) *method of system operation and any fire or gas detection equipment required;*

l) *any special considerations, such as the use of electrical equipment in areas where flammable vapours may be present;*

m) *reserve foam concentrate supply;*

n) *drainage and bunds;*

p) *environmental conditions.*

13 Foam quality

The expansion and drainage time values of foam produced by an aspirating system shall be not less than the values given in Table 1, when tested in accordance with Appendix B.

Table 1 — Minimum values for expansion and 25 % drainage (aspirated foam)

Application	Expansion	25 % drainage time
		min
Surface or semi-subsurface	5	2.0 (P, FP) or 1.5 (AFFF, FFFP)
Subsurface	2 but not more than 4	1.5

Values for AR foam shall be not less than the values for the parent class (P, FP, FFFP or AFFF).

COMMENTARY AND RECOMMENDATIONS ON CLAUSE **13**. *The expansion and drainage time of non-aspirated foam may be difficult to measure. Values for these are not given in this standard.*

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 during fire emergency."

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 and 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, unless an alternative, independent supply of electric power is provided.

The use of one diesel driven and one electrically driven pump of appropriate size is an acceptable arrangement.

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. The actual concentration, for a fixed system operating at the design application rate, when determined in accordance with Appendix C, shall be:

a) for a nominal percentage concentration equal to or greater than 5 %, within plus or minus 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 plus 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 plus one quarter 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 C.

Only AFFF, FFFP or FP foam concentrate shall be used in subsurface systems.

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

COMMENTARY AND RECOMMENDATIONS ON **15.1**.
Protein (P) foam is not suitable for subsurface systems but may be used in top application or semi-subsurface systems.

AR foams are formulated for use against fires of foam destructive liquids, but are also suitable for use on hydrocarbon liquids. The fire performance of AR foams against hydrocarbon fuels generally corresponds to the performance of the parent concentrate. The high viscosity of some concentrates needs to be considered when specifying the proportioning system.

The solutions of some AR concentrates are required to be foamed within a specific time of the solution being mixed; it is essential that the solution transit time (the time for foam solution to flow from the point at which concentrate enters the water stream to the point at which air enters the stream, usually expressed in seconds) is less than this limiting time.

When applied forcefully to deep layers of foam destructive liquids, all types of AR foams may show a significant loss of performance compared with results using gentle application. For flammable liquids that are only partially soluble in water, the loss of performance may only be slight but in some cases equipment designed to give very gentle application may be necessary. In all cases tests should be conducted or advice sought from the suppliers regarding these liquids.

In portable, transportable and semi-fixed systems the conditions of induction are not controlled by the system design. The actual concentration of use in such systems should be within the above limits when the equipment is used under the conditions specified by the manufacturer.

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 may accelerate any deterioration due to aging of the solution.*

For smaller hazards 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 Quantities of foam concentrate

15.3.1 The quantity of foam concentrate or foam solution 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 foam solution (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 nominal concentration (in %);
- T is the duration of application (in min);

plus a quantity not less than that needed to maintain foam application from any supplementary protection provided in accordance with **18.3**.

COMMENTARY AND RECOMMENDATIONS ON **15.3.1**. *Values for the area of application are specified in clauses **18**, **19**, **20**, **21** and **22** and are not less than:*

for fixed roof tanks: the area of the bund

for floating roof tanks: the area of the rim seal

for spills: the area of the spill

*for bunds: the bund area except for branchpipe and monitor systems when the area of application is half the bund area (see **18.2.1**).*

The area of a bund may be taken as the gross area, less the area of any non-elevated tank or tanks within the bund.

15.3.2 The hazard requiring the greatest quantity of foam concentrate shall be used to determine the amount to be held at immediate readiness.

15.3.3 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.

15.3.4 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 **15.3.4**. *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 re-commission 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 steel or other alloy 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 provided with a means of draining after use 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 tanks where the contents are normally at a temperature above 100 °C *should be provided with a full bore spar pipe with means to drain away any initial discharge of water or incompletely formed foam to reduce the risk of boil-over or slop-over.*

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 **16.7**).*

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 electrolyte action, and non-conducting separating means should be used in the joint between any which are used.

16.2.6 *Pipework for tank protection.* All pipework inside bund areas or within 15 m of non-bunded tanks shall either be buried under at least 0.3 m depth of earth, or be properly supported and protected against mechanical damage as well as fire.

COMMENTARY AND RECOMMENDATIONS ON **16.2.6**. *Above-ground pipework within the bunded area or within* 15 m *of non-bunded tanks should withstand the upward shock due to a tank roof rupture. All welded steel pipe construction is to be preferred; although one flanged or union joint within* 1.5 m *of the ground should be provided in each riser which can be opened to permit hydrostatic testing of the pipework system up to this joint.*

When pipework is buried, a metal flexible joint built-up from fittings complying with ***16.5*** *should be provided at the base of each tank riser.*

When pipework is supported above ground, it should have the necessary upward and lateral support but should be unconstrained within 15 m *of the tank shell, so as to permit sufficient flexibility in an upward direction to obviate the need for a flexible joint. If threaded connections are used within this distance, they should be back welded for strength.*

Tank risers of 100 mm *diameter or larger may be welded to the tanks by means of steel brace plates positioned perpendicular to the tank, and centred on the riser pipe. One brace should be provided at each shell course. This design may be used instead of flexible joints or unconstrained pipework.*

16.2.7 *Accommodation of relative movement.* Pipework shall accommodate, without leakage or damage, any relative movement between pipes, pipe supports and tanks caused by thermal expansion or by the filling or emptying of the system or part of the system.

16.3 Valves

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

COMMENTARY AND RECOMMENDATIONS ON **16.3**. *Control valves to direct the foam or solution to the appropriate hazard may be either in a central control house, or at points where pipework to the hazard branches from a main feed line. Control valves for tank systems should be located outside bunds and should be either protected against fire, or not less than one tank diameter or* 15 m, *whichever is greater, from the tank shell, or remote control valves situated inside the bund and resistant to the effects of fire.*

16.4 Pipe

Pipe shall comply with BS 3601, API 5L, ASTM A53-84, ASTM A120-84 or ASTM 135-84.

16.5 Pipe fittings

Pipe fittings shall comply with BS 143 & BS 1256, BS 1560, BS 1640, BS 1740 or BS 3799.

16.6 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 **16.6**. *Where possible the pipes should be colour coded in accordance with BS 1710 or painted signal red in accordance with reference 537 of BS 381C (equivalent to 04 E 53 of BS 5252).*

16.7 Flushing

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

16.8 Strainers

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

COMMENTARY AND RECOMMENDATIONS ON **16.8**. *Strainers should be provided in the line upstream of foam making equipment where this appears desirable.*

16.9 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 premises are 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.

17.2 Operating instructions and training

Operating instructions for the system shall be provided at the control equipment and also at 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 control points.*

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.*

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.

