BRITISH STANDARD

BS EN 13565-2:2009

Incorporating corrigenda July 2009 and April 2010

Fixed firefighting systems — Foam systems

Part 2: Design, construction and maintenance

ICS 13.220.20

British Standards

National foreword

This British Standard is the UK implementation of EN 13565-2:2009, incorporating corrigendum July 2009. It supersedes BS 5306-6.1:1988 and BS 5306-6.2:1989, which are withdrawn.

The UK participation in its preparation was entrusted to Technical Committee FSH/18/7, Foam systems.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 August 2009

ISBN 978 0 580 69363 2

Amendments/corrigenda issued since publication

Date	Comments
31 August 2009	CEN Corrigendum July 2009 modifies Figure 2
30 April 2010	Addition of supersession information in the National foreword

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 13565-2

May 2009

ICS 13.220.20

Incorporating corrigendum July 2009

English Version

Fixed firefighting systems - Foam systems - Part 2: Design, construction and maintenance

Installations fixes de lutte contre l'incendie - Systèmes à émulseurs - Partie 2: Calcul, installation et maintenance

Ortsfeste Brandbekämpfungsanlagen - Schaumlöschanlagen - Teil 2: Planung, Einbau und Wartung

This European Standard was approved by CEN on 24 May 2007.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN Management Centre has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: Avenue Marnix 17, B-1000 Brussels

Ref. No. EN 13565-2:2009: E

Contents

page

Foreword ... 5

Introduction ... 6

1 Scope ... 8

2 Normative references ... 8

3 Terms and definitions ... 8

4 Foam extinguishing systems ... 12
4.1 General ... 12
4.1.1 General requirements ... 12
4.1.2 Environmental considerations ... 13
4.1.3 Planning ... 13
4.1.4 Documentation ... 13
4.1.5 Supplementary manual foam fire fighting provisions ... 14
4.1.6 Equipment ... 14
4.2 Water supply ... 15
4.2.1 Water demand ... 15
4.2.2 Operating time ... 15
4.2.3 Quality of water ... 15
4.2.4 Power supply for water pumps ... 16
4.3 Foam concentrate ... 16
4.3.1 General ... 16
4.3.2 Foam concentrate supply – low and medium expansion foams ... 16
4.3.3 Foam concentrate pumps ... 17
4.3.4 Supplementary external connections ... 17
4.4 Foam proportioners ... 17
4.5 Pipework ... 18
4.5.1 Water and foam solution pipework ... 18
4.5.2 Foam concentrate piping ... 18
4.5.3 Non Newtonian foam concentrate ... 18
4.5.4 Piping of aspirated foam (including that for subsurface foam applications) ... 18
4.5.5 Marking ... 19
4.6 Foam discharge outlets and generators ... 19
4.7 Operation and control systems ... 19
4.7.1 Detection of fires ... 19
4.7.2 Release of fixed foam extinguishing systems ... 19
4.7.3 Alarms ... 20

5 Design ... 20
5.1 Application rates ... 20
5.2 Flammable liquid storage tanks, bunds and process areas ... 22
5.2.1 General ... 22
5.2.2 Number of foam discharge outlets ... 24
5.2.3 Fixed cone roof tanks ... 24
5.2.4 Floating roof tanks ... 27
5.2.5 Bunded/diked areas and process areas ... 28

6 Foam sprinkler and deluge systems ... 31
6.1 Deluge systems ... 31
6.1.1 Deluge applications ... 31
6.1.2 Deluge limitations ... 31
6.1.3 Deluge design ... 31

6.2 Foam enhanced sprinkler systems ... 31
6.2.1 Foam enhanced sprinkler applications ... 31
6.2.2 Foam enhanced sprinkler limitations ... 31
6.2.3 Foam enhanced sprinkler design ... 32
6.3 Foam concentrate ... 32
6.3.1 Aspirated foams ... 32
6.3.2 Non aspirated foams ... 32
6.4 Foam proportioning ... 32
6.5 Drain and flushing connections ... 32
1.1.1 NA ... 33
1.1.2 NA ... 33
1.1.3 N.A ... 34

7 High expansion foam systems ... 35
7.1 General ... 35
7.2 Foam concentrate ... 36
7.3 Equipment ... 36
7.4 System design ... 36

7.5 Equipment location considerations ... 37
7.6 Personnel safety ... 37
7.7 Discharge rate (total flooding systems) ... 38
7.8 Discharge time (total flooding systems) ... 38

8 Marine loading and unloading docks ... 39
8.1 Water supplies ... 39
8.2 Foam concentrate ... 39
8.3 Foam water monitors ... 39
8.4 Below dock foam systems ... 39

9 Aircraft hangars ... 40
9.1 General ... 40
9.2 Hangar partitioning ... 40
9.3 Fire detection ... 40
9.4 System design philosophy ... 40
9.5 System duration ... 42
9.6 Foam and water pumps ... 42
9.7 Acceptable application methods ... 42
9.8 Foam types ... 42
9.9 Monitors ... 42
9.10 Foam-water deluge systems ... 42
9.11 Medium expansion systems (Type 3 hangars only) ... 43
9.12 High expansion systems ... 43
9.13 Headlines ... 43
9.14 Commissioning tests ... 43

10 Liquefied flammable gases (LNG/LPG) ... 44
10.1 General ... 44
10.1.1 Liquefied Natural Gas (LNG) ... 44
10.1.2 Liquefied Petroleum Gas (LPG) ... 44
10.2 Controlled burn-off ... 44
10.3 Un-ignited spills ... 44
10.4 Fire detection ... 44
10.5 Foam properties ... 44
10.6 Foam proportioning system ... 45
10.7 Application techniques ... 45

11 Commissioning, testing, and periodic inspections ... 46
11.1 Instruction of operating personnel ... 46
11.2 Commissioning ... 46
11.2.1 General ... 46
11.2.2 Visual inspection ... 46
11.2.3 Pressure tests ... 46

11.2.4 Tests 46
11.2.5 Completion certificate 46
11.3 The periodic inspection and testing of foam systems.....47
11.3.1 General.....47
11.3.2 Inspections 47
11.4 Shut-down 49
11.5 Maintenance 49
11.6 Alterations 49

Bibliography 50

Foreword

This document (EN 13565-2:2009) has been prepared by Technical Committee CEN/TC 191 “Fixed firefighting systems”, the secretariat of which is held by BSI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by November 2009, and conflicting national standards shall be withdrawn at the latest by November 2009.

EN 13565 *Fixed firefighting systems — Foam systems* consists of the following parts:

Part 1: Requirements and test methods for components

Part 2: Design, construction and maintenance

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: : Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

Introduction

It has been assumed by the drafting of this European Standard, that the application of the contained requirements shall be given to qualified and experienced personnel only. It is considered to apply to new foam systems and so it is not considered to apply to existing foam systems.

Foam systems are designed to provide a homogeneous layer of bubbles, of aerated fire fighting foam concentrate and water, over the surface of flammable liquids (Class B) and/or combustible materials (Class A). The layer of bubbles will suppress the release of flammable vapours, exclude air, and cool the fuel and hot surfaces.

In addition, High Expansion Foam may be used to provide total flooding of enclosures with 3 dimensional hazards of either Class A and/or Class B fuels.

Prior to the selection and design of foam systems the hazards should undergo a risk assessment; however this is outside the scope of this European Standard. Applications for foam systems can be diverse so no one type of foam system can be prescribed. This European Standard provides guidance for the design of various foam systems available to persons with knowledge and experience in determining the selection of foam fire extinguishing systems which will be effective in protecting specific hazard configurations. The requirement for foam systems derives from risk assessment by those competent to carry out such assessments which are outside the scope of this European Standard. Nothing in this European Standard is intended to restrict new technologies or alternative arrangements, provided the level of safety prescribed by this European Standard is not lowered.

Typical uses of the various types of foam system are set out in Table 1 below:

Table 1 — Typical uses of the various types of foam system

Hazard	Low expansion	Medium expansion	High expansion (indoors)
Flammable liquid storage tanks	Yes	No	No
Tank bunds/collecting areas	Yes	Yes	Yes + LNG/LPG
Process areas	Yes	Yes	Yes
Aircraft hangers	Yes	< 1 400 m^2 only	Yes
Fuel transfer areas	Yes	Yes	Yes
Plastic packaging and storage	Yes	No	Yes
Plastic recycling	Yes	No	No
Refuse handling and storage	Yes	No	No
Liquefied Natural Gas	No	No	Yes (and outdoors)
Tyre storage	Yes	No	Yes
Rolled paper	No	No	Yes
Marine jetties	Yes	Yes	No
Oil filled transformers and switchgear	Yes	No	Yes
Cable tunnels	No	No	Yes
LPG (Liquefied Petroleum Gas)	No	Yes	Yes (and outdoors)
Warehouses – Class A and B fuels	Yes	No	Yes

NOTE These typical uses are not prescriptive and do not preclude other uses, providing there is a fire engineering basis.

Foam systems may be used to suppress the release of toxic vapours but this application is outside the scope of this European Standard.

The engineering of foam systems is deemed to utilise proportioners and discharge devices evaluated and tested in accordance with EN 13565-1 using foam concentrates complying with EN 1568.

Low and Medium Expansion Foam Systems are not suitable for fire extinguishment of cascading fuel or spray fires, however, they will/may be of value in the control of resultant spill fires.

All foam systems are generally unsuitable for the following:

— chemicals, such as cellulose nitrate, that release sufficient oxygen or other oxidising agents which can sustain combustion;

— energised unenclosed electrical equipment;

— metals such as sodium, potassium and sodium-potassium alloys which are reactive to water;

— hazardous, water–reactive materials such as triethyl-aluminium and phosphorous pentoxide;

— combustible metals such as aluminium and magnesium.

Foam systems reduce the environmental impact of fire by reducing fire effluent both into the atmosphere and onto the ground. This is achieved through a more efficient application of fire extinguishing agent onto the seat of the fire. Such systems also provide increased safety for fire fighting personnel and neighbouring communities.

1 Scope

This European Standard specifies the requirements and describes the methods for design, installation, testing and maintenance of low, medium, and high expansion foam fire extinguishing systems.

This European Standard provides guidance for the design of various foam systems available to persons with knowledge and experience in determining the selection of foam fire extinguishing systems which will be effective in protecting specific hazard configurations.

This European Standard does not cover a risk analysis carried out by a competent person.

Nothing in this European Standard is intended to restrict new technologies or alternative arrangements, provided that the level of safety prescribed in this standard is not lowered, and supported by documented evidence/test reports.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 54, *Fire detection and fire alarm systems*

EN 1568 (all parts), *Fire extinguishing media — Foam concentrates*

EN 12094-1, *Fixed firefighting systems — Components for gas extinguishing systems — Part 1: Requirements and test methods for electrical automatic control and delay devices*

EN 12259-1, *Fixed firefighting systems — Components for sprinkler and water spray systems — Part 1: Sprinklers*

EN 12845:2003, *Fixed firefighting systems — Automatic sprinkler systems — Design, installation and maintenance*

EN 13565-1:2003, *Fixed firefighting systems — Foam systems — Requirements and test methods for components*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 13565-1:2003 and the following apply.

