

PETRONAS TECHNICAL STANDARDS

DESIGN AND ENGINEERING PRACTICE

MANUAL

FIRE-FIGHTING AGENTS AND MOVABLE FIRE FIGHTING EQUIPMENT FOR ONSHORE APPLICATIONS

PTS 80.47.10.32

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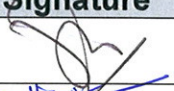
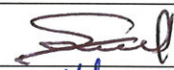
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This revision of PTS 80.47.10.32 – Fire Fighting Agents and Movable Fire Fighting Equipment for Onshore Applications has been updated incorporating PETRONAS Lessons Learnt, Best Practice and new information issued by relevant industry code and standards. All updates in the document are highlighted in *italic font*.

The previous version of this PTS (Revision 1 January 2000) will be removed from PTS binder/ e-repository from herein onwards.

Document Approval

	Name	Designation	Date	Signature
Prepared/Reviewed	Jamaliah Burok	Staff Engineer	23-Dec-08	
Approved	Bijay Kumar Nepak	Principal Engineer	Jan-09	
Verified	Samsudin Dato' Harun	Senior Manager, Engineering - GTS	27/2/09	
Verified	Pau Kiew Huai	General Manager, Engineering - GTS	4.3.09	
Endorsed	Pramod Kumar Karunakaran	Senior General Manager, GTS	5.3.09	

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PREFACE

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They are based on the experience acquired during the involvement with the design, construction, operation and maintenance of processing units and facilities. Where appropriate they are based on, or reference is made to, national and international standards and codes of practice.

The objective is to set the recommended standard for good technical practice to be applied by PETRONAS' OPU/Divisions in oil and gas production facilities, refineries, gas processing plants, chemical plants, marketing facilities or any other such facility, and thereby to achieve maximum technical and economic benefit from standardisation.

The information set forth in these publications is provided to users for their consideration and decision to implement. This is of particular importance where PTS may not cover every requirement or diversity of condition at each locality. The system of PTS is expected to be sufficiently flexible to allow individual operating units to adapt the information set forth in PTS to their own environment and requirements.

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1. INTRODUCTION

1.1 SCOPE

This PTS specifies requirements and gives recommendations for the following:

- fire fighting agents;
- movable fire extinguishing equipment;
- components used for hose systems;
- movable foam generating and associated equipment;
- personal protective equipment for fire fighters;
- miscellaneous equipment associated with fire fighting operations.

This PTS is a revision of the PTS of the same number dated January 2000 and it has also incorporated the contents of PTS 80.47.10.10 ("Fire-fighting agents", dated March 1991) which is now withdrawn. A summary of the main changes since the last edition is given in (1.5).

This PTS is applicable to onshore plants, both for new projects and for modification and extension of existing facilities.

This PTS shall be used in conjunction with the following PTSs:

PTS 80.47.10.30 Assessment of the fire safety of onshore installations

PTS 80.47.10.31 Active fire protection systems and equipment for onshore facilities

PTS 80.47.10.33 Fire-fighting vehicles and fire stations

The appropriate NFPA, CEN or equivalent standards shall be consulted for fire fighting agents and equipment not included in this PTS.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by PETRONAS, the distribution of this document is confined to companies forming part of PETRONAS Group, and to Contractors and Manufacturers/Suppliers nominated by them.

This PTS is intended for use in oil refineries, chemical plants, gas plants, storage facilities, jetties, terminals, loading and unloading facilities, and onshore oil and gas production installations.

If national and/or local regulations exist in which some of the requirements may be more stringent than in this PTS, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable as regards safety, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this document which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned with the object of obtaining agreement to follow this document as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party which carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party which manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party which initiates the project and ultimately pays for its design and construction. The Principal will generally specify the technical requirements. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

1.3.2 Specific definitions

AFFF (Aqueous Film Forming Foam) concentrate	synthetic foam concentrate containing fluorocarbon surfactants that influence the physical properties of the foam solution so that it can float and spread across the surface of a hydrocarbon fuel.
ARFC (Alcohol Resistant Foam Concentrate)	specialty formulated foam for use on water miscible fuels, such as alcohols and other polar solvents.
application rate	rate at which solution should be applied on a fire. This is normally expressed in terms of a solution flow in litres per minute per square metre.
assessment	process of analysing and evaluating hazards. It involves both causal and consequence analysis and requires determination of likelihood and risk.
burnback resistance	ability of a foam blanket to resist direct flame contact such as would be evident in a partially extinguished (petroleum) fire.
class A fires	fires in ordinary combustible materials such as wood, cloth, paper, rubber and many plastics (according to CEN and NFPA)
class B fires	fires in flammable liquids, oils, greases and tars (according to CEN)
class B fires	fires in flammable liquids, oils, greases, tars and flammable gases (according to NFPA)
class C fires	fires that involve flammable gases (according to CEN)
class C fires	fires that involve energised electrical equipment (according to NFPA)
class D fires	fires in combustible metals, such as magnesium, sodium, potassium (according to CEN and NFPA)
clean agent	electrically non conducting, volatile, or gaseous fire extinguishant that does not leave a residue upon evaporation.
combustible product	substance having a flash point > 37.8 °C. Other codes define it as a substance having a flash point > 61 °C. See also flammable product.
critical application rate	lowest application rate at which a foam will extinguish a fire under laboratory conditions.
critical shear stress	measure of the stiffness of a foam.