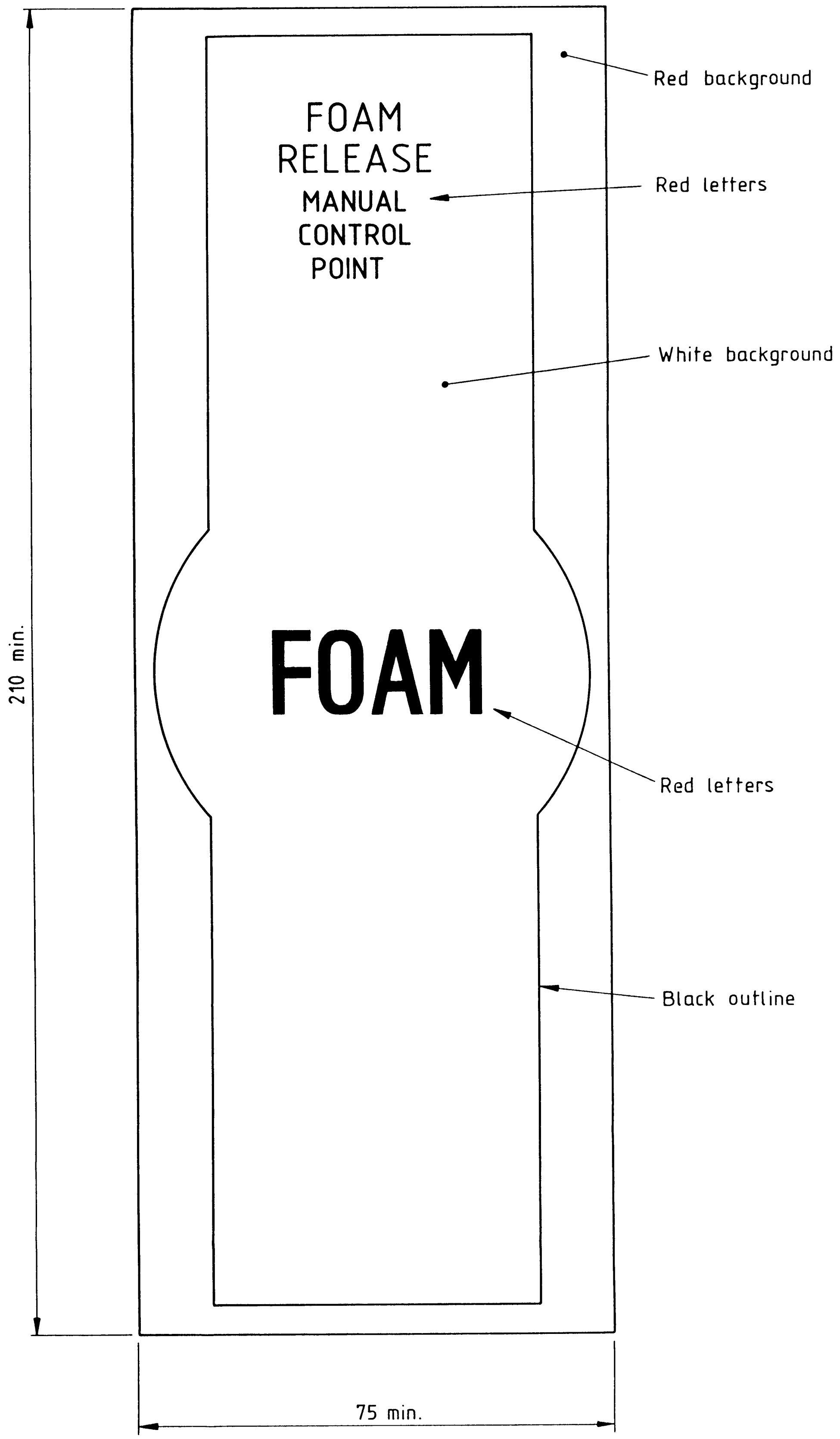
Automatic detection equipment shall provide a local alarm at the control point of each automatic system, as well as at the plant or central control point.

COMMENTARY AND RECOMMENDATIONS ON **17.5**. *Automatic systems should include a facility for coincidental shut-down 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 Part of BS 5445 or BS 5839.*

17.6 Warning signs

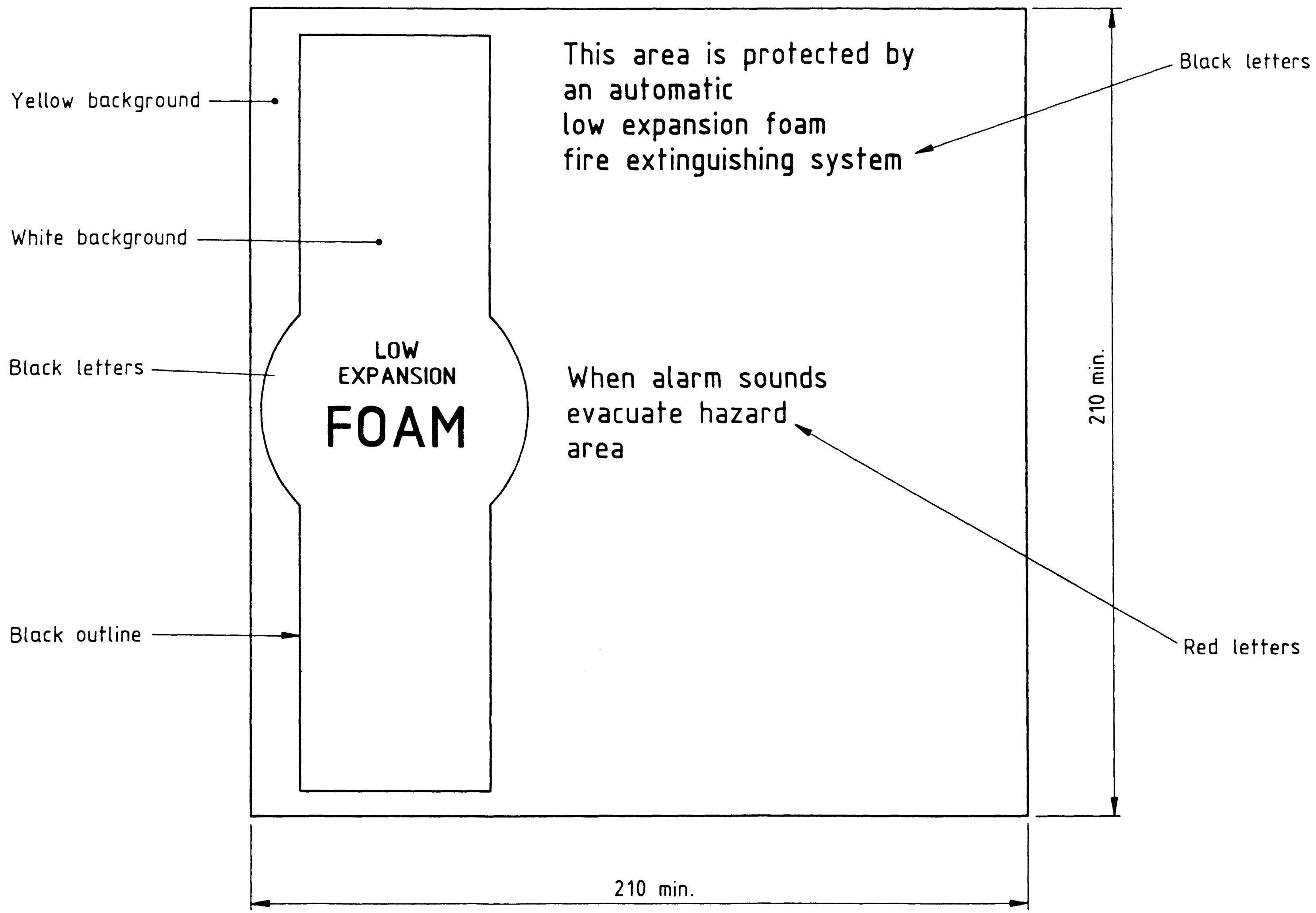
The warning sign shown in Figure 2 shall be displayed at the entrances to enclosed areas or compartments protected by an automatic low expansion foam system.

COMMENTARY AND RECOMMENDATIONS ON **17.6**. *The sign may also be used at the entrances to other protected areas where it may serve as an information notice.*



All dimensions are in millimetres.

Figure 1 — Sign for display at manual control



All dimensions are in millimetres.

Figure 2 — Sign for display at entrance to hazard

Section 5. Specific types of system

18 Foam monitor and branchpipe systems

18.1 General

The requirements of this clause are applicable where foam monitors and branchpipes are used to provide:

a) primary protection for bunds and flammable liquid spills;

b) primary protection for storage tanks smaller than the sizes given in the commentary;

c) supplementary protection for storage tanks.