3.1
mode of application
method for the transportation of the foam onto the surface to be protected with the following subdivisions

3.2
semi-subsurface
system where foam is delivered under the surface of the fuel and directed by a floating hose onto the surface to be protected

3.3
subsurface
system where foam is delivered under the surface of the liquid

3.4
conventional (top pouring)
system where foam is delivered onto the surface to be protected

3.5
density/application rate
calculated amount of foam solution in litres per square metre per minute

3.6
type of foam extinguishing systems
subdivided into fixed, semi-fixed and mobile systems

3.7
mobile foam extinguishing system
system where all components are mobile (portable/transportable) and handled, positioned and directed by authorised personnel

3.8
semi-fixed foam extinguishing system
system where extinguishing foam is delivered through a fixed installed pipework and stationery foam making components whilst the foam concentrate only, or both the foam concentrate and water, are supplied from mobile appliances by authorised personnel

3.9
fixed foam extinguishing system
system where all components of the foam extinguishing system and the foam solution supply are permanently installed to provide protection of a facility

3.10
area of operation
minimum area for the design of the water and foam concentrate supplies

3.11
operation time
minimum time for the supply of the extinguishing system with water

3.12
fire-fighting foam
complex medium of air filled bubbles formed from a foam solution

3.13
aspirating component
component within which air and foam solution are mixed to make foam

3.14
branchpipe
component which projects foam in the form of a jet or spray

3.15
component
item or piece of equipment conforming to EN 13565-1 and intended for use in a fixed foam fire extinguishing system

3.16
high back pressure foam generator
component which introduces air into the foam solution stream for delivery against a high back pressure, for example, as is found in tank sub-surface mode

3.17
high expansion foam
foam which has an expansion ratio greater than 200:1

3.18
foam generator
component which introduces air into the foam solution stream for delivery against a low back pressure, i.e. discharging against atmospheric pressure

3.19
low expansion foam
foam which has an expansion ratio not greater than 20:1

3.20
foam chamber
component that incorporates a vapour seal, a foam expansion chamber, and which delivers foam into a flammable or combustible liquid storage tank

NOTE A foam generator may be connected to the foam chamber inlet

3.21
medium expansion foam
foam which has an expansion ratio greater than 20:1 but not greater than 200:1

3.22
monitor
component consisting of a branchpipe and turret

3.23
non-aspirating
components which discharge a spray of foam solution so that mixing with air and formation of foam takes place outside the component

3.24
fixed foam pourer (foam discharge outlet)
component which discharges foam gently and indirectly onto the fuel surface

NOTE Some pourers are designed to discharge the foam tangentially in order to create a circular motion, and thus promote foam distribution.

3.25
proportioning component
component which controls the mixing of foam concentrate into a water flow, at a predetermined ratio, to produce a foam solution

NOTE Proportioning components are variously described as inline, bypass and round the pump inductors, injectors, eductors, proportioners, venturis, constant and variable flow valves, orifice plates, water powered foam pumps and displacement proportioners.

3.26
semi-subsurface hose unit
component which delivers foam below the surface of a flammable liquid so that it rises to the liquid surface within a flexible hose and spreads over the liquid surface

3.27
sprayer
open sprinkler, sprayer, or nozzle without integral air aspiration

3.28
sprinkler/sealed sprayer
nozzle with a thermally sensitive sealing device which opens to discharge foam solution or water for fire fighting. (see EN 12259-1)

3.29
foam water sprinkler/sprayer
aspirating nozzle with or without a thermal release element

3.30
vapour seal
frangible component designed to prevent tank contents vapours entering the foam pipework system while allowing foam to flow into the tank during system operation

3.31
working pressure
pressure at which the component is used in the system

3.32
pipework
pipes and connections including fittings and supports for the transportation of water, foam concentrate, foam solution and sometimes foam

3.33
foam extinguishing system
installation comprising components, devices, and pipework configured to produce and disperse low, medium or high expansion foam to extinguish fire

NOTE A foam extinguishing system comprises foam/water proportioning components, foam concentrate tank, foam generating/discharge components, pipework, and the associated water supply. Foam extinguishing systems can be fixed, semi-fixed or mobile

3.34
medium expansion foam extinguishing system
system producing medium expansion foam as firefighting agent

3.35
low expansion foam extinguishing system
system producing low expansion foam as firefighting agent

3.36
foam concentrate
liquid that is diluted with water to produce foam solution

[EN 1568]

3.37
foam solution
solution of foam concentrate in water

[EN 1568]

3.38
expansion ratio
ratio of the volume of foam to the volume of the foam solution

3.39
premixed solution
foam solution stored at nominal concentration

3.40
operating time
minimum time for the supply of the foam extinguishing system with foam concentrate

3.41
spill hazard
depth of flammable liquid less than or equal to 25 mm

3.42
fuel in depth hazard
depth of flammable liquid greater than 25 mm

3.43
high expansion foam extinguishing system
system, producing high expansion foam as firefighting agent

3.44
maximum flow demand (Q_{max})
flow at the point of intersection of the pressure-flow demand characteristic of the foam system and the water supply pressure-flow characteristic at maximum water level in the suction tank

4 Foam extinguishing systems

4.1 General

4.1.1 General requirements

The component materials of foam extinguishing systems shall be selected in such a way that they are resistant to the substances they come into contact with. Details of the foam concentrate used shall be kept – these shall include type, brand, proportioning rate, manufacturing date, batch numbers and EN 1586 classification. These records shall be updated as stocks are used and replaced.

Foam extinguishing systems shall be able to effectively cover the area/volume to be protected with due consideration of:

- type of fuel;
- spreading characteristics of the foam;
- type of application;
- obstacles;
- foam destruction due to burning, drainage, mechanical breakdown and leakage;
- foam losses due to wind and thermal updrafts.

The covering of the surface to be protected with foam can be done with fixed, semi-fixed or mobile foam generators.

Where foam-extinguishing systems are used for the fire prevention by the creation of a foam layer over a flammable liquid surface, the foam layer shall be maintained in order to prevent or suppress the release of flammable vapours to atmosphere. Any breakdown or destruction of the foam should be replenished by further foam application.

4.1.2 Environmental considerations

Fires where foam application is used can be of sufficient magnitude to produce significant quantities of fire-water run-off, and airborne pollution, which may be detrimental to the environment. This run-off is likely to contain fuel, combustion products, contaminated water and foam solution. It should be contained/collected for analysis and disposal in accordance with national environmental regulations.

NOTE Foam systems and the protected objects should be flushed with fresh water after system operation to minimise potential risk of corrosion.

4.1.3 Planning

Foam systems should not be considered in isolation, but as part of risk management along with process controls and manual fire fighting resources.

Planning, installation, alteration and extension of foam systems shall only be carried out under the responsible supervision of an expert, competent in the engineering of foam fire extinguishing systems.

The proportioning of foam concentrate with water may be carried out in an equipment room (central proportioning) or in the vicinity of the hazard to be protected (decentralised proportioning). For central proportioning the foam solution is fed through pipework and distribution valves to the foam generators. For decentralized proportioning the foam concentrate is proportioned directly into the foam distribution pipework serving the hazard.

If pumping-in connections for the fire brigade are provided at fixed foam extinguishing systems, the water demand of the foam extinguishing system shall be determined and marked at the connection.

In case of semi-fixed installations the mobile water supply as well as the pump and proportioning performance shall be in accordance with the maximum required foam extinguishing system demand.

The pumping-in connections shall be marked with the type of foam, the proportioning rate (%), and the minimum pumping-in pressure. A check valve shall be fitted upstream of the foam extinguishing system to prevent withdrawal of water.

4.1.4 Documentation

The installer shall provide the user of the foam extinguishing system with at least with the following documentation:

- operating instructions;
- general lay-out drawings;
- hydraulic calculation;
- design data (proportioning ratio, water demand, foam concentrate supply);
- list of components;
- water/foam concentrate tank drawings;
- foam concentrate material safety data sheet;
- programme for inspection and maintenance with time intervals;
- certification of conformity by the installer, declaring the conformity with the requirements of this European Standard.

4.1.5 Supplementary manual foam fire fighting provisions

In addition to the fixed foam system requirements there should be means provided for manual fire fighting using foam. These shall enable hose streams to reach any point within the hazard area. These provisions may be added to the fixed foam system or by separate provisions. The connection of hose lines to the water supply of foam extinguishing systems may be used if the necessary water supply and quantity of foam concentrate is available for the operating time. The flow rate per hose stream should be at least be 200 lpm for 30 min.

If foam solution for hose streams is drawn from the foam extinguishing system the necessary amount of additional foam concentrate shall be stocked.

The components of foam extinguishing systems shall be according to the requirements in EN 13565-1.

4.1.6 Equipment

For pumps, foam concentrate tank(s), proportioner(s), operating devices and the associated controls shall fulfil the following requirements:

a) shall be safeguarded from fire by adequate separation distance from fire hazards, or by fire proof enclosure, or by active fire protection – or a combination of these;

b) shall be accessible in case of fire;

c) shall be protected against unauthorised access;

d) shall have suitable ventilation (if indoors);

e) provision of devices for flushing the system and components;

f) shall not be installed in areas which are used for flammable or combustible storage and/or production;

g) shall have sufficient markings;

h) shall be safeguarded against mechanical damage;

i) shall be suitable for the maximum and minimum temperatures, and environment in which they are located.

Water and foam pumps shall start on demand and run continuously until stopped manually, or until the supply is exhausted. There shall be an audible and visual pump running alarm in a constantly attended control room.

Where multiple pumps are involved they should be provided with automatic sequential starting.

Where manifold pressures are required to be maintained, auxiliary pressure maintenance pump(s) shall be provided to avoid frequent operation of the main pumps.

Operating instructions and plans shall be fixed permanently and be clearly visible in the equipment area.

The locations of decentralized parts of foam extinguishing systems shall fulfil the same requirements. The locations shall be included in the plans.

4.2 Water supply

4.2.1 Water demand

The water demand depends upon the area of operation, the application rate and the operation time, plus manual fire fighting demands connected to the same water supply.

The water demand shall be designed for the largest design scenario (largest water quantity requirement as determined by risk assessment – including water cooling where appropriate) – or where there are several foam systems served by a common supply. The water supply shall be protected from freezing.

If the water supply is connected to other systems, such as water spray systems, in addition to the foam extinguishing system, the water demand for the foam extinguishing system shall be ensured at all times.

The necessary water pressure depends on the working pressure of the foam generators and the pressure loss due to elevation, and the friction losses in the pipework, hoses, fittings, and proportioning components.

The pump-set(s) should comply with prEN 12259-12.

4.2.2 Operating time

The water supply shall be designed for an operating time of at least equal to the minimum operating time, for the highest water demand (quantity of water), as laid down in Clauses 5 to 10. The maximum flow demand shall be determined by hydraulic calculation to determine the maximum theoretical flow and pressure in the system with a specific configuration of piping and discharge devices supplied by the water distribution system (Q_{max}). For foam enhanced sprinkler and spray systems the water supplies shall comply with the operating time requirements as laid down in the associated sprinkler or water spray design code.

For fuel in depth hazards (fuel depth > 25 mm) the foam system(s) shall be capable of operating for the duration specified in this European Standard. For spill fire hazards (fuel depth < 25mm) the operating time may be reduced if the application rate is higher than the specified minimum, but in no case shall this be less than 70 % of the minimum operating time specified in this European Standard.