drainage time	rate at which foam solution liquid drains from an expanded foam (i.e. a measure of the foam's stability and an indication of the foam's viscosity). It is normally expressed as "25% Drainage Time" ("Quarter-Life"), which is the time (minutes) required to drain 25% of the solution liquid contained in the foam sample.
dry chemical	according to NFPA, various mixtures of finely divided solid particles additionally treated to provide resistance to packing, moisture absorption and proper flow characteristics. These agents are non-conductors and are designed for extinguishment of Class A, B and C fires.
dry chemical powder	powder composed of small particles, with an approximate size band between 20 µm and 100 µm, usually of sodium bicarbonate, potassium bicarbonate, urea based potassium bicarbonate, potassium chloride, or mono-ammonium phosphate with added particulate material supplemented by special treatment to provide resistance to packing, resistance to moisture (caking) and to provide the proper flow capabilities. This term is used in PTSs for extinguishing agents used for the extinguishment of Class A, B, C and D fires.
dry chemical powder system	supply system of dry chemical powder which can be automatically or manually activated to discharge through a distribution system onto or into the protected hazard by means of (hand) nozzles or monitors.
dry powder	according to NFPA, solid materials in powder or granular form designed to extinguish Class D fires.
expansion	ratio of the volume of the expanded foam formed to the volume of the foam solution used to generate that foam. Expansion can be categorised further into low, medium or high expansion: - low expansion - up to 20:1 - medium expansion - between 20:1 and 200:1 - high expansion - between 200:1 and 1000:1
fire incident	event or chain of events resulting in an undesirable combustion process of one or more substances which has caused or could have caused injury or damage to assets or the environment.
fire risk	product of the chance that a specified undesired fire incident will occur and the severity of the consequences of the event.
flammability	NFPA 704 defines flammability as the degree of susceptibility of materials to burning. NFPA 325 identifies the flammability rating of a large number of substances.
flammable product	according to NFPA a substance having a flash point below 37.8 °C and a maximum vapour pressure of 276 kPa (abs) at 37.8 °C. Other codes define it as a substance having a flash point below 61 °C. See also combustible product and flammability.

fluoroprotein foam	protein based foam with additional selected fluorinated surfactants which are loosely bonded to the protein to provide the foam with fuel resistance properties.
foam (finished foam, expanded foam)	product formed by mixing air with the foam solution homogeneously.
foam branchpipe (foam nozzle)	hand-held air aspirating foam nozzle.
foam concentrate (liquid)	medium which is added to water to make a foam solution. This solution mixed with air will form the expanded foam. Foam concentrates can be purchased for mixing with water into solutions of 2, 3, 4, 5 and 6 % by volume. Foam concentrate is also called foam agent .
foam generator (foam maker)	device in which air is mixed with foam solution to form foam. Suitable for back pressures of maximum 0.5 bar.
foam premix	liquid (foam solution) in which foam concentrate and water are already mixed in the correct ratio; thus ready for immediate use in the appropriate foam generator.
foam solution	liquid formed when foam concentrate is mixed with water. This solution, mixed with air, gives a (fire-fighting) foam.
fuel resistance	ability of foam to restrict fuel penetration between expanded air bubbles, thus withstanding foam breakdown by fuel.
fuel tolerance	ability of a foam to withstand fuel pick-up so that the air-filled foam bubble will not become saturated with fuel and thus support flames.
halocarbon agent	clean agent that contains as primary components one or more organic compounds containing one or more of the elements fluorine, chlorine, bromine, or iodine.
hazard	potential to cause harm, including ill health and injury, damage to property, plant, products or the environment; production losses or increased liabilities.
heat resistance	ability of foam to withstand the effects of exposure to heat through radiation or contact with a hot surface.
high back pressure foam generator	device, used in selected foam applications, in which air is mixed with foam solution. The maximum allowable backpressure is expressed as a percentage of the generator's inlet pressure. The minimum inlet pressure is 7 bar.
inductor	type of jet mixer operated by fire water, in which the foam concentrate, by means of suction, is entrained with firewater thereby forming foam solution. Only at specified flow is an inductor able to deliver foam solution of the required concentration. Typical inductor pressure loss is 30 % of the inlet pressure.
inert gas agent	clean agent that contains as primary components one or more of the gases helium, neon, argon or nitrogen. Inert gas agents that are blends of gases can also contain carbon dioxide as a secondary component.
knockdown	ability of an agent to extinguish a fire.