COMMENTARY AND RECOMMENDATIONS ON **18.1**.
Foam branchpipes are portable devices and are hand held during use. Monitors have larger foam outputs and reaction forces are countered by transference to the ground, and can operate unmanned. They may be portable, transportable or mounted at a fixed point.

*The principles involved in the protection of bunded areas are governed by the size and shape of the bund, and the type of system used. Easy access should be provided to the bund for portable and transportable equipment which should be used to apply foam progressively (see **18.2.1**). The necessary numbers, sizes and range of the equipment should be matched to the hazard.*

Foam branchpipes should not be used to provide primary protection for fixed roof tanks more than 9 m *in diameter or* 6 m *high. Foam monitors should not be used to provide primary protection for fixed roof tanks more than* 20 m *in diameter.*

Fixed systems are the preferred means of providing primary protection for floating roof tanks; foam branchpipes may be used for rim fires where operator access can be achieved safely; foam monitors are not generally suitable for rim fires but may be used for fires that extend beyond the rim area.

Consideration should be given to the following when selecting one of many variations of this type of system.

a) *Foam can be projected over considerable distances and to significant heights under favourable circumstances, but wind can disperse or deflect the foam discharge from the fire area, when rates higher than the specified minimum (see **18.2**) will be necessary.*

b) *Portable and mobile equipment may be housed out of the weather and protected from explosion or flame exposure before fire fighting commences, and can be made available for use on one or more of a number of hazards, it can be set-up in the most favourable up-wind position, although the time taken to set up the equipment may mean extinction is more difficult because of the longer preburn.*

c) *Uniform foam distribution may not be achieved easily but automatically oscillating monitors discharge foam evenly over very large areas.*

d) *Fixed monitors may be remotely controlled from considerable distances thus rendering them suitable for example in oil jetty protection and fire tug use.*

e) *Fires in tanks with ruptured roofs and only limited access for foam are not easily extinguished by monitor application from ground level.*

f) *In the case of fixed automatic monitors, obstructions, such as vehicles or equipment temporarily positioned, may be present when the system is operated, and may interfere with the discharge.*

g) *Application by monitor or branchpipe may not be suitable for foam destructive liquids such as amines and anhydrides.*

18.2 Primary protection systems

18.2.1 *System discharge rate.* The discharge rates of portable branchpipe and monitor systems shall be not less than the appropriate minimum application rate given in Table 2 multiplied by the area of the tank or spill, or by half the area of the bund, as appropriate, when tested in accordance with Appendix D.

COMMENTARY AND RECOMMENDATIONS ON **18.2.1**.
Higher minimum rates may be needed if there is exceptional loss of foam because of wind or fire updraught.

Minimum rates for liquids with flash point not above 40 °C, *and for other liquids not listed in the table should be determined by specific test, or from the concentrate manufacturer's data.*

For bund protection systems, in addition to the above requirement the system discharge rate and the actual area of application should be such that the actual rate of application is not less than that given in Table 2.

18.2.2 *Duration of discharge.* The minimum duration of discharge of systems discharging at the minimum rate specified in **18.2.1** shall be as given in Table 3. The minimum duration of discharge 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 3.

18.3 Supplementary protection for storage tanks

18.3.1 *Portable foam branchpipes.* A portable foam branchpipe for the protection of storage tanks shall have a discharge rate of not less than 200 L/min.

The number of branchpipes provided shall be as given in Table 4.

Sufficient additional foam concentrate shall be provided to permit operation of all extra branchpipes simultaneously with the primary means of fire protection and for the minimum discharge duration given in Table 4.

18.3.2 *Hydrants.* In addition to a primary fixed piping system and any supplementary protection as specified in **18.3.1**, foam hydrants may be provided for use with portable or mobile equipment or water hydrants with suitable foam producing equipment in the event that a fixed discharge outlet on the primary protection system is damaged.

The number of hydrants, which may have more than one outlet, shall be as shown in Table 5.

COMMENTARY AND RECOMMENDATIONS ON **18.3.2**.
Each hydrant should be located between 15 m *and* 75 m *from the shells of the tanks being protected by the associated primary system.*

The flow from hydrants should be sufficient for all the portable equipment to be used.

Table 2 — Minimum application rates for monitor and branchpipe systems

Foam concentrate class	Minimum application rates of foam solution			Hazard
	Spill fires	Tank fires	Bund fires[a]	
	L/m^2 per minute	L/m^2 per minute	L/m^2 per minute	
AFFF	4	6.5	4	Hydrocarbon, flash point above 40 °C
FFFP	4	6.5	4	
FP	5	6.5	5	
P	6.5	8	6.5	Hydrocarbon, flash point above 40 °C
AR	By test	By test	By test	Foam destructive liquids, flash point above 40 °C

[a] See commentary and recommendations on **18.1**.

Table 3 — Minimum discharge times for monitor and branchpipe systems discharging at the minimum rate

Hazard	Equipment type	Fuel flash point	Minimum discharge time
		°C	min
Indoor and outdoor spills of hydrocarbon	Fixed monitors and fixed foam branchpipes	Any	10
	Transportable/portable monitors and foam branchpipes	Any	15
Tanks containing liquid hydrocarbons	Any	Below 40	60
		Above 40	45
Foam destructive liquids	Any using AR class foam	Any	15
Bunds	Any	Any	60

Table 4 — Minimum number of supplementary branchpipes for tanks, and minimum discharge time

Diameter of largest tank	Minimum number of foam branchpipes	Minimum discharge time
m		min
Up to 10	1	10
Over 10 and up to 20	1	20
Over 20 and up to 30	2	20
Over 30 and up to 40	2	30
Over 40	3	30

Table 5 — Minimum number of hydrants for supplementary protection of storage tanks

Tank diameter	Minimum number of hydrants
m	
Up to 20	1
Over 20	2

19 Foam spray systems

19.1 General

The requirements of this clause are applicable to systems discharging a spray of aspirated foam or non-aspirated foam solution to provide primary protection for flammable liquid spills.

COMMENTARY AND RECOMMENDATIONS ON **19.1**. *The spray nozzles may be arranged to discharge downwards in overhead systems, horizontally or upwards as in ground level pop-up sprayers.*

Spray systems are particularly suitable both outdoors and indoors where flammable liquids may be spilled in large quantities. Typical examples include loading racks, horizontal tanks, pump rooms, dip tanks and bunds.

Generally these systems are not suitable for use on water miscible liquids exceeding 25 mm *in depth.*

Any type of foam concentrate may be used in aspirating systems, but for non-aspirating systems only AFFF or FFFP may be used. Non-aspirating systems may be regarded as water spray systems discharging foam solution.

Consideration should be given to the following when selecting one of the many variations of this type of system.

a) *Hot surfaces in contact with the fuel can be effectively cooled by a spray discharge. Structures may also be protected from heat radiation by a spray discharge.*

b) *The system is particularly suitable for automatic operation. Automatic operation is recommended for indoor or unmanned hazards.*

c) *Even distribution of the foam over the fuel surface is achieved but discharge may be carried by the wind beyond the area of the fuel spill except where ground level pop-up nozzles, which deliver foam at the seat of the fire, are used.*

d) *Foam sprayers have small passages susceptible to blockage.*

e) *Obstructions, such as vehicles or equipment temporarily positioned, may be present when the system is operated and may interfere with the discharge.*

f) *Pipework for overhead nozzles may obstruct normal activities, or impose an undue load on the roof structure.*

g) *Overhead application may need supplementary low level application to provide coverage below large obstructions, such as aircraft in hangars.*

h) *For hazards where a large spill area is likely to be involved, the foam spray system may be subdivided into zones, each protecting a specific floor area and individually actuated by a suitable fire detection system.*

j) *Non-aspirated nozzles can be used to apply a spray of water, instead of foam solution, which can provide effective fire control of some flammable liquids.*

19.2 Discharge rate

Systems shall deliver foam solution at not less than the appropriate minimum application rate given in Table 6 multiplied by the area of the spill when tested in accordance with Appendix D.