4.2.3 Quality of water

Consideration shall be given to the quality of the water used. Salt water or hard water, and/or corrosion inhibitors, antifreeze agents, marine growths, oil or other contaminants could result in a reduction in foam expansion or stability. Not all foams are suitable for use with sea water and the performance classification for specific foam may differ due to the water quality.

Water quality is particularly important when using high and medium expansion foam generators as water contaminants and minerals can reduce foam expansion and stability. The supplier of the foam concentrate should be consulted.

The water quality may influence the efficiency and function of the foam extinguishing system, therefore a foam concentrate should be selected which is compatible with the available water.

WARNING — Foam quality may be adversely affected by increased amounts of sediments and other pollutants. Reduced foam production or decreased free cross sections may result due to formation of deposits in the components

NOTE Performance classification of foams according to EN 1568 is made at an air temperature between 10 °C and 20 °C and a water temperature of 15 °C to 20 °C. Using the foam at elevated air and water temperatures (> 35 °C) may reduce the fire fighting performance and require higher application rates - consult the foam concentrate manufacturer.

4.2.4 Power supply for water pumps

Using fixed pumps and where availability and reliability are critical, consideration should be given to dual sources of water supply. These may be provided by two or more pumps whose power sources are such that 100% duty is available should one source fail. Mobile pumping units may also be considered.

4.3 Foam concentrate

4.3.1 General

Foam concentrates shall be tested and verified to be in accordance with EN 1568. Specific requirements are also given for low-expansion foams suitable for water-miscible fuels.

NOTE 1 Foams tested as low expansion foams according to EN 1568 Parts 3 and 4 will achieve a performance classification based on its extinguishing and burnback properties. For a low expansion foam for water-immiscible fuels (EN 1568-3), there are three extinguishing classes (I, II, III) and four burnback levels (A, B, C, D), performance classification IA being the highest classification. For a low expansion foam for water-miscible fuels (EN 1568-4), there are two extinguishing classes (I, II) and three burnback levels (A, B, C). It is important to notice that not all foams are suitable for use with sea water and that the performance classification might be different when using fresh water or sea water.

In a foam extinguishing system the foam proportioner and foam concentrate shall be compatible in accordance with EN 13565-1. The viscosity properties of the foam concentrate determined according to EN 1568 shall therefore be within the approved viscosity range for the proportioner according to EN 13565-1.

Foam concentrates of different types and manufacture should not be mixed unless compatibility has been determined by test and a test report provided. In the event of a change of foam concentrate, the performance classification of the new foam shall be equal to or better than the replaced foam or the minimum performance data specified in designing the system. The necessary performance data of the foam extinguishing system shall be kept on file.

The quantity of foam concentrate provided shall be sufficient to ensure that the minimum specified operation time is achieved.

NOTE 2 In addition, appropriate contingency planning is required to provide significant additional stocks of foam concentrate for post fire security.

WARNING — The extinguishing effect of premixed solutions, in storage vessels or pipework, may be reduced considerably depending on the storage time and the quality of water used. Polymeric film forming foams should not be pre-mixed unless written confirmation of suitability has been provided by the foam manufacturer.

Foam concentrates shall be stored within the temperature limits given by the foam concentrate supplier.

The quality of the stored foam concentrate should be checked using the guidelines described in Clause 11.

4.3.2 Foam concentrate supply – low and medium expansion foams

Reserve supplies of foam concentrate shall be made available to re-activate the foam system in line with the hazard risk assessment for the site.

The foam concentrate quantity *V* in litres shall be calculated as follows:

$$V = Q_{\max}\ t \frac{Z}{100} \tag{1}$$

where

Q_{max} is the maxium water demand, in litres per minute;

Z is the proportioning rate of the foam concentrate in percent;

t is the operating time, in minutes.

Continuous proportioning of the foam concentrate, for the complete operation time, shall be provided.

The foam concentrate storage tanks shall be provided with a contents verification device, drain and fill connections. Consideration shall be given to the design of the storage containers and their pressure/vacuum venting to minimise vapourisation and/or oxidation of concentrate.

4.3.3 Foam concentrate pumps

4.3.3.1 General

The design, materials and construction of foam concentrate pumps shall be suitable for use with the type of foam concentrate used in the system(s). The viscosity properties of the foam concentrate determined in accordance with EN 1568 shall therefore be within the approved viscosity range for the foam pump. Pumps shall be permanently filled with foam concentrate to minimise corrosion, foaming and sticking. Where centrifugal pumps are used they shall be fitted with mechanical seals to prevent the ingress of air. Test and re-circulation lines shall be provided from the pump delivery back into the foam storage container to enable the pump to be tested and for pressure relief/control where required. The pump shall be able to deliver the flow and pressure of foam concentrate required to for the maximum system flow with the reduced pipe friction of new pipe, for the maximum water supply operating pressure and for the proportioning rate at the maximum proportioning tolerance (+30 %). Positive displacement pumps should be used for Non Newtonian foam concentrates.

Automatic pump starters should comply with the requirements of prEN 12259-12.

4.3.3.2 Power supply for foam concentrate pumps

Using fixed pumps, and where availability and reliability are critical, consideration should be given to dual sources of supply. These may be provided by two or more pumps whose power sources are such that 100 % duty is available should one source fail. Mobile pumping units may also be considered.

4.3.4 Supplementary external connections

Where appropriate, valved connections for the withdrawal and/or feeding in of foam concentrate shall be provided up and down stream of the foam concentrate pump. Consideration may also be given to the provision of pumping-in connections for water and/or foam solution, e.g. for fire brigade use.

4.4 Foam proportioners

Foam proportioners shall meet the requirements of EN 13565-1 using the foam concentrate concerned or a concentrate with similar viscosity properties.

Foam proportioners shall be installed and operated in accordance with the parameters laid down for the use of the proportioner by the supplier and the conformity tests.

Provisions shall be made, in the proportioning system, for the accuracy of proportioning to be verified by testing at maximum and minimum flow conditions, in accordance with the maintenance and testing requirements as laid down in Clause 11.

4.5 Pipework

4.5.1 Water and foam solution pipework

All water and foam solution piping shall be designed, hydraulically calculated, supplied and installed in accordance with EN 12845. The minimum design application rate shall be applied at the most hydraulically remote protected area/zone. Corrosion resistant materials or finishes shall be used where it may be subjected to corrosive atmospheres. Normally empty pipework shall be hot dip galvanised steel as a minimum, however, piping for foam concentrate, or in continuous contact with foam solution, shall not be galvanised and shall be compatible with the foam concentrate used.

Pipework, not installed underground, shall be designed and sited so as to minimise or eliminate the risk of mechanical damage or, where this is not possible, pipework with sufficient inherent strength shall be used. Where possible, piping shall be routed outside the potential fire area(s) so that possible exposure to fire is minimised. Suitable passive protection of the piping may be required.

At all times water and foam solution filled pipework shall be protected from frost. Care shall also be taken to safeguard piping containing foam concentrate from the risk of freezing.

In stand-by condition empty pipework shall be fitted with devices for flushing and drainage. Complete drainage shall be possible.

The dimensioning of the pipework shall be determined by hydraulic calculation to ensure the required rates of flow at the foam generators. For subsurface foam systems the friction losses, plus the static pressure from the height of fuel in the tank, shall not exceed the outlet pressure from the high back-pressure foam generator as determined for the system design inlet pressure (this shall be established by testing in accordance with EN 13565-1).

Piping shall be generally in accordance with EN 12845:2003, Clause 17. Piping, in manual or semi fixed systems that may be exposed to fire, shall have only welded or screwed jointing.

Where a fixed foam system is provided for a fixed roof tank, each foam outlet should be individually supplied from outside the bund, with each supply line they shall have an isolating valve fitted. This will enable isolation of any individual foam chamber(s) damaged by fire and/or explosion (see also 5.2.3.1), alternatively a foam ring main connecting the foam pourers may be used.

4.5.2 Foam concentrate piping

Foam concentrate piping shall be resistant to the concentrate used. Friction loss calculations should be undertaken using the Darcy formula.

4.5.3 Non Newtonian foam concentrate

Non Newtonian foam concentrates have viscosities that increase as their flow rate (shear rate) decreases. These foam concentrates also have viscosities that increase as temperatures decrease – foam manufacturers should be consulted. In view of these properties special care and attention should be taken when designing their foam concentrate distribution pipework. In particular the lengths of pipework that are filled with non Newtonian foam concentrates under no flow conditions should be minimised.

4.5.4 Piping of aspirated foam (including that for subsurface foam applications)

Friction loss calculations shall be carried out using:

$$\Delta P = 1{,}042\ Q^2/d^5 \quad (2)$$

where

ΔP is the pressure loss (bar/m);

Q is the flow (lpm) – aspirated foam;

d is the internal pipe diameter (mm);

4.5.5 Marking

All manually operated controls and devices shall be clearly marked according to the foam systems they serve and the function they perform.

4.6 Foam discharge outlets and generators

Foam discharge outlets and generators shall:

a) comply with EN 13565-1;

b) be made from steel or equivalent materials;

c) be situated so that regular maintenance is possible and the function is not adversely effected by fire gasses;

d) be protected against blockage.

Provisions should be made to discharge the foam gently onto the area to be protected.

The foam should be distributed evenly on the surface to be protected – particularly for protection involving water miscible fuels.

4.7 Operation and control systems

4.7.1 Detection of fires

Fire or conditions likely to produce fire can be detected by human senses or by automatic means. Automatic detection shall be achieved using devices suitable for the conditions they are expected to detect and complying with the relevant parts of EN 54 and installed in accordance with national regulations. Devices indicating heat, smoke, or flame combustible vapours may be used. Other devices indicating abnormal conditions that are likely to produce fire may also be utilised.

Where a threat to personnel safety may arise/can occur, automatic fire detection and alarm should be provided.

NOTE For hazards such as outdoor full surface area storage tank fires it may be appropriate to delay foam discharge whilst other hazard mitigation measures are completed or in place. For other hazards, especially indoors or where a danger to personnel can exist, immediate automatic system operation may be required to safeguard personnel, and/or to limit the potential for fire spread.

Detection systems shall have a reliable and adequate source of energy. Power supplies for electrical control devices shall be in accordance with EN 12094-1 with emergency, battery-powered supply with automatic change-over shall be provided if the primary supply fails.

4.7.2 Release of fixed foam extinguishing systems

The protected areas shall be clearly identified.

Devices which will automatically operate fixed foam extinguishing systems shall comply with European Standards e.g. EN 12094- 1 and -2, for such fire system devices where applicable. An adequate and reliable source of energy shall be used. All operating devices shall be suitable for the service they will encounter and shall not be rendered inoperative or susceptible to accidental damage or operation. All operating devices shall be located so that they are not subject to mechanical, chemical, climatic or other conditions that can render them inoperative. Foam systems within buildings should have automatic control devices.

All fixed foam extinguishing systems shall have facilities for manual operation, which shall be conveniently and easily accessible at all times. For large hazard areas and/or where access may be limited, manual release devices both local to, and remote from, the operating devices may be required. Where a source of energy is required for actuation of the operating devices an emergency mechanical means of actuation shall be provided from at least one location. Manual release stations shall be clearly marked and the area each serves shall also be clearly identified.