master plan fire safety systems	drawings covering the entire installation (location) on which all fire, smoke and gas detection systems, active fire protection systems and fire-fighting equipment (fixed, mobile and portable) are indicated.
manned area/room	space which will be normally occupied 24 hours per day or can be reached by people within 10 minutes.
monitor	device, normally either portable, fixed, trailer-mounted or truck-installed, to which a large throughput nozzle is attached to allow the operator to direct the fire fighting agent as required.
movable equipment	equipment that can be immediately moved to another location when required.
multipurpose dry chemical powder	powder, usually ammonium phosphate based. Effective on fires involving both ordinary combustibles, such as wood or paper, and fires involving flammable liquids.
non-aspirated foam	foam solution, discharged through a nozzle, in which no air is entrained intentionally.
pick-up rate	percentage at which foam concentrate is proportioned into the water flow. Normally this is either 3% or 6%, but may differ for certain types of fire or type of foam concentrate, or depend on the viscosity of the concentrate.
portable equipment	movable equipment which can be hand carried by maximum two persons.
prevailing wind	direction from which the wind is most likely to blow, based on local meteorological observations.
proportioner	device in which foam concentrate and water are mixed to form a solution. It is suitable for varying flow rates, e.g. between 10 - 100 % with a pressure loss of 10 % of the inlet pressure.
protein foam concentrate	concentrated solution of hydrolysed protein to which chemicals are added to obtain vapour suppression, freezing point depression and other desirable characteristics.
semi-subsurface foam injection	discharge of foam at the liquid surface in a tank by means of a foldable hose, through a rupture disc from an inlet near the bottom of the tank to avoid submerging foam in the liquid.
subsurface foam injection	discharge of foam into a tank near the tank bottom (above the free water layer), allowing the foam to travel through the product to the surface.
trailer mounted equipment	movable equipment mounted on a trailer and intended to be moved to an other location by towing.
universal foam concentrate	alcohol-resistant foam concentrate that may be applied on hydrocarbons and water-miscible fuels.
unmanned area/room	space which is intended for unoccupied use and cannot be reached by personnel within 10 minutes.
vapour suppression	ability to suppress the formation of flammable vapours, thus minimising the risk of re-ignition.

water branch pipe	hand-held water nozzle, with a typical application rate of 200-400 l/min. at 7 bar.
trailer mounted equipment	movable equipment mounted on a trailer and intended to be moved to an other location by towing.
wheeled equipment	movable equipment equipped with wheels to improve its mobility. Suitable for hand pulling by one person.

1.4 CROSS REFERENCES

Where cross-references to other parts of this PTS are made, the referenced section number is shown in brackets. Other documents referenced by this PTS are listed in (9).

1.5 SUMMARY OF CHANGES

This revision has been essentially only editorial, with no significant technical changes.

2. FIRE FIGHTING AGENTS

2.1 GENERAL

2.1.1 Fire classification

Fire fighting agents are subdivided according to the types of fires for which they are suitable. Fires are classified into groups in accordance with the flammable materials involved:

American class (UL 711)	Material involved	European class (EN 2)
A	Wood, paper, rubber (glowing embers)	A
B	Flammable liquids such as petroleum products, varnish, lacquer thinners, etc.	B
B	Vapours and gases	C
C	Energised electrical equipment	None
D	Combustible metals such as magnesium, sodium, titanium, potassium, lithium and zirconium	D

In order to avoid misunderstanding, the UL 711 classification is used in this PTS.

2.2 WATER

2.2.1 General

Water is the most commonly used agent for:

- cooling adjacent equipment;
- controlling fires and vapour releases.

Water may be used for extinguishing certain fires. As such it is highly effective on fires of solid materials (class "A" fires) such as wood, paper, natural rubber etc.

In office buildings and warehouses water can be applied by means of fixed installed sprinkler systems.

Water may only be applied to extinguish fires of liquid materials if both the following conditions are met:

- the product, cooled down by the ambient water, has a high flash point (typical application rate: up to 12.2 l/min/ m²);
- the bulk temperature of the liquid (on fire) is below 100 °C, thus avoiding steam "explosions". Above 100 °C water shall be applied intermittently and with low application rate (typically: 2 l/min/m²) to avoid frothing.

For these applications fixed systems are normally not used; water is applied by mobile equipment.