COMMENTARY AND RECOMMENDATIONS ON **19.2**. *Application rates for foam destructive liquids should be determined by specific test or taken from the foam concentrate manufacturer's data.*

19.3 Duration of discharge

The minimum duration of discharge of systems discharging at the minimum rate specified in **19.2** shall be as given in Table 7. The minimum duration of discharge 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 7.

COMMENTARY AND RECOMMENDATIONS ON **19.3**. *The minimum duration of discharge for foam destructive liquids should be determined by specific test or taken from the foam concentrate manufacturer's data.*

Table 6 — Minimum application rates for sprayer systems (hydrocarbon liquids only)

Foam concentrate class	Height of discharge point above lowest point of hazard	Minimum application rate	
		Aspirated	Non-aspirated
	m	L/m² per minute	L/m² per minute
P	Up to and including 10 Above 10	6.5 8	Not suitable
FFFP AFFF	Up to and including 10 Above 10	6.5 8	4 6.5
FP	Up to and including 10 Above 10	6.5 8	Not suitable

Table 7 — Minimum discharge times for sprayer systems (hydrocarbon liquids only) discharging at the minimum rate

Hazard	Area of system or zone	Minimum discharge time for all classes of foam concentrate
	m^2	min
Indoor contained liquid hydrocarbon spills	50 or less	5
	More than 50	10
Indoor open top process tanks containing liquid hydrocarbons	50 or less	5
	More than 50	10
Outdoor applications	Any area	10

19.4 Number and location of discharge outlets

There shall be not less than one discharge outlet per 10 m^2 of protected area.

COMMENTARY AND RECOMMENDATIONS ON **19.4**.
Generally, sprayers should be spaced to provide even distribution over the whole area. For some hazards it may be advantageous to cluster sprayers in areas where fire is likely to originate.

20 Foam pourer systems

20.1 General

The requirements of this clause are applicable to systems applying foam through pouring devices usually on to the internal face of the wall of a tank or bund to flow gently down on to the liquid surface.

COMMENTARY AND RECOMMENDATIONS ON **20.1**.
Fixed foam pourers are used to provide primary protection for outdoor fixed roof tanks with or without an internal floating roof, for open top floating roof tanks and for bunds. These systems are used in tank farms, oil refineries and chemical plants, and are usually operated manually. They are suitable for use on atmospheric tanks with vertical sides. They are not suitable for horizontal cylindrical tanks or in pressure tanks.

Floating roof tanks have a good fire record and fixed protection is normally provided only for the rim seal area.

Floating roof seals may be of the pantograph type (see Figure 3) or the tube seal type (see Figure 4). Foam should be discharged into the seal area behind a foam dam (see ***20.6****) secured to the floating roof, below the pantograph seal, or behind the metal weather shield of tube seal designs.*

Consideration should be given to the following when selecting one of the many variations of this type of system.

a) *The total foam output is applied gently, without severe mixing, to the fuel surface.*

b) *An even foam distribution is achieved; some pourers are designed to discharge foam tangentially, creating circular movement and promoting foam distribution.*

c) *The system comprises simple equipment capable of withstanding fire exposure, but equipment attached to tanks may be damaged by explosion or severe fire exposure.*

d) *Only moderate maintenance of the foam-making vapour seal box and pouring equipment is required.*

e) *Where foam is injected below any seal of a tank, it is essential that the foam generator be capable of producing foam at the pressure required to force foam around the rim seal.*

f) *Adverse winds and obstructions projecting through the fuel surface may reduce the effectiveness of the system and allowance should be made in the rate of application of foam.*

20.2 Discharge rate

20.2.1 *Fixed roof tanks and bunds.* The discharge rate shall be not less than the appropriate rate given in Table 8 multiplied by the area of the tank or bund when tested in accordance with Appendix D.

20.2.2 *Floating roof tanks with a foam dam.* The discharge rate (in L/min) shall be not less than 10 times the area of the annular surface between the foam dam and the tank shell (in m^2) when tested in accordance with Appendix D.

20.2.3 *Floating roof tanks without a foam dam.* The discharge rate (in L/min) shall be not less than 20 times per minute the area of the annular surface between the floating roof and the tank shell (in m^2) when tested in accordance with Appendix D.

COMMENTARY AND RECOMMENDATIONS ON **20.2**. *Minimum rates for liquids with flash point not above* 40 °C *and for other liquids not listed in the table should be determined by specific test, or taken from the foam concentrate manufacturer's data.*

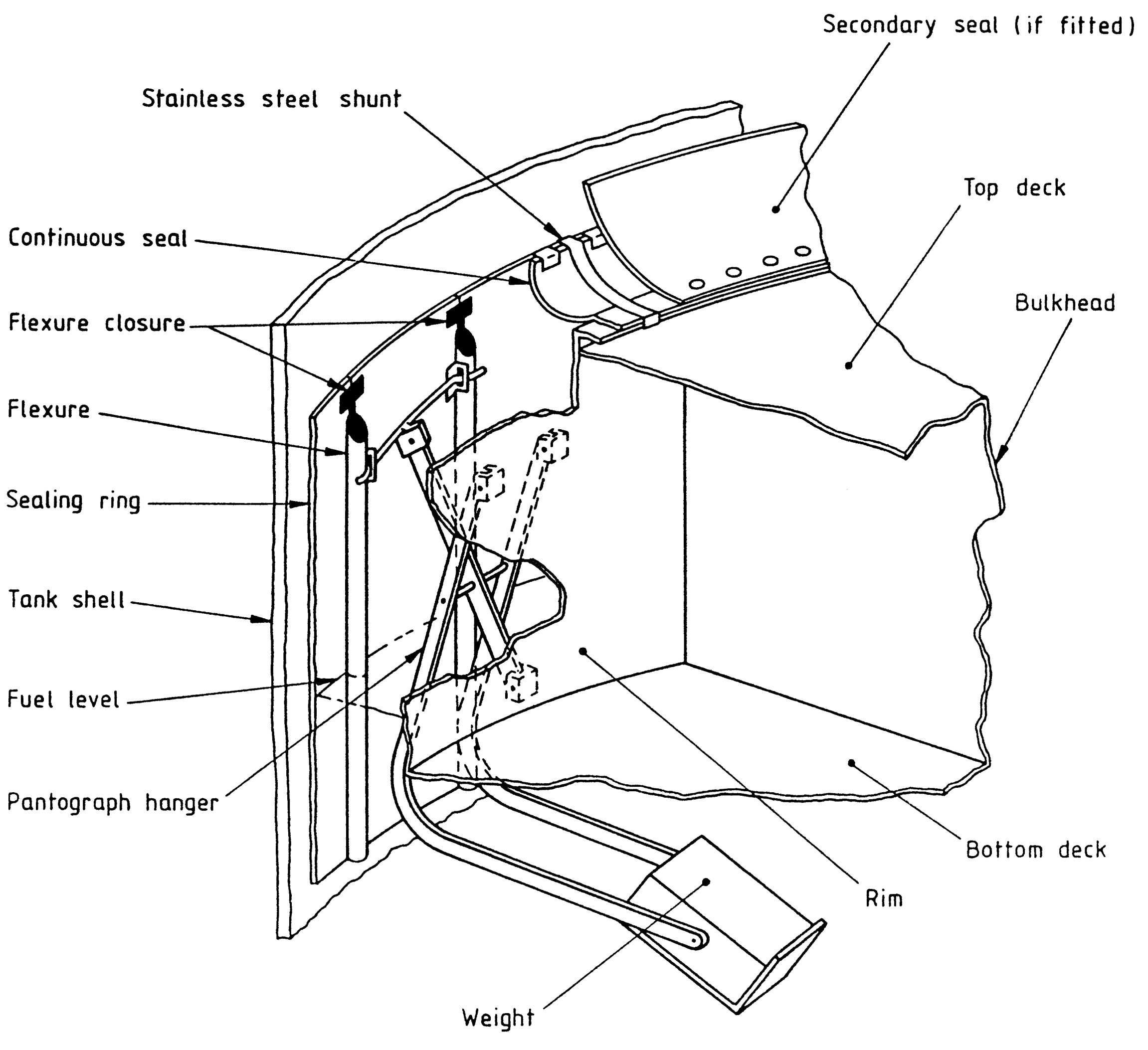


Figure 3 — Typical pantograph seal

Table 8 — Minimum application rates for pourer systems (fixed roof tanks and bunds) and semi-subsurface systems

Foam concentrate class	Flammable liquid	Minimum application rate
		L/m² per minute
Any	Hydrocarbon Flash point above 40 °C	4
AR	Foam destructive liquids	6.5
NOTE Minimum application rates for floating roof tanks are given in **20.2.2** and **20.2.3**.		