Facilities shall be provided to enable testing of release devices without discharge of foam.

4.7.3 Alarms

All automatic detection and manual control devices (electrical and non electrical) where provided shall be arranged so that there is immediate indication of any alarm.

An alarm shall be provided to show that a system has operated. An alarm signal to a permanent manned location shall be provided in all cases, and audible and/or visual evacuation alarms activated through the protected area.

Alarms shall be provided to give warning of pending discharge where hazards to personnel can occur.

Alarms indicating failure of supervised devices or equipment shall give prompt and clear indication of any failure and alarms shall be distinctive from those alarms indicating operation or hazardous conditions.

5 Design

5.1 Application rates

The application rates for low and medium expansion foam shall be calculated as follows:

$$q = q_{th} \cdot f_C \cdot f_O \cdot f_H \quad (3)$$

where

q are the minimum application rates for the foam solution, in litres per minute per square metre;

q_{th} are the nominal application rates for the foam solution, in litre per minute per square metre;

with: q_{th} = 4,0 l/m^2 min

f_C is the correction factor for the class of foam concentrate according to EN 1568 (see Tables 2a and 2b);

f_O is the correction factor for the kind of object (see Tables 3 and 5);

f_H is the correction factor for nozzle distance in outdoor deluge systems = 1,0 for nozzles < 5m from the protected surface; 1,25 for nozzles > 5 m from the protected surface (low expansion only).

The correction factor for medium expansion nozzles shall be determined by test for specific applications.

The application rates in this European Standard are to be treated as the rates delivered by the various discharge devices - they take into account possible delivery losses. The application rates have been based upon operational data.

WARNING Monitor protection of internal floating roof tanks is only suitable for full surface fires, and it can be potentially dangerous to use monitors against fires such as vent fires or rimseal fires.

NOTE Monitor application rates assume appropriate large capacity equipment and effective fire-ground deployment. These application rates assume longer pre-burn times before effective foam application. Fixed system application rates assume shorter pre-burn times before effective foam application.

Table 2a — Correction factors fc – low expansion – water immiscible (per EN 1568-3)

Extinguishing performance Class – EN 1568-3	**Correction factor – spill (f_c)**	**Correction factor – fuel in depth (f_c)**	**Typical foam types for information only (all foams shall have the required EN 1568 performance classification)**
1A	1,0	1,0	AFFF(AR), FFFP(AR), FFFP
1B	1,0	1,1	AFFF(AR), FFFP(AR), FFFP
1C	1,1	1,25	AFFF, FFFP
1D	1,1	**NA**	AFFF, FFFP
2A	1,0	1,0	FP, FP(AR)
2B	1,0	1,1	FP, FP(AR)
2C	1,1	1,25	FP
2D	1,1	**NA**	FP
3B	1,5	**NA**	S, P
3C/3D	1,75	**NA**	S
NOTE NA denotes that these applications would require both higher application rates and longer discharge times in order to achieve extinguishment and are therefore not recommended.			

Foam concentrates tested for use at Medium Expansion in accordance with EN 1568-1 shall have a correction factor (f_c) of 1,0 for spill fire applications and 1,5 for fuel in depth applications. Foam concentrates also tested to EN 1568-3 and have obtained a 1A/B/C or 2 A/B/C rating they shall be used with a correction factor of 1,0 for fuel in depth applications.

Table 2b — Correction factors f_c – low expansion – water miscible (per EN1568-4)

Extinguishing performance class – EN 1568-4	Correction factor – spill (f_c)	Correction factor – fuel in depth (f_c)	Typical foam types for information only (all foams shall have the required EN 1568 performance classification)
1A	1,5	2,0	AFFF(AR), FFFP(AR),
1B	1,5	2,25	AFFF(AR), FFFP(AR),
1C	1,5	2,5	AFFF(AR), FFFP(AR),
2A	2,0	2,5	AFFF(AR), FFFP(AR), FP(AR)
2B	2,0	2,75	AFFF(AR), FFFP(AR), FP(AR)
2C	2,0	3,0	AFFF(AR), FFFP(AR), FP(AR)
NOTE These are minimum correction factors are based upon gentle pouring application on Methanol, Iso Propyl Alcohol, or Acetone. More foam destructive fuels may require higher correction factors – to be determined by documented testing. Consult the foam manufacturer.			

AR type foam concentrates may be used at medium expansion when verified by test and the test report is provided.

5.2 Flammable liquid storage tanks, bunds and process areas

5.2.1 General

Foam application rates shall be determined using Equation (3) and the foam object (f_o) correction factors set out in Table 3.

Table 3 — Correction factors f_o – Flammable liquid storage tanks – low expansion with their associated operating times (t)

HAZARD	TYPE OF FIRE	HANDLINES	MONITORS [a]	FIXED SYSTEMS	
				Top pouring	**Sub-surface + semi sub-surface [b]**
Open top floating roof tanks	Full surface area	< 10 m dia **2,5** **t: 60 min**	< 45 m dia **2,5 t: 60 min** > 45 m < 60 m dia **2,75 t: 90 min** > 60m dia **3,0 t: 90 min**	Treat as fixed cone roof tanks	N/A
Open top floating roof tanks	Rimseal area only	BACKUP ONLY **2 outlets each** **200 l/min** **t: 30 min**	N/A	**3,0 t: 20 min**	N/A
Fixed cone roof tanks	Full surface area	< 10 m dia **2,5** **t: 60 min** larger tanks N/A WM – **NA**	Treat as open top floating roof – full surface area	< 45 m dia **1,0 t: 60 min** > 45 m < 60 m dia **1,25 t: 60 min** > 60 m dia **1,5 t: 60 min** Consideration may have to be given to foam application to the tank centre on large tanks	**1,0 t for 60 min**
Internal floating roof tanks – ALL types of floating roof	Full surface area	**NA**	**NA** except in the rare event of no roof and full surface fire – treat as open top floating roof tank	**Treat as fixed cone roof tank**	**NA**
Internal floating roof tank [c]	Rimseal	**NA**	**NA**	**Treat as open top floating roof tank - rimseal**	**NA**

NOTE NA denotes that this type of protection is not considered suitable for this application unless independently validated tests have established its suitability and effectiveness.

[a] Monitors are not suitable for WM fuels.

[b] Subsurface application rates are based upon uniform foam distribution with minimised travel distances (see Table 4).

[c] The following types of roof construction shall be considered suitable for rimseal area protection:

- steel double deck;
- steel pontoon;
- full liquid surface contact, closed cell honeycomb, of metal construction conforming to API 650, welded steel tanks for oil storage.

Fuel types: WM = Water miscible (shall be AR type foams) – correction factor is dependent on fuel type. This may increase if determined by fire test.

NOTE 1 Included in this table are petroleum/alcohol mixtures and unleaded petroleum containing no more than 10 % oxygenated additives by volume. Where oxygenated additives content exceeds 10 % by volume, protection is normally in accordance with WM requirements (AR foams) unless there are specific independent test data to verify other foam concentrates being suitable.

NOTE 2 Flammable liquids having a boiling point of less than 40 °C might require higher rates of application. Suitable rates of application should be determined by test. Flammable liquids with a wide range of boiling points might develop a heat layer after prolonged burning and then can require correction factors of 2,0 or above.

NOTE 3 Care should be taken in applying foam to high-viscosity materials normally heated above 90 °C. Lower initial rates of application could be desirable to minimize frothing and expulsion of the stored liquid.

NOTE 4 Care should also be taken when applying foam to tanks containing hot liquids (i.e. those tanks that have been burning for in excess of 1 h.).

Internal floating roof tanks with floating roofs of constructions other than those specified in footnote [c] in Table 3, shall be treated as requiring full surface area protection.

WARNING — At the time of writing this European Standard, no practical experience exists in fighting fires in tanks over 82 m diameter and little experience on fires in crude oil tanks or tanks containing WM fuels.

5.2.2 Number of foam discharge outlets

The foam discharge outlets of fixed or semi-fixed foam extinguishing systems shall be equally distributed around the circumference. The distance between the foam discharge outlets at the circumference shall not exceed:

— 26 m for floating roof tanks and

— 30 m for fixed roof tanks.

At least two foam discharge outlets shall be provided for floating roof tanks with foam dams.

These requirements are not applicable for cone roof tanks (see 5.2.3).

5.2.3 Fixed cone roof tanks

5.2.3.1 General

Foam discharge outlets shall be installed beneath the weak seam (junction of vertical side and roof) of fixed roof tanks.

When planning pipework for a fixed roof tank consideration shall be given to the lifting off of the tank bottom caused by a tank eruption (for example following a deflagration in the tank). To prevent catastrophic damage to the foam delivery pipes, the pipework through the bund area shall be supported in such a way as to allow a vertical movement of the tank of at least 0,5 m. This may be achieved by appropriate pipe lay-outs (bends and/or pipe offsets with suitable lengths).

Vapour seals shall be provided to prevent a back-flow of gases or vapours from fixed roof tanks to the open air. These devices shall be resistant to the vapours of the stored products. They shall be destroyed or open easily in the event of the release of the foam system.

Vapour seals shall be in accordance with the requirements of EN 13565-1.

See also 4.5.1.

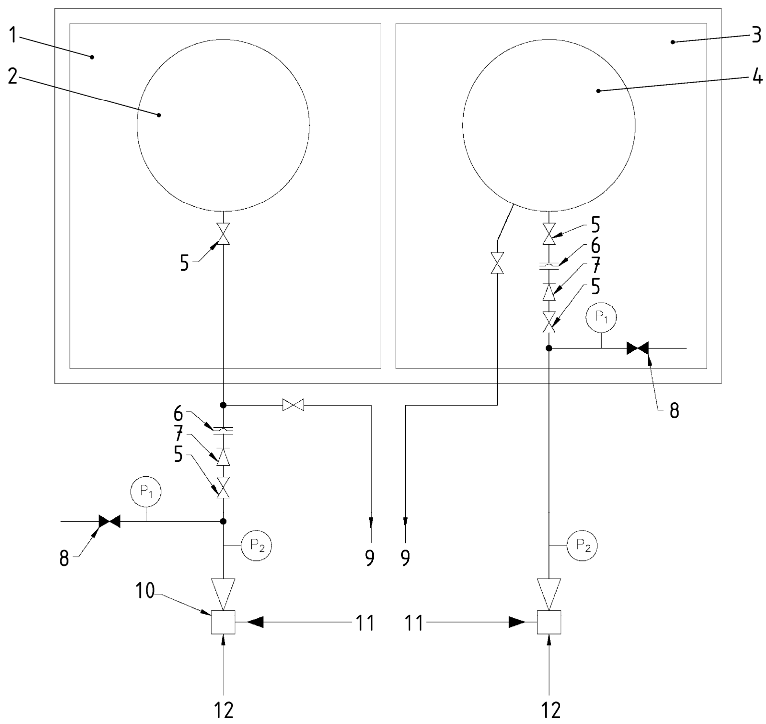
The number of top pouring outlets, using foam chambers, shall be provided in accordance with Table 4a.