20.3 Duration of discharge

20.3.1 *Fixed roof tanks and bunds.* The minimum duration of discharge of systems discharging at the minimum rate specified in **20.2.1** shall be as given in Table 9. The minimum duration of discharge 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 9.

20.3.2 *Floating roof tanks with a foam dam.* The duration of discharge shall be not less than 20 min.

20.3.3 *Floating roof tanks without a foam dam.* The duration of discharge shall be not less than 10 min.

20.4 Number and location of pourers

20.4.1 *General.* Where there is more than one pourer, they shall be evenly spaced at the tank shell.

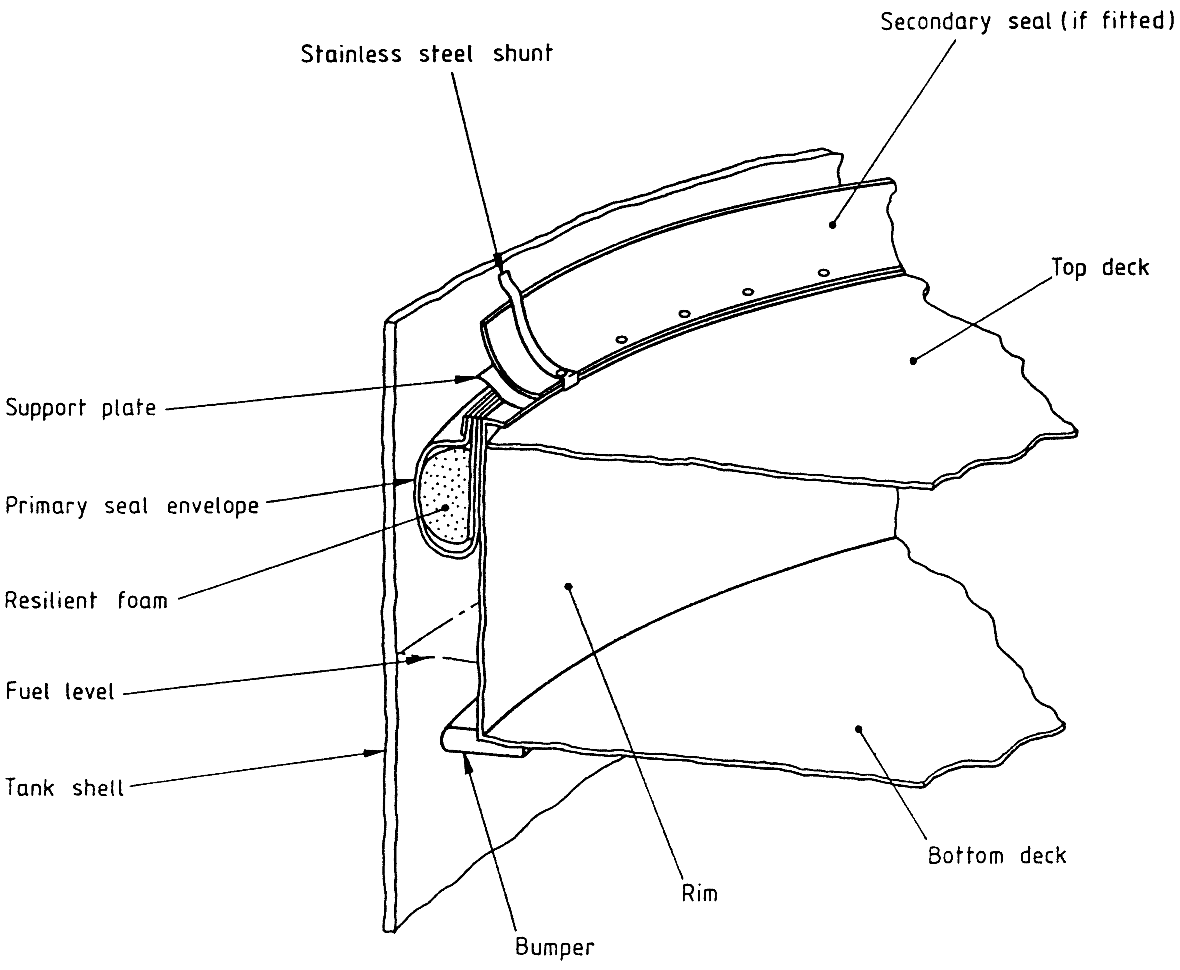


Figure 4 — Typical tube seal

20.4.2 *Fixed roof tanks.* The minimum number of pourers shall be as given in Table 10.

20.4.3 *Floating roof tanks.* The circumferential spacing between pourers shall be not more than:

a) 12 m where foam is applied above the seal behind a dam less than 0.6 m high;

b) 24 m where foam is applied above the seal behind a dam 0.6 m or more high;

c) 40 m where foam is injected below a pantograph seal;

d) 18 m where foam is injected between a tube shield and a weather shield.

COMMENTARY AND RECOMMENDATIONS ON **20.4**. *For bund protection the pourers should be fixed to discharge on to the inside of the bund wall. On tanks foam pourers should be securely attached to the inside wall of the tank shell, adjacent to the top. They should be mounted in such a way as to ensure that displacement of the tank roof will not damage them sufficiently to render them inoperative.*

Their location should preclude the possibility of the tank overflowing into the foam lines. Where more than one pourer is installed, they should discharge foam at approximately the same rate.

20.5 Foam dams for floating roof tanks

Foam dams shall be provided where:

a) foam is discharged above the seal area; or

b) foam is discharged below the weather shield of a tube seal design, if the distance between the top of the tube seal and the top of the roof is less than 150 mm.

COMMENTARY AND RECOMMENDATIONS ON **20.5**. *Foam dams are circular and secured to the top of the roof plates adjacent to any weather shield to hold foam in position on the rim seal area. The foam is applied from above using a foam supply line and pourer shield. The shield is a metal plate mounted flush to the inner face of the tank rim to which the foam pourer is fitted. This provides a vertical surface for the foam to flow down on to the inner side of the tank shell to the rim seal area where foam is applied above the seal. A typical dam is shown in Figure 5.*

Table 9 — Minimum discharge times for semi-subsurface and fixed foam pourer systems (except open-top floating roof tanks) discharging at the minimum rate

Hazard	Minimum discharge time
	min
Spillage	10 (all classes of foam concentrate)
Tanks containing liquid hydrocarbons:	
flash point not above 40 °C	55 (P) 45 (AFFF, FP and FFFP)
flash point above 40 °C	30 (all classes of foam concentrate)
Tanks containing foam destructive liquids	55 (AR)
Bunds	60

NOTE Minimum discharge times for floating roof tanks are given in **20.3.2** and **20.3.3**.

Table 10 — Minimum number of foam pourers for fixed roof tanks and bunds

Tank diameter	Minimum number of foam pourers	Bund area
m		m^2
Up to 24	1	450
Over 24 up to and including 36	2	1 020
Over 36 up to and including 42	3	1 380
Over 42 up to and including 48	4	1 810
Over 48 up to and including 54	5	2 290
Over 54 up to and including 60	6	2 830
Above 60	6, plus one for each 450 m^2 above 2 820 m^2 of hazard area	above 2 820

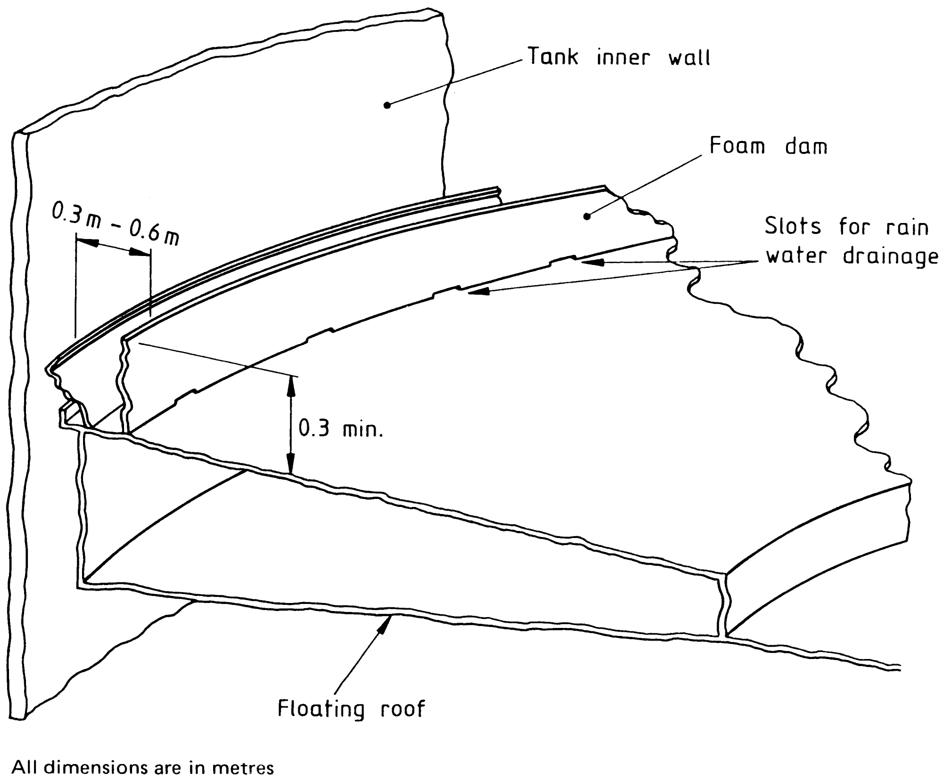


Figure 5 — Typical foam dam

Foam dams should be fabricated from steel plate, not less than 3.4 mm *thick, welded or otherwise securely fastened to the floating roof at a distance of* 0.3 m *to* 0.6 m *from the tank shell The dam should be not less than* 0.3 m *high and should be provided with slots to allow for the drainage of rain water. The slots should be approximately* 10 mm *high and should provide a drainage area of* 280 mm^2/m^2 *of area enclosed between the foam dam and the tank shell and small enough to prevent undue escape of foam during application. The dam should extend at least* 50 mm *above any non-combustible secondary seal.*

Secondary seals consisting of fabric sections between metal plate areas should be protected with a foam system using 0.6 m *high dams.*

20.6 Sealing of pourers on fixed roof tanks

Foam pourers for fixed roof tanks shall be fitted with an effective and durable seal, frangible under low pressure, to prevent entry of vapour into the foam pourer and pipe lines. Access should be provided to permit inspection and maintenance, including replacement of the vapour seals.

COMMENTARY AND RECOMMENDATIONS ON **20.6**. *This seal is usually provided in the form of a foam chamber or vapour seal box.*

21 Subsurface foam systems

21.1 General

The requirements of this clause are applicable to systems used for the protection of fixed roof storage tanks containing low viscosity hydrocarbon liquids, in which foam is injected (through a product line or through a special foam line) at the base of the tank and rises to the surface through the liquid in the tank.

COMMENTARY AND RECOMMENDATIONS ON **21.1**. *The typical arrangement shown in Figure 6 should be used where it can be ensured that the isolating stop valve at the base of the tank is normally open.*

Where a subsurface system has been installed for tank protection, arrangements may be made to allow the system to discharge into the surrounding bund, in order to supplement other methods of bund protection.

Subsurface systems are not suitable for foam destructive fuels or for some high viscosity fuels.

Subsurface systems are not recommended for the primary protection of floating roof tanks because the roof will prevent complete foam distribution.

Only FP, FFFP and AFFF foams which will tolerate severe mixing with fuel are suitable for subsurface application (see **15.1***). Protein foam is not suitable.*

Subsurface systems are sometimes called base injection systems.

Consideration should be given to the following when selecting one of the variations of this type of system.

a) *The total foam output reaches the tank.*

b) *With large tanks, inlets are suitably distributed to allow even foam spread over surface of the fuel.*

c) *The system is essentially simple and, being at ground level, is less likely to be damaged by fire or explosion than overhead systems.*

d) *The rising foam stream induces vertical circulation of cold fuel from the base of the tank to the burning surface dissipating hot fuel layers at the burning surface and assisting extinction.*

e) *Essential equipment and operating personnel can be located at a safe distance from the fire.*

f) *The system is easy to check and maintain.*

g) *The high back-pressure foam generator and foam solution supply may be fixed or portable for connection to foam inlet pipes or product line connections outside the bunded area.*

h) *A high back-pressure foam generator is used to produce foam at a pressure sufficient to overcome the high pressure head of fuel as well as all frictional losses in the foam pipework. Frictional losses with foam differ from those with foam solution.*

j) *Where the foam is injected through the product line, it is essential that automatic closure fire valves are not fitted.*

21.2 Discharge rate

The discharge rate (in L/min) shall be not less than four times the area of the tank (in m^2) when tested in accordance with Appendix E.

COMMENTARY AND RECOMMENDATION ON **21.2**. *With some fuels, where there has been a long preburn prior to the application of foam, a hot zone may exist near the burning surface at temperatures in excess of* 100 °C. *In order to avoid frothing and slop-over, continuous application of foam should be avoided in the initial stages. Intermittent application of the foam can induce circulation of the fuel in the tank, thereby bringing the cooler layers of fuel to the surface. The foam injected intermittently will disperse without sufficient steam formation to produce frothing.*

The rates of foam discharge from each outlet should be approximately equal.

21.3 Duration of discharge

The minimum duration of discharge of systems discharging at the minimum rate specified in **21.2** shall be as given in Table 11. The minimum duration of discharge 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 11.

Table 11 — Minimum discharge times for subsurface systems discharging at the minimum rate

Risk	Minimum discharge time
	min
Tanks containing liquid hydrocarbons	
Flash point not above 40 °C	45
Flash point above 40 °C	30

21.4 Number and position of foam outlets

21.4.1 Foam outlets shall be hydraulically balanced and evenly spaced at the tank shell or inside the tank. Foam outlets shall be above any water layer present in the tank.