Table 4a — Foam chamber requirements

Tank diameter (m)	Number of outlets
≤ 24	1
> 24 up to 36	2
> 36 up to 42	3
> 42 up to 48	4
> 48 up to 54	5
> 54 up to 60	6
> 60	6 + 1 outlet per additional 465 m^2 Tank area in excess of 2827m^2

5.2.3.2 Sub surface

Foam may be injected into a tank beneath the fuel surface either via the product piping, or via dedicated foam injection points. A typical arrangement for subsurface discharge outlets is given in Figure 1.



Key

1 bund 1
2 tank 1
3 bund 2
4 tank 2
5 stop valve (N/O)
6 bursting disc
7 non-return valve
8 foam test valve
9 product lines
10 high back-pressure foam generator (fixed or mobile)
11 air inlet
12 foam solution via pipework (fixed) or hose (semi-fixed)

Figure 1 — Typical arrangements for subsurface discharge outlets

Foam velocities (in the final 3 m of foam delivery pipework) shall not exceed 3 m/s into fuels with flash points < 25 °C and boiling points > 40 °C; and 6 m/s for all other fuels.

Foam injection points shall be at least 300 mm above the highest possible water level with outlets not subject to sediment accumulation.

A test connection shall be provided for each high back pressure foam generator, suitable for the design flow of the generator, with test and isolation valves and a gauge connection to measure back pressure.

Each foam inlet pipe shall be fitted with an isolating gate valve, burst disc and non-return valve.

The burst disc shall be fitted on all foam inlet pipes upstream of each non-return valve. The disc and its holder shall be constructed of materials suitable for the fuel and environment to which they are exposed. They shall be capable of withstanding the thermal relief pressure exerted by the fuel in the tank and able to rupture at or below the minimum pressure delivered by the high back pressure foam generator at the specific system design inlet pressure (using the results from the testing of the high back pressure foam generators in accordance with EN 13565-1).

The pipework between the foam injection point, into the tank or product piping, and the high back pressure foam generator, should be installed at a slope ≥ 200:1 and equipped with adequate drainage facilities.

Where foam injection is via product piping:

— isolating valves between the tank nozzle and the foam injection point shall be secured in the open position;

— foam isolating valve, burst disc and non-return valve shall be installed as close as possible to the foam line connection to the product piping.

The number of subsurface outlets shall be provided in accordance with Table 4b.

Table 4b — Subsurface and semi-subsurface outlet requirements

Tank diameter (m)	Number of outlets	
	Fuel flash point ≤ 40 °C	**Fuel flash point > 40 °C**
≤ 24	1	1
> 24 up to 36	2	1
> 36 up to 42	3	2
> 42 up to 48	4	2
> 48 up to 54	5	2
> 54 up to 60	6	3
> 60	6 + 1 outlet per 465 m^2 Tank area in excess of 2827m^2	3 + 1 outlet per 700 m^2 Tank area in excess of 2827m^2

5.2.3.3 Restrictions for semi-subsurface-mode

This mode shall not be used for products, which are stored at temperatures higher than 80 °C and/or having a viscosity ≥ 100 mm^2/s.

5.2.3.4 Restrictions for subsurface mode

This mode shall not be used:

— for water miscible fuels (WM) such as alcohol, ester, ketone, aldehyde or other products needing a alcohol resistant foam (AR) concentrate for extinguishing;

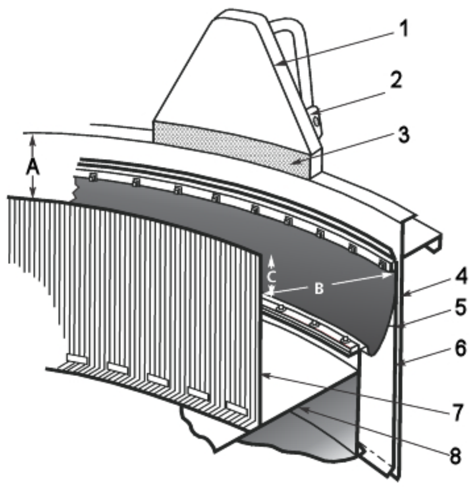
— hydrocarbon fuels with flash points < 25 °C and boiling points > 40 °C;

— for fuels, which are stored at temperatures higher than 80 °C and/or having a viscosity ≥ 100 mm^2/s.

5.2.4 Floating roof tanks

5.2.4.1 Rimseal protection

The foam discharge outlets shall be positioned above the highest possible position of the floating roof. A typical rimseal protection arrangement is given in Figure 2.



Key

1 Rimseal foam pourer
2 Rimseal foam generator with mesh to stop insects entering
3 Mesh to stop birds nesting and improve foam quality
4 Tank shell
5 Fabric seal
6 Shoe plate
7 Circular foam dam
8 Floating roof

Distance	Minimum distance in mm (in)
Tank rim above foam dam height A	500 (20)
Foam dam to tank shell B	600 (24)
Dam height above top of seal	50 (2)
Drain slots height in foam dam	7 to 10 max. (0,25 to 0,37)

Figure 2 — Typical Foam Dam for Floating Roof Tank Protection

Fixed rimseal foam pourers shall be mounted above the top of the tank shell (vertical side) to discharge foam onto the seal area. A foam dam shall be installed on top of the floating roof. A distance of at least 500 mm between the top of the foam dam and the top of the tank shell shall be maintained at the maximum permissible filling level of the tank to achieve effective foaming of the seal area. The foam dam shall:

1) be circular and constructed from steel plate with a minimum thickness of 3,5 mm;

2) be welded or otherwise secured to the floating roof;

3) be designed to retain foam at the seal area at a depth to cover the seal area while causing foam to flow laterally to the point of seal rupture;

4) be not less than 600 mm high;

5) extend not less than 50 mm above any metal secondary seal or combustible secondary seal;

6) be not less than 50 mm above any burnout panels in metal secondary seals;

7) be not less than 600 mm from the tank shell;

8) have rainwater drainage slots incorporated which provide 280 mm^2 per m^2 of dammed area, with a maximum slot height of 10mm.

In case of fire weather shields or parts of the seal shall not affect the flow of the foam into the seal area.

NOTE This can be achieved by a circular gap of 100 mm height between weather shield and pontoon, or burn out openings with closures, or the choice of the material of the secondary seal, which will be destroyed at 300 °C in such a way to allow a regular foaming of the circular gap.

Rimseal foam pourers, with foam guides as necessary, shall ensure the uniform and free flow of all foam onto the seal area.

One of the two backup foam handlines specified in Table 3 shall be a dry riser outlet positioned close to the stairs at the top of the tank.

Rim seal foaming shall only be applicable to floating roofs constructed as closed pontoon types.

5.2.4.2 Restrictions for rimseal protection

Rimseal protection shall not used for floating roofs where the roof:

- is a floating diaphragm;
- is a plastic blanket;
- has plastic or other floatation material even if encapsulated in metal or fibreglass;
- relies on floatation device closure that can easily be submerged if damaged;
- is a pan roof.

5.2.5 Bunded/diked areas and process areas

The foam discharge outlets shall be arranged to ensure an even foam discharge.

Provisions shall be made to avoid damage to the bund surfaces by foam flowing out of the foam discharge outlets, if necessary.

For bund protection medium expansion foam generator aspiration shall not exceed 80:1.

The foam flow distance shall not exceed 30 m.

The effective range of monitors shall be reduced by 30 %, from that determined through testing in accordance with EN 13565-1, to make allowance for the effects of wind.

Foam application rates shall be determined using Equation (3) and the foam object (f_O) correction factors set out in Tables 5 and 6.

Table 5 — Correction factors f_o – Outdoor spill and bunded/diked areas with operating times (t)

HAZARD	FUEL TYPE	HANDLINES		MONITORS		FIXED FOAM POURING SYSTEMS	
		Low Exp.	Medium Exp.	Non-aspirated	Aspirated – Low Exp.	Low Exp.-pouring	Medium Exp.-pouring
Spill fires (< 25 mm fuel depth)	WI-V	< 400 m² **1,0 t: 15 min** > 400 m² **NA**	< 400 m² **1,0 t: 15 min** > 400 m² **NA**	**1,5 t: 30 min**	**1,5 t: 30 min**	**0,75 t: 15 min**	**0,75 t: 15 min**
Bund/dike fuel in depth fires (> 25 mm fuel depth) Process/loading areas - increased splashing and escalation risk	WI-V	< 400 m² **1,0 t: 30 min** > 400 m² **NA**	< 400 m² **1,0 t: 30 min** > 400 m² **NA**	< 400 m² **1,5 t: 30 min** > 400 m² < 2 000m² **2,25 t: 45 min** >2 000 m² **2,5 t: 60 min**	< 400m² **1,5 t: 30 min** > 400 m² < 2 000 m² **2,0 t for 45 min** > 2 000 m² **2,25 t: 60 min**	< 400m² **1,0 t: 20 min** > 400 m² <2 000 m² **1,00 t: 45 min** > 2 000m² **1,25 t: 45min**	< 400 m² **1,0 t: 15 min** > 400 m² < 2 000 m² **1,00 t: 30 min** > 2 000 m² **1,25 t: 30min** [b]
Bund/dike fuel in depth (> 25 mm fuel depth) Process/loading areas - increased splashing and escalation risk	WM	< 400 m² **1,0* t: 30 min** (AR foams only) > 400 m² **NA**	< 400 m² **1,5* t: 20 min** (AR foams only) > 400 m² **NA**	**NA**	**NA**	< 400 m² **1.0 * t: 20 min** (AR foams only) > 400 m² < 2 000m² **1,0* t: 45 min** (AR foams only) >2,000m² **1,25 t: 45 min**	< 400m² **1.0* t: 15 min** (AR foams only) >400 m² < 2 000 m² **1,0* t: 30 min** (AR foams only) > 2 000 m² **1,25 t: 30 min** [a] [b]

NOTE NA denotes that this type of protection is not considered suitable for this application unless independently validated tests have established its suitability and effectiveness.

a See 5.1 requirements for medium expansion foam.

b Process/loading areas the expansion ratio should be < 80:1. Medium expansion use should be limited to ground level use, or where there is containment.

WM = Water miscible (shall be AR type foams). WM Minimum correction factor * is dependent on fuel type. The application rate may increase –if determined by fire test.

Fuel types:

WI-V = Water immiscible – Volatile (Flashpoints less than 40 °C), WI-C = Water immiscible – Combustible (Flashpoints greater than 40 °C).

6 Foam sprinkler and deluge systems

6.1 Deluge systems

6.1.1 Deluge applications

Foam deluge shall describe a network of open pipework fitted with open sprayers/nozzles or pourers. This European Standard defines the requirements for the protection of areas where spill hazards (fuel depth < 25 mm) may be encountered involving flammable liquids.

Foam deluge is suitable for the protection of areas involving chemical process plant, fuel transfer, aircraft hangars, plastics packaging, plastics recycling, refuse, block storage of tyres, oil filled transformers and switchgear.

6.1.2 Deluge limitations

Where deluge systems are also required to serve as waterspray cooling systems, they shall be designed as a waterspray system and then foam enhanced using foam concentrate suitable for the types of nozzles used.

6.1.3 Deluge design

The foam shall be distributed by nozzles above the objects to be protected and shall also incorporate nozzles along the periphery of the protected area. Where obstructions can effect the effective distribution of foam, additional low-level nozzles may be required. The positioning shall provide overlap of the distribution spray throughout the protected area and shall be in accordance with the coverage as determined when tested in accordance with EN 13565-1.