COMMENTARY AND RECOMMENDATIONS ON **21.4.1**. *Even distribution of foam may be achieved using a single inlet pipe through the tank shell, terminating in a central manifold with separate outlets arranged radially. Contact with the water layer causes foam breakdown.*

21.4.2 The number of foam outlets shall be not less than that given in Table 12.

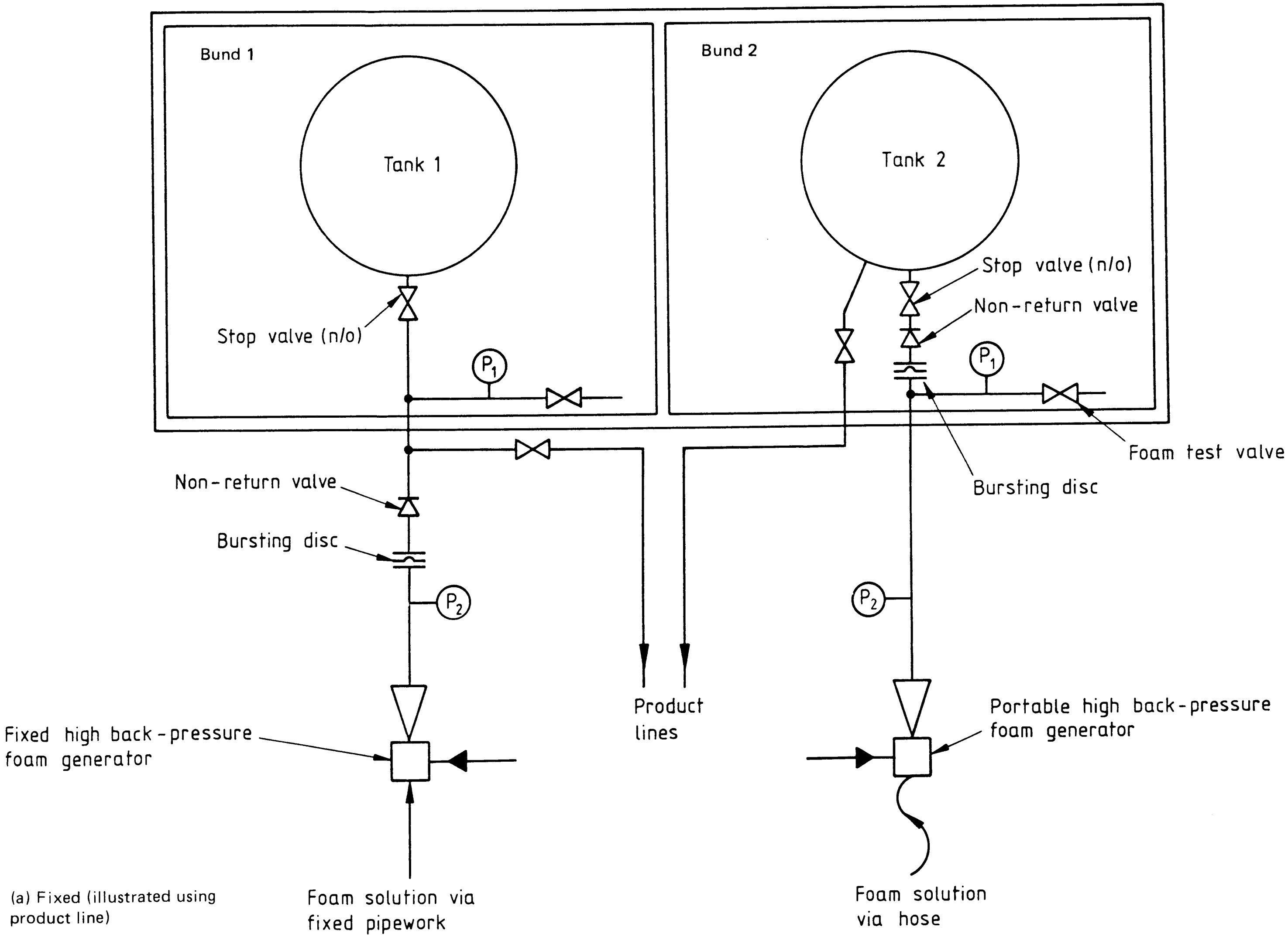
21.5 Pipe sizes

The injection point pipe shall be of such a size that the nominal discharge velocity (calculated from the foam solution rate assuming an expansion ratio of 4) of foam into the tank is less than

3 m/s for hydrocarbons with flash point not above 40 °C, or

6 m/s for hydrocarbons with flash point above 40 °C,

over a distance of not less than 20 diameters from the outlet. For other pipework the foam velocity shall not exceed 9 m/s.



(a) Fixed (illustrated using product line)

(b) Semi-fixed (illustrated using special foam line)

Key

N/O Normally open

P Pressure gauge

Figure 6 — Typical fixed and semi-fixed subsurface systems

Table 12 — Minimum number of foam outlets for subsurface systems for tanks

Tank diameter	Hydrocarbons with flash point not above 40 °C	Hydrocarbons with flash point above 40 °C
m		
Up to 24	1	1
Over 24 up to and including 36	2	1
Over 36 up to and including 42	3	2
Over 42 up to and including 48	4	2
Over 48 up to and including 54	5	2
Over 54 up to and including 60	6	3
Above 60	6, plus one inlet for each 450 m^2 of tank area above 2 820 m^2	3, plus one for each 700 m^2 of tank area above 2 820 m^2

21.6 Prevention of leakage

To prevent product leaking back to the foam generators, a bursting disc and an isolating valve shall be installed in the foam pipework.

COMMENTARY AND RECOMMENDATIONS ON **21.6**. *A non-return valve should be located between the tank isolating valve and the high back-pressure generator (see Figure 4).*

22 Semi-subsurface systems

22.1 General

The requirements of this clause are applicable to systems used to apply foam to the surface of fixed roof storage tanks via a flexible hose rising from the base of the tank.

COMMENTARY AND RECOMMENDATIONS ON **22.1**. *The system is not normally considered appropriate for floating roof tanks with or without a fixed roof, because the floating roof prevents foam distribution.*

The hose is initially contained in a sealed housing and is connected to an external foam generator capable of working against the maximum product head. On operation the end of the hose is released to float to the liquid surface.

Consideration should be given to the following when considering the selection of this type of system.

a) *The total foam output reaches the surface of the burning liquid.*

b) *With large tanks, the semi-subsurface units can be arranged to produce an even distribution over the fuel surface.*

c) *Any type of concentrate suitable for gentle surface application to the particular fuel may be used.*

d) *Foam generating equipment and operating personnel may be located at a distance from the fire.*

e) *The system may be used for the protection of foam destructive liquids provided the flexible hose is not affected by them.*

f) *Certain high viscosity fuels may not be suitable for protection by this system.*

g) *Circulation of the cold fuel which could assist extinction is not induced.*

h) *The system may be difficult to check, test and maintain.*

i) *The foam generator has to produce foam at a pressure sufficient to overcome the high back pressure of the head of fuel as well as all frictional losses in the foam pipework. Frictional losses with foam differ from those with foam solution.*

22.2 Discharge rate

The discharge rate shall be not less than the appropriate rate given in Table 8 multiplied by the area of the tank when tested in accordance with Appendix E.

22.3 Duration of discharge

The minimum duration of discharge shall be as given in Table 9.

22.4 Number and position of units

The number of units shall be not less than that given in Table 13.

Where more than one unit is required, these shall be spaced equally around the tank shell, away from tank level indicator devices and swing arm product pipes.

COMMENTARY AND RECOMMENDATIONS ON **22.4**. *Semi-subsurface units should be secured by straps for support and sited within the base of the tank.*

22.5 Prevention of leakage

Non-return valves shall be fitted at the foam entry points adjacent to the tank wall.

Table 13 — Minimum number of semi-subsurface units for tanks

Tank diameter	Number of semi-subsurface units
m	
Up to 24	1
Over 24 up to and including 36	2
Over 36 up to and including 42	3
Over 42 up to and including 48	4
Over 48 up to and including 54	5
Over 54 up to and including 60	6
Over 60	6, plus one for each 450 m^2 of tank area above 2 820 m^2

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 are 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 resistant 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 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 hydro-carbon 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 %. They are not generally used in low expansion foam systems and are not considered in this standard.

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, and at 3 % or 6 % concentration on hydrocarbon fuels.

Appendix B Determination of expansion and drainage time

NOTE See clause **13**.

B.1 Apparatus

B.1.1 *Brass drainage pan* (see Figure 7).

B.1.2 *Stop clock.*

B.1.3 *Balance,* preferably with digital readout.

B.1.4 *Stand,* to support the pan vertically when drainage is occurring.

B.1.5 *Graduated measuring cylinder,* of capacity between 100 mL and 250 mL.

B.2 Procedure

Carry out the procedure as follows.

a) Weigh the empty pan (W_1).

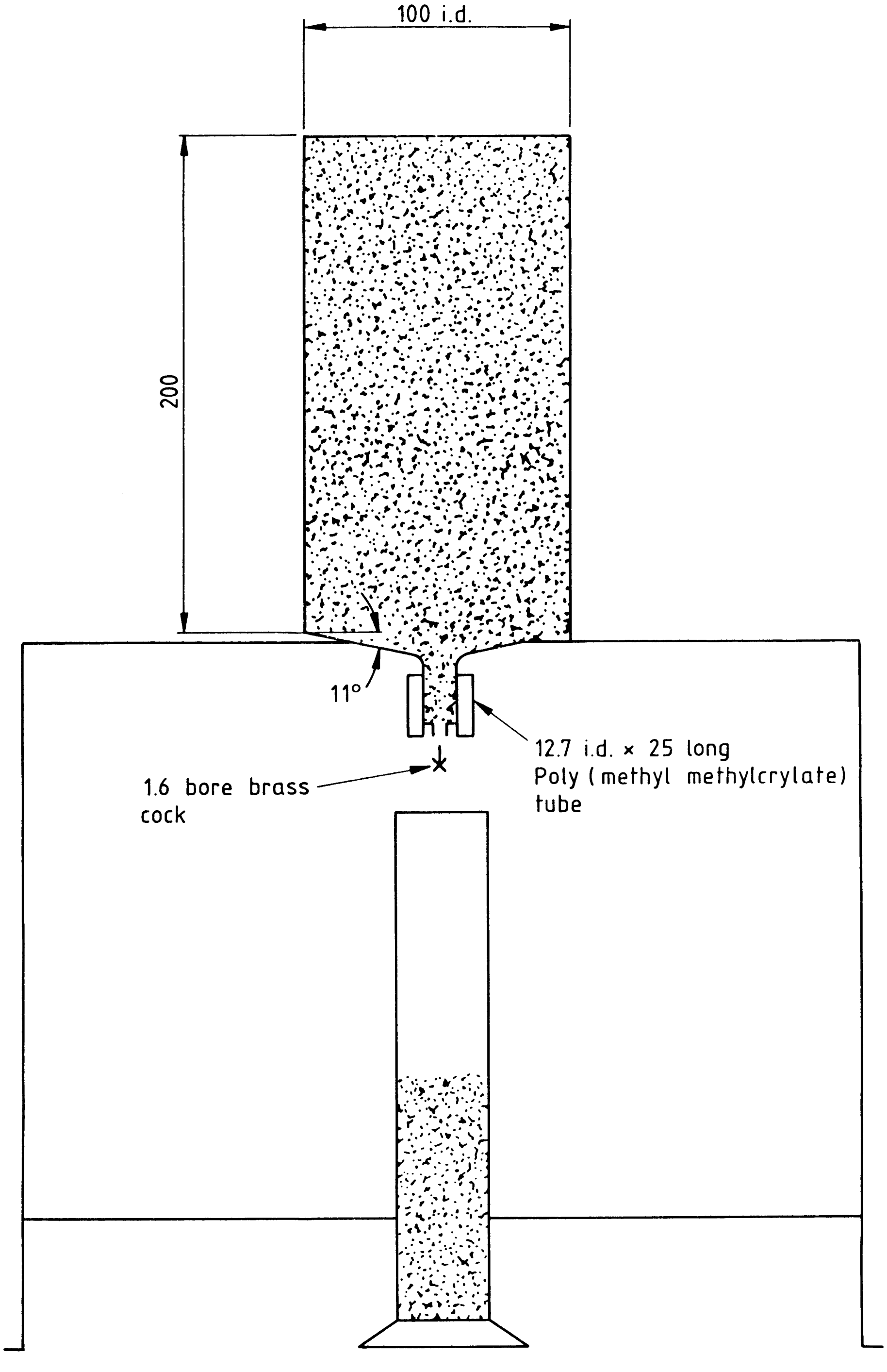
b) With the cock closed collect a sample of foam, directly into the pan. Collect the sample either from the foam outlet and as close as possible to the point at which the foam would be applied to the fuel or from a foam sampling point in the system as close as possible to the outlet.

c) Start the clock as soon as the pan is full.

d) Skim the foam from above the level of the rim and remove any foam adhering to the outside.

e) Carefully transfer the pan to the stand above the graduated cylinder. Open the cock and allow the drained liquid to flow into the cylinder. Record the volume (in mL) drained at a series of lapsed times and draw a drained volume-time curve.

f) Close the cock and return the drained liquid to the pan, and weigh with the contained liquid and foam (W_2).



All dimensions are in millimetres.

Figure 7 — Drainage pan and stand for testing low expansion foam

B.3 Calculation

Calculate the foam expansion E from the equation:

$$E = \frac{1\,600}{W_2 - W_1} \quad (1)$$

where

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

W_2 is the mass of the full pan (in g);

1 600 is the volume of the foam (in mL).

Read the 25 % drainage time which is the time to collect a quantity $(W_2 - W_1)/4$ in the graduated cylinder, from the curve of drained volume time.

The volume of foam is the volume of the pan, 1 600 mL and $W_2 - W_1$ is the volume of water (equal to the mass of the foam) contained in it.

Appendix C Determination of percentage concentration

NOTE See **15.1**

C.1 Method 1

C.1.1 *Apparatus*

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

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

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

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

C.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).

C.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 1 The concentrations used should cover a range from about 0.5 times to 2 times the specified concentration.

NOTE 2 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.

C.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.

Appendix D Determination of rate of application for branchpipe, monitor, spray and pourer systems

NOTE See **18.2.1**, **19.2** and **20.2**.

D.1 Apparatus

D.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.

D.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 B.

D.3 Calculation

Calculate the foam solution discharge rate Q (in L/min) from the equation:

$$Q = N \times K \times \mathrm{P}^{0.5} \quad (2)$$

or, where more than one type of nozzle is fitted, from the equation:

$$Q = \sum^{n} N \times K \times P^{0.5} \quad (3)$$

where

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

K is the nozzle discharge coefficient;

N is the number of each type of nozzle fitted;

P is the steady state nozzle pressure (in bar[3]);

n is the number of types of nozzle.

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

$$R = Q/A \quad (4)$$

[3] 1 bar = 10^5 N/m^2 – 10^5 Pa.

where

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

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

Appendix E Determination of rate of application for subsurface and semi-subsurface systems

NOTE See **21.2** and **22.2**.

E.1 Apparatus

E.1.1 *Foam sampling and test valve with pressure gauges,* as shown in Figure 6.

E.1.2 *Pressure gauge,* to indicate the inlet pressure to the foam generator.

E.2 Procedure

Shut the tank isolating valve and open the foam sampling and test valve. Start the foam generator and then adjust the foam test valve and, if fitted, the back-pressure control valve to obtain the design back-pressure and the design inlet pressure. Record the pressure drop (P) across the foam generator (the back-pressure). Sample the foam from the sampling valve and measure expansion and drainage in accordance with Appendix B.

E.3 Calculation

Determine the discharge rate (foam solution flow rate) Q (in L/min) from the following equation:

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

where

K is the foam generator discharge coefficient;

P is the pressure drop across the foam generator (in bar).

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

$$R = Q/A$$

where

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

NOTE The discharge coefficient is determined by separate tests measuring rates over the range of back-pressures used.

E.4 Systems with more than one foam generator

Repeat the test, measurements and calculations for each generator.

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Publications referred to

BS 143 & BS 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 1560, *Specification for steel pipe flanges (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 21 R-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 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 A120-84, *Specification for pipe steel, black and hot-dipped zinc coated (galvanized), welded and seamless, for ordinary uses.*
ASTM A135-84, *Specification for electric-resistance welded steel pipe.*

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