Operation of foam deluge should de-energise power supplies to the hazard area.

The maximum area per individually valved deluge system shall be 3 000 m^2.

Foam application rates shall be determined using equation 3 and the foam object (f_O) correction factors set out in Table 5.

Aspirating nozzles and pourers shall conform to EN 13565-1. Non aspirating nozzles shall comply with EN 12259-1.

The foam and water supplies shall be designed to provide the specified minimum design density over the deluge system protected area as required in Table 5 and Table 6.

6.2 Foam enhanced sprinkler systems

6.2.1 Foam enhanced sprinkler applications

For the purpose of this European Standard foam enhanced sprinkler systems shall describe closed head non-aspirating sprinkler systems that have foam concentrate proportioned into their water supply. Such systems may be charged with water, foam solution, or air. The nozzles shall be sprinkler heads sealed by heat frangible elements in accordance with EN 12259-1. Foam enhanced sprinkler systems should be used where flammable liquids are stored in containers and the initial release of flammable liquid will be limited.

6.2.2 Foam enhanced sprinkler limitations

Where the initial release of flammable liquid is likely to create a large fire area the use of closed head sprinklers is not recommended, due to the delay in the delivery of foam at the required application rate, pending the individual operation of sufficient sprinkler heads.

6.2.3 Foam enhanced sprinkler design

Sprinkler systems, with foam enhancement, shall be designed in accordance with EN 12845 and Table 6.

There shall be sufficient foam concentrate for operation at the maximum design flow rate of the sprinkler system.

6.3 Foam concentrate

6.3.1 Aspirated foams

Foam concentrates shall meet the requirements of the appropriate part(s) of EN 1568.

6.3.2 Non aspirated foams

When water sprinklers and/or water sprayers are used, EN 1568-3 class 1A/B/C rated foam concentrates shall be used where only water immiscible fuel hazards occur, but EN 1568-4 class 1A/B rated foam concentrates shall be used where water miscible and other fuels are being used..

6.4 Foam proportioning

The foam proportioning system shall be capable of supplying the maximum and minimum flow conditions of the sprinkler system at the required proportioning ratio, within the limits of accuracy specified in EN 13565-1.

6.5 Drain and flushing connections

Where a system is to be pre-primed with foam solution, drain and flushing connections shall be provided on the ends of the distribution mains. These shall enable the foam solution in the mains to be removed and replenished with fresh foam solution. The foam solution drained from the system shall be disposed of by environmentally responsible means.

Table 6 — Correction factors f_o – Other hazards with operating times (t)

HAZARD	Fuel Type	HANDLINES		MONITORS		Automatic FIXED SYSTEMS				
		Low exp.	Medium exp.	Non-aspi-rated	Aspi-rated	Non-aspirated foam-water deluge	Aspirated foam-water deluge	Low exp. pourers	Medium exp. pourers	High exp.
Indoor bund/dike areas (> 25 mm depth) (increased escalation risk)		1 x 200 l/min t: 20 min Supplementary protection only	1 x 200 l/min t: 20 min Supplementary protection only			2,0 t: 30 min	1,5 t: 30 min	1,0 t: 20 min	1,0 t: 15 min	See Clause 7
Indoor process areas/fuel handling areas and flammable liquid stores (< 25 mm depth) [a]	WI & WM	< 10 m² 1,0 t: 30 min	< 10 m² 1,0 t: 30 min	NA	NA	1,5 t: 15 min	1,5 t: 15 min	1,5 t: 15 min	1,5 t: 15 min	See Clause 7
Plastic packaging, storage, recycling	Class A and plastics	N.A.	N.A.	N.A.	N.A.	Closed head sprinkler system to EN 12845 foam enhan-ced for 30 min [c]	[c]	N.A.	< 1 m stack height 2,0 t: 10 min > 1 m [d]	See Clause 7
Flammable liquid rack storage in warehouses		N.A.	N.A.	N.A.	N.A.	Closed head sprinkler system to EN 12845 foam enhan-ced for 30min [c]	[d]	N.A.	N.A.	See Clause 9

Refuse handling and storage	**Class A and plastics**	**N.A.**	**N.A.**	**1,5 [b] t: 20 min (open top storage only)**	**1,5 [b] t: 20 min (open top storage only)**	**Closed head sprinkler system to EN 12845 foam enhan-ced for 30 min [c]**	**1,5 [b] t: 20 min**	**N.A.**	**N.A.**	
In rack tyre storage		**N.A.**	**N.A.**	**N.A.**	**N.A.**	**Closed head sprinkler system to EN 12845 foam enhan-ced for 30 min [c]**	[d]	**N.A**	**N.A**	See Clause 9

[a] Additional discharge devices may be required for congested areas.

[b] Minimum correction factor dependent on solvent type. This may increase –determine by independently witnessed fire test.

[c] Time dependent upon risk assessment and local facilities.

[d] Design basis to be determined by risk assessment/ fire tests.

7 High expansion foam systems

7.1 General

High expansion foam is most effective in indoor spaces where it is used to submerge a fire and exclude the air needed to sustain combustion. It's relatively low water content does not have a great cooling effect on solid surface and relies on smothering the fire. Some destruction of the foam by the fire will occur, which is compensated for by an additional application rate.

High expansion foam is most effective in total flooding of enclosures such as cable tunnels, underground storage facilities, basements, ship's hold, warehouses and aircraft hangars. As well as being used on liquid fires, it is also very effective for fires in combustible solids such as paper and wood.

High expansion foams are also used for other purposes:

a) to provide an insulating barrier for protection of exposed materials or structures, not directly involved in the incident;

b) to provide vapour suppression from toxic or flammable spills, see Clause 10;

c) to contain an inert gas in tanks when welding is in progress.

The important difference between these systems and other foam types is that it is the volume of foam generated rather than the foam solution application rate that is important.

For total flooding systems, this European Standard gives maximum, "submergence times" permissible under differing circumstances. The submergence time is the time taken to achieve the submergence depth. The submergence depth shall not be less than the hazard height +3,0 m unless the enclosure is completely filled with high expansion foam.

Partial application systems may be used to protect areas where the hazard is not totally enclosed e.g. segregated area with foam containment screens within a larger area. Higher leakage factors may apply in these applications.

High expansion foam will displace air from within the enclosure. Provisions shall be made for adequate venting, above the height of the submergence volume, to enable the submergence volume to be achieved.

High expansion foam generators shall be able to draw an adequate supply of fresh air i.e. air free of combustion products – unless the generator and foam concentrate are specifically designed and tested to perform adequately under such conditions (see 7.2).

High expansion foam generators shall not be subjected to direct heat exposure unless they have successfully passed the heat exposure test described in EN 13565-1.

High expansion foam generators may be expected to produce foam with expansion ratios between 500:1 and 1 000:1. The selection of expansion ratio shall be determined with consideration for:

— wetting required;

— stability in wind (outdoor applications);

— stability against thermal updrafts.

Specific guidelines for hangar protection are given in Clause 9.

7.2 Foam concentrate

A high expansion foam concentrate which meets the requirements of EN 1568-2 shall be used.

Where high expansion foam generators utilise air from within the protected space, special concentrates are required that have been performance tested for this application with the relevant fuels with the specific generators to be used.

7.3 Equipment

High expansion foam is generated by air being introduced into the solution with or without a fan (water driven or electric motor driven). Where electric motors are used their power supplies shall be taken from a reliable and safeguarded supply available at all times during a fire emergency (see 4.2.4).

7.4 System design

Two different methods can be used for calculating the foam filling capacity:

a) calculating minimum growth of foam per minute (pool fires only). The minimum filling rate shall be 1,5 m/min net growth, increased by compensation factors (CN and CL) for losses as specified in 7.7 below.

or

b) calculating maximum submergence time (3 dimensional hazards).

The recommended maximum submergence times from start of foam discharge (min) for different hazards are as follows:

Table 7 — Maximum submergence time for high expansion foam systems

HAZARD	30 min. fire resistive building construction	90 min. fire resistive building construction
Flammable liquids with flash points below 40 °C	2 min.	3 min.
Combustible liquids with flash points above 40 °C	3 min.	3 min.
Low density combustibles, i.e. foam rubber foam plastic rolled tissue or crepe paper	3 min.	4 min.
High density combustibles, i.e. rolled paper kraft or coated-branded	5 min.	6 min.
High density combustibles, .e. rolled paper kraft or coated-unbanded	4 min.	5 min.
Rubber tyres	3 min.	4 min.
Combustibles in cartons, bags, fibre drums	5 min.	6 min.

Where use of high-expansion foam is contemplated on these materials, the foam equipment supplier shall substantiate its suitability for the intended use.

NOTE 1 These submergence times might not be directly applicable to high-piled storage above 4,6 m or where fire spread through combustible contents is very rapid unless established by tests.

NOTE 2 Water miscible fuels are not included in this table and may require higher application rates.

NOTE 3 The above submergence times serve as a guideline, where a net submergence rate of 3 m/min should serve as a minimum.

It is not recommended that high expansion foam protection be used in conjunction with automatic sprinkler systems. Where both systems are installed, provisions should be made to prevent operation of the sprinkler system when the high expansion foam system is operating.

7.5 Equipment location considerations

Foam generators shall be spaced such that foam flow will ensure total coverage of the protected volume. If necessary, the foam can be distributed through ducting to achieve the desired distribution.

7.6 Personnel safety

Personnel exposed to high expansion foam may suffer breathing difficulties and disorientation. Inside high expansion air systems may also cause increased exposure to combustion gases. It is recommended that, prior to any system discharge; adequate evacuation time shall be given to any personnel in the area. Unenclosed electrical apparatus should be switched off when a system is activated.

High expansion foam systems are unlikely to be suitable for applications where the personnel evacuation time significantly delays the activation of the system.

7.7 Discharge rate (total flooding systems)

The maximum rate of discharge is given by:

$$R = \frac{V}{T} \times CN \times CL \quad (4)$$

where

R is the rate of foam discharge (m^3/min);

V is the submergence volume (m^3);

T is the submergence time (min);

CN is the compensation factor for normal foam shrinkage due to solution drainage, fire, wetting of dry surfaces, etc. Minimum 1,15;

CL is the compensation factor compensating for loss of foam due to leakage around doors and windows where these are closed but not sealed. Minimum 1,2. Higher factors may be required depending upon the integrity of the enclosure boundaries.

The submergence times specified in Table 7 are based upon a maximum of 30 s delay between fire detection and start of foam discharge. Any delays in excess of 30 s shall be deducted from these submergence times when calculating the discharge rate.

As the efficiency of high expansion foam systems depends on the development and maintenance of a depth of foam within an enclosure, leakage of foam from the enclosure shall be avoided. Openings below the filling depth shall be arranged to close automatically at or before the start of foam discharge (with due consideration for the evacuation of personnel). If unclosable openings exist the system shall be designed to compensate for the probable loss of foam and shall be tested to ensure proper performance.

7.8 Discharge time (total flooding systems)

Sufficient foam concentrate should be available to meet the requirements for continuous operation of the system four times the submergence volume, but in no case less than enough for 15 min full operation. Consideration should be given to provision of supplementary foam stocks for use during post fire operations.

8 Marine loading and unloading docks

8.1 Water supplies

The water supplies for marine loading and unloading docks should be taken from a virtually unlimited source such as the sea, rivers or dock basins. Design of water supplies shall take into account the minimum water level condition. Where stored water is to be used there shall be sufficient capacity to enable 4 h fire fighting operations at the maximum design demand.

A minimum of two 100 % duty pumpsets, or three 50 % duty pumpsets shall be provided. The pump and equipment rooms shall be safeguarded against fire on the adjoining waterway.

The water distribution mains shall be protected from frost, corrosion, fire, and mechanical damage.

8.2 Foam concentrate

There shall be sufficient foam for 30 min operation at the maximum system flow rate, including manual foam fire fighting provisions where connected to the foam supply. The foam concentrate, associated proportioning equipment and discharge devices shall deliver low expansion foam suitable for the fuels being loaded/unloaded.

8.3 Foam water monitors

The foam system shall be designed to deliver at least 2 monitor streams over the area of the ship and shore manifold areas, connection points and the full length of any hoses used. Each monitor shall deliver a minimum of 1 500 lpm. The coverage of the monitors shall assume a 30 % loss of range, due to wind, from the 'still air' test figures for monitors and nozzles.

The monitor nozzles shall have jet and spray capability, and shall be operable from a safe position. Where monitors are elevated they shall have remote controls. The monitors should have dedicated power supplies.

8.4 Below dock foam systems

Where the dock extends over water and is constructed of unprotected non fire resistive materials, a below dock fixed foam system may be provided. When fitted the system shall be designed to deliver 6,5 lpm/m^2 over the area beneath the dock.

9 Aircraft hangars

9.1 General

The risk of fire associated with aircraft hangars increases with the size of the hangar, quantity of aircraft being stored and level of maintenance being undertaken.

Hangars are categorised by fire area and maximum aircraft height.

Type 1 hangars > 3 700 m^2 and commonly have access doors of > 8,5 m height to accommodate large aircraft.

Type 2 hangars involve a single fire area ≥ 1 400 m^2 < 3 700 m^2 and commonly have access doors up to 8,5 m height.

Type 3 hangars involve a single fire area < 1 400 m^2 and commonly have access doors less than 8,5 m height.

Landing gear pits, ducts and tunnels shall be provided with an automatic fire protection system unless the hangar fire protection is adequate to protect each pit.

9.2 Hangar partitioning

For zoning within a hangar space, provision for fire separation shall be provided. See also 9.3.

9.3 Fire detection

All aircraft hangars shall have rapid dual action detection systems and minimise spurious activation of the fire protection system installed. Adequate audible and visual pre-activation alarms for personnel evacuation shall be provided, within the protected space and in a constantly attended location. Actuation of roof mounted foam systems (where fitted) shall simultaneously actuate supplementary (low level/under-wing) foam systems.

A risk assessment should be completed to define the most appropriate detection systems; however some form of flame detection is essential.

Fire detection for Type 1 hangars should have at least 2 forms of flame detection to detect the fire prior to system actuation. Fire detection for Type 2 and 3 hangars shall have at least one form of flame detection with a secondary form of detection to activate each zoned or protected area prior to protection system discharge. (See also 4.7.)

Draft curtains shall be provided where roof mounted heat or smoke detection is used. Draft curtains shall be constructed of non-combustible materials, tightly fitted to the underside of the roof/ceiling, and not subject to disintegration or fusion in the early stages of a fire. The draft curtains shall match the fire suppression system zones, with a single area not exceeding 65 m^2 to ensure operation of only the fire affected zones. The depth of Draft curtains shall be not less than $1/8^{th}$ the overall floor to roof/ceiling height. Structural members may serve as draft curtains.

9.4 System design philosophy

Each system shall be designed to cover the entire aircraft storage and servicing floor area of the hangar. The design objective is to achieve control of the fire within 30 s from commencement of full capacity foam discharge and extinguishment within 60 s to protect life, property and the environment from fire. Water lines to foam making equipment shall be kept charged as close to the delivery device as possible. Protection may be provided by foam systems mounted at low level (above floor), roof level or intermediate level, but where aircraft with large wing areas (over 280 m^2) are protected using over-wing protection systems, additional supplementary underwing protection systems shall be provided by horizontal foam discharge from outlets located above floor level.

Table 8 — Foam application and correction factors (f_0) for aircraft hangars with operating times (t)

HAZARD	FUEL TYPE	HANDLINES		MONITORS		Automatic FIXED SYSTEMS				
		Low exp. Supplementary protection only	Medium exp. Supplementary protection only	Non-aspirated	Aspirated – Low exp.	Non-aspirated foam-water deluge f_o	Aspirated foam-water Deluge - f_o	Low exp. Pourers - f_o	Medium exp. Pourers - f_o	High exp. [a]
Aircraft hangars	WI	**2 x 200 l/min for 20 min**	**2 x 200 l/min for 20 min**	**1,6 t: 10min** (1,0 t: 10 min as supplementary underwing protection)	**1,6 t: 10 min** (1,0 t: 10 mins as supplementary underwing protection)	**1,6 t: 10 min** < 1 400 m^2 per zone	**2,0 t: 10 min** < 1 400 m^2 per zone	**N.A.**	< 1 400 m^2 **1,0 t:10min**	≥ 1,65 m/min net growth [b] t: 12 min

[a] Generators shall be located to ensure that a minimum foam layer of 1 m depth is achieved across the whole protected area within the first 60 s of system operation.

[b] The design discharge rate is determined by the net growth increased by the compensation factors for losses (CN and CL) as specified in 7.7.

Water supplies shall be capable of supplying the maximum actual foam demand for 30 min.

Foam coverage shall be provided to within 1,5 m of the perimeter walls and doors of the hangar.

9.5 System duration

All foam systems shall be capable of operating for the duration period stated in Table 8. A 100 % reserve foam concentrate built into the proportioning system. To prevent accidental depletion of this reserve supply it shall be available to the system only by intentional manual intervention.

9.6 Foam and water pumps

Water and foam pumps shall be started automatically from the fire alarm/detection system and run continuously until stopped manually, or until the supply is exhausted. Where multiple pumps are involved they should be provided with automatic sequential starting (see also 4.1.6).

9.7 Acceptable application methods

These are defined as:

- oscillating monitors;
- remote control monitors;
- foam-water deluge systems (open head);
- medium expansion pourers;
- high expansion systems;
- handlines/mobile foam units;
- self-contained mobile foam systems (detection and protection).

9.8 Foam types

To achieve the necessary speed of fire control, with monitors, deluge, medium expansion foam pourers, handlines and self-contained systems, a film forming foam is required. EN 1568-3 class 1A/B/C rated foam concentrates shall be used where only water immiscible fuel hazards occur, but EN 1568-4 class 1A/B rated foam concentrates shall be used where water miscible and other fuels are being used.

9.9 Monitors

To ensure rapid coverage and control of any fire incident, only Oscillating and Remotely Controlled Monitors are acceptable for hangar applications. These should always be set in their automatic oscillating mode. Each monitor shall have a manual isolating valve fitted. Monitors shall be positioned to provide coverage both over and under wing.

9.10 Foam-water deluge systems

These systems should be considered as supplementary to the low-level floor coverage system. They are intended to provide additional over-wing protection where necessary. Actuation of these systems shall also simultaneously operate the supplementary underwing protection systems.

Maximum hazard area protected per nozzle shall be 12 m² and maximum planned distance between nozzles shall be 3,7 m for non-aspirating nozzles tested in accordance with EN 12259-1, or the declared coverage area for nozzles tested in accordance with EN 13565-1.

9.11 Medium expansion systems (Type 3 hangars only)

Floor area coverage is limited to 1 400 m^2 for practical reasons of foam flow across the area from wall mounted pourer units. Consideration should be given to providing an alternative acceptable system to offer over-wing protection where required.

9.12 High expansion systems

The maximum flow range of any generator should not exceed 30 m. Generator units shall be mounted around outside walls and/or roof of the hangar to ensure effective coverage is achieved, but with capability to build up a deep foam layer on and around the aircraft. Adequate provision shall be made to prevent smoke being incorporated into the high expansion foam bubbles. Generators should be tested in accordance with Annex G of EN 13565-1:2003.

High expansion systems shall only use fresh air ducted from outside unless the generators and foam concentrate have been specifically independently tested for this application. (see 7.2)

Adequate smoke ventilation in the hangar roof shall be provided.

9.13 Headlines

At least two foam hand lines (each of minimum 200 l/min at adequate working pressure) shall be provided to allow manual intervention for small incidents anywhere within the hangar including within the fuselage of the aircraft. Sufficient foam shall be provided for both streams to be operational for a minimum of 20 min duration.

9.14 Commissioning tests

In addition to the general commissioning requirements specified in Clause 11, for hangars the following additional tests are required:

— pressure test of the pipework for leaks;

— provision for all pumps to be flow tested at operational flows;

— flushing with water to verify system functionality and adequate coverage;

— run systems with fire fighting foam (or an adequate substitute) to test all devices and equipment installed to verify the foam quality and system design criteria. Adequate time should be allowed for the foam system to stabilise prior to foam sampling;

— maximum number of systems that possibly could be expected to operate (including the supplementary systems) shall be in full operation simultaneously to check the adequacy and condition of the water supply. Suitable gauge connections and pressure gauges shall be provided to verify hydraulic calculations;

— high and medium expansion systems shall be tested and timed to achieve full coverage.

10 Liquefied flammable gases (LNG/LPG)

10.1 General

10.1.1 Liquefied Natural Gas (LNG)

The risk of fire associated with a spillage of LNG is high and increases with size of the spill. Any accidental leakage of LNG boils instantly, gaining heat from its surrounding environment, the ground, concrete, pipework and even the air into which it is rapidly evaporating. LNG (C1 hydrocarbons) is 83 % to 99 % methane, stored as a cryogenic liquid by refrigeration below its boiling point of -164 °C.

Initially the gas released is heavier than air, but as more heat is absorbed over time, it gets closer to ambient temperature making the gas lighter than air. In this 'lighter-than-air' state the evaporating gas is carried away by the air currents and wind which may carry it towards a source of ignition. A mixture with air is flammable at low concentrations (5 % to 15 % by volume) and ignition will rapidly spread back to the spill resulting in a rapid increase in radiant heat output. LNG burns with approximately three times the heat output of an equivalent pool of gasoline.

10.1.2 Liquefied Petroleum Gas (LPG)

The risk of fire associated with a spillage of LPG is high and increases with size of the spill. Liquefied Petroleum Gases (LPG), comprising propane and butane, have a higher boiling point than LNG. Propane (C3 hydrocarbons) has a boiling point of -42,5 °C (at 1 Atm) whilst butane (C4 hydrocarbons) is around 0,5 °C. When exposed to air LPGs expand rapidly into the gaseous phase but are always heavier than air so sink to ground level and flows downhill to occupy hollows, basements, underground tunnels etc.

A mixture with air is flammable at low concentrations (2 % to 9,5 % by volume) and ignition will rapidly spread back to the spill. It is the edges of the gas cloud along the ground, where fire is most likely to start.

10.2 Controlled burn-off

The prime objective of fixed foam system with fire detection and radiation control shall be to reduce radiant heat and fire intensity, bring the fire under control and to maintain that control until all liquefied flammable gas has burnt away through the foam blanket and self extinction occurs.

NOTE Premature extinction is not recommended as it may lead to a build up of flammable vapours which may be ignited.

10.3 Un-ignited spills

Foam should be applied onto un-ignited liquefied gas spills to reduce the risk of ignition and to limit potential damage resulting from the incident.

NOTE A risk assessment of structural and tank cooling requirements should be undertaken to minimise the risk of Boiling Liquid Expanding Vapour Explosions (BLEVE) particularly LPG containers. Protection of surrounding buildings should also be considered. Radiant heat levels can be such that mobile and portable high expansion foam generators shall not be used as they could expose firefighters to unsafe conditions.

10.4 Fire detection

A coincidence fire detection system shall be installed to automatically activate the high expansion foam system. Detection and system activation shall be achieved within 15 s.

10.5 Foam properties

High expansion foams for this application shall have been tested on the appropriate liquefied gas to prove their suitability. 25 % drainage times shall be greater than 15 min (freshwater). Expansion ratios of 500:1 ± 50:1 shall be provided for LNG, and for LPG -medium expansion ratios of 60:1 ± 10:1 and high expansion ratios of 500:1 ± 50:1.

The foam concentrate selected shall meet the requirements of EN 1568-2 (EN 1568-1, medium expansion) for use in seawater where seawater is used.

NOTE 1 Foam blankets using the above expansion ratios have been shown to resist wind attack and minimise liquefied gas evaporation.

The foam blanket should be topped up regularly, once the initial depth of foam has been achieved.

NOTE 2 This will maintain a fluid and warming layer on the surface to ensure the pool continues to vaporize at a controlled rate for burn-off above the foam surface.

10.6 Foam proportioning system

A dedicated foam proportioning system shall be used with a centralised foam storage tank.

Foam stocks shall be provided to allow for a continuous operating time of 1 h.

10.7 Application techniques

It is imperative that no water shall enter the liquefied gas pool prior to foam application. The foam system shall produce foam immediately, or an alternative means of preventing (pre-foam) water from entering the liquefied gas area shall be incorporated.

Foam of uniform quality shall be discharged onto the liquefied gas pool surface under any adverse (i.e. windy) conditions. Extended length foam discharge ducting may be used when required.

Foam shall be applied using the generators at the minimum application rates specified in Table 9.

Table 9 — Liquefied gas foam generators and application rates

Fuel	Foam generator type	Foam solution application rate [a] $^{l}/m^{2}$ min	Fire control time (90 % radiation reduction) s
LNG	High expansion	10	60
LNG	High expansion	7 [b]	100
LPG	High expansion	10	60
LPG	Medium expansion	12	60

[a] Unless otherwise determined by independent test.

[b] Where the pit is located far away from plant and other exposures, escape routes, personnel or adjoining properties which could be adversely affected by radiant heat.

Thereafter foam application shall be intermittently applied to limit radiation levels. Automated sensing devices shall be installed to measure radiation and control this intermittent foaming. Radiation levels should not exceed 1,4 kW/m² at a distance of 50 m from the liquefied gas pool edge.

Foam generators shall be manufactured from robust materials such that they will function correctly when exposed to the initial severe radiant heat flux from the liquefied gas fire (high temperature exposure test report shall be provided).

Foam generators shall not be spaced more than 20 m apart and located such that flammable vapours are not drawn into the foam making equipment.

11 Commissioning, testing, and periodic inspections

11.1 Instruction of operating personnel

During commissioning, instruction of the personnel responsible for the operation of the foam fire protection systems shall take place.

11.2 Commissioning

11.2.1 General

The foam extinguishing system shall be inspected, before setting into operation, by a person competent in foam fire extinguishing systems.

11.2.2 Visual inspection

The inspection shall be carried out to ensure that the system has been correctly installed in accordance with design drawings and specifications. This shall include continuity of pipework, removal of temporary blinds, accessibility of valves, controls and gauges; and proper installation of foam makers, vapour seals and proportioning devices.

11.2.3 Pressure tests

Pipework should be flushed, at the maximum practicable flow rate, to purge any foreign material. All pipework, except that pipework inside the tank serving surface or semi-subsurface applications, shall be hydrotested to 1,5 times the maximum operating pressure for 1 h, without permanent distortion or rupture; and without substantial leakage.

11.2.4 Tests

Tests shall be conducted to verify:

— functional performance of valves and foam proportioners;

— foam distribution;

— foam properties;

— running pressures.

After testing, strainers shall be inspected and cleaned, and the system placed in operational condition. Pipework which is normally empty, or only charged with water, shall be flushed to remove foam.

Consideration shall be given to the requirements for environmentally safe collection and disposal of foam. See 4.1.1.

11.2.5 Completion certificate

A completion certificate shall be issued stating that the system complies with the specification requirements.

11.3 The periodic inspection and testing of foam systems

11.3.1 General

Regular checks and maintenance are necessary to keep the operational readiness of foam extinguishing systems.

The user shall nominate a responsible person and a deputy taking care for the execution of the operation and maintenance instructions given by the installer and the legal regulations and the following inspections. Necessary repair-work shall be arranged. All applied measures as well as events shall be recorded in a log book.

11.3.2 Inspections

11.3.2.1 Weekly inspections (by user/ trained personnel)

- Check the levels in water, pump priming and foam concentrate tanks (excluding bladder tanks) – all tanks shall be kept full;
- check the correct function of heating systems (during heating period);
- visual check of the correct position and securing of all stop valves;
- check the correct status of automatic and manual pump start devices;
- check for evidence of leakage, damage, corrosion and action remedial work if any is found.

11.3.2.2 Monthly inspection (by user/ trained personnel)

- Check the correct function of the pumps and their drives (except foam concentrate pumps). The test run shall last for a period in which the normal operation conditions of the drive like power consumption, oil and cooling water temperature have been reached. At the end of the test run power consumption in the case of electrical drives and revolutions, oil and cooling water temperature in the case of diesel engine drives shall be measured. Test run diesel engines to reach operating temperatures (minimum 10 min).
- check of the flow pressure in case of systems feed directly from public or factory mains;
- check of batteries concerning the maintenance instructions given by the battery manufacturer as well as function of the battery charger;
- check of minimum fuel supply of diesel engines;
- check of oil level of pumps, compressors and diesel engines;
- visual check of pipework, foam outlets, nozzles and pipe supports for damage or deterioration;
- check frost protection for the permanently charged pipework system;
- function test of automatic refill devices of water tanks;
- function test of automatic and manual pump start devices of foam concentrate pumps;
- check of alarm signalling to a permanent manned location in the case of automatic released extinguishing systems;
- check the air inlet opening of foam generating devices/nozzles are free from obstruction.

11.3.2.3 Half-yearly inspections (foam system specialists)

- Visual check of strainers;
- functionally test the foam concentrate proportioner using water without the use of foam concentrate (where specified by the manufacturer);
- test the free movement of all valves and mechanically operated components.

11.3.2.4 Yearly inspections (foam system specialists)

Foam concentrate quality

A check of the foam concentrate properties shall be carried out by competent and trained foam laboratory personnel. The sampling shall be carried out according to the manufacturer's instructions. The checks shall include:

- foam type;
- specific gravity;
- PH;
- undissolved solids/sediment;
- drain time;
- foam expansion ratio;
- spreading coefficient - film formation (on Cyclohexane) – film forming foams only;
- alcohol burnback test (AR foams only).

The results, and 'pass' or 'fail' conclusions, shall be given in a report.

If the foam concentrate report does not give a 'pass' i.e. fit for use, as a result of its quality check tests, it shall be replaced immediately using foam concentrate of the same type which is passed fit for use.

Foam proportioning accuracy test

A test of the proportioner and associated fittings shall be carried out. The test shall be carried out at the maximum and minimum system design flow rates. The accuracy of foam proportioning shall be in accordance with the tolerance given in EN 13565-1. These tests should, where possible, be carried out with environmentally compatible foam substitutes.

Discharge test

A discharge test should be carried out on each system to verify:

- correct function of the system;
- nozzles are free from blockage;
- correct functioning of valves;
- required discharge coverage is achieved.

Premix

A check of the premixed foam solutions properties shall be carried out by competent and trained foam laboratory personnel. If the premixed foam solution report does not give a ‘pass’ i.e. fit for use, as a result of its quality check tests, it shall be replaced immediately using foam concentrate of the same type which is passed fit for use.

Component check

Check the foam concentrate tanks and components permanently in contact with foam concentrate for signs of external defects, e.g. leakage, debris on seals.

Inspect integrity of vapour seals on tank foam pourers and burst discs in subsurface systems.

Free operation of valves

The free operation of stop valves shall be checked.

11.3.2.5 Other inspections

Water and foam concentrate pumps shall be checked in accordance with the national regulations.

11.4 Shut-down

Special fire prevention measures shall be taken during shut-down of the foam fire extinguishing system. These measures shall ensure that a fire is detected in an early stage and fought quickly and effectively with pre-positioned equipment.

11.5 Maintenance

Maintenance shall consist of measures necessary for ensuring that all parts of the foam system remain in operating condition. The availability and reliability of the foam systems shall be assured.

Inspection and maintenance by an approved competent organisation is recommended.

11.6 Alterations

If alterations on protected sections shall been carried out, e.g. structural changes, the foam extinguishing system shall be adapted to the new conditions.

Bibliography

[1] EN 2, *Classification of fires*

[2] EN 12094-2, *Fixed firefighting systems — Components for gas extinguishing systems — Part 2: Requirements and test methods for non-electrical automatic control and delay devices*

[3] prEN 12259-12, *Fixed firefighting systems — Components for sprinkler and water spray systems — Part 12: Pumps*

This page has been intentionally left blank

BSI - British Standards Institution

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

Revisions

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

It is the constant aim of BSI to improve the quality of our products and services. We would be grateful if anyone finding an inaccuracy or ambiguity while using this British Standard would inform the Secretary of the technical committee responsible, the identity of which can be found on the inside front cover. Tel: +44 (0)20 8996 9000. Fax: +44 (0)20 8996 7400.

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

Buying standards

Orders for all BSI, international and foreign standards publications should be addressed to Customer Services. Tel: +44 (0)20 8996 9001. Fax: +44 (0)20 8996 7001 Email: orders@bsigroup.com You may also buy directly using a debit/credit card from the BSI Shop on the Website http://www.bsigroup.com/shop

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

Information on standards

BSI provides a wide range of information on national, European and international standards through its Library and its Technical Help to Exporters Service. Various BSI electronic information services are also available which give details on all its products and services. Contact Information Centre. Tel: +44 (0)20 8996 7111 Fax: +44 (0)20 8996 7048 Email: info@bsigroup.com

Subscribing members of BSI are kept up to date with standards developments and receive substantial discounts on the purchase price of standards. For details of these and other benefits contact Membership Administration. Tel: +44 (0)20 8996 7002 Fax: +44 (0)20 8996 7001 Email: membership@bsigroup.com

Information regarding online access to British Standards via British Standards Online can be found at http://www.bsigroup.com/BSOL

Further information about BSI is available on the BSI website at http://www.bsigroup.com.

Copyright

BSI Group Headquarters 389 Chiswick High Road, London, W4 4AL, UK
Tel +44 (0)20 8996 9001
Fax +44 (0)20 8996 7001
www.bsigroup.com/standards