Water shall be applied on the target in spray form to obtain effective cooling and to avoid splashing of a liquid fire. For longer distances, water may be issued as a jet provided that the water will reach the target as droplets. For application rates for cooling see PTS 80.47.10.30

A non-ignited vapour cloud can be diverted by inducing large volumes of air which will reduce the (relative) vapour concentration downwind. This can be done by applying water as a conical spray (semi-jet).

In most cases water is more economical than other fire fighting agents.

2.2.2 Use

At ambient temperature, water may be used for:

- cooling (protection against exposure to fire);
- producing foam to cool fuel surfaces and to extinguish pool fires;
- extinguishing fires of liquid hydrocarbons with a flash point above 38 °C up to flash points of 93 °C; NFPA Class II and IIIA, (e.g hot asphalts);
- for directing pools of burning liquids;
- for dispersion of escaping gases and vapours;
- protection of personnel;
- bending away of flames;
- extinguishing fires of water soluble products by dilution;
- extinguishing smouldering fires in solids by dilution.

2.2.3 Heat absorption

The ability of water to cool hot surfaces is a function of its heat capacity, i.e. the heat required to raise its temperature to boiling point and to vaporise it into steam. The efficiency of heat transfer is proportional to the exposed water surface in contact with the heat source. In practice most cooling is achieved by directing water droplets onto a hot surface. Such droplets have a relatively large surface area. This implies that water should be applied as a spray in most cases.

2.2.4 Vaporisation

When water is converted from liquid to vapour, its volume at atmospheric pressure increases about 1700 times. This large volume of water vapour (saturated steam) displaces an equal volume of air surrounding a fire, thus reducing the volume of air (oxygen) available

to sustain combustion.

2.2.5 Restrictions

Water can increase corrosion rates particularly if it is salty or contaminated.

Since water is conductive, it should not be used on electrical fires. Factors influencing the likelihood of shock from live electrical equipment are:

- electrical loading (voltage and current);
- distance separating water application equipment and live electrical equipment;
- dispersion of the water stream or spray, i.e. the electrical conductivity of the water stream.

NFPA gives recommendations about safe distances between hose nozzles and electrical equipment at different voltages.

Water shall not be used on burning metal fires and other water reactive products.

2.2.6 Compatibility

2.2.6.1 Water and foam

Water shall not be used where foam is applied since water spray will destroy foam bubbles, water will displace the foam from its desired locations and a water jet will destroy the foam blanket.

Water may be used to cool down adjacent/nearby equipment while foam is being applied onto a pool fire.

2.2.6.2 Water and powder extinguishing agents

Care shall be taken in using water together with powder as the powder's extinguishing efficiency will be adversely affected. However, immediately after flames have been extinguished by powder it may be necessary to apply water to cool adjacent hot surfaces to avoid flash fires.

2.3 FOAM

2.3.1 General

Foam will normally be applied onto a flat service to form a blanket. Foam is generally used for suppressing and extinguishing pool fires (then called fire fighting foam), but it may also be applied on non-ignited liquids to suppress vapour emission.

The currently used fire fighting foams are of the mechanical (physical), not chemical, foam type. Foam concentrate is added to water in small quantities (between 1 and 6 %) to form a foam solution. This is mixed with air to form the finished fire fighting foam. Thus (expanded) foam is an aggregate of air filled bubbles and a small percentage of foam solution. Foams can be divided into three types: low, medium and high expansion foam (refer to 2.3.6). Prevention of a fire may be achieved by applying a foam blanket to fuel spills, reducing the evaporation rate. Foam shall not be applied to water reactive products. Fire fighting foams are particularly suited for extinguishing fires in storage tanks. They are also used for spill fires, fires in process areas, at truck or rail car loading facilities and at jetties. Commercially available fire fighting foams can be divided into two main groups:

- protein based foams;
- synthetic based foams.

Foam concentrates possessing components of both groups are available. See (2.3.8).

2.3.2 Specification, testing and procurement of foam

2.3.2.1 Standards

Standardisation organisations which deal with the quality of foam are:

National Fire Protection Association	- NFPA
Underwriters Laboratories Inc.	- UL
Factory Mutual	- FM

Their specifications and standards include requirements for foam concentrate and foam quality.

The UL 162 test correlates to realistic fires in the oil and chemical industry and is SIOP's preferred test method.

2.3.2.2 Testing

Independent testing authorities, such as Underwriters Laboratories Inc. (UL), are the customers' guarantee that the foam concentrate Manufacturer has demonstrated, through extensive fire testing and evaluations, that the product complies with the rigid requirements and specifications of the testing authority. In addition a UL-listed manufacturing source will be checked at regular intervals to confirm the quality of product and manufacturing process in the factory. Any deviation from these standards can lead to the foam concentrate Manufacturer being removed from the approval listings.

Foam types and/or applications not covered in the UL standards shall be tested to an agreed protocol before acceptance by the Principal.

2.3.2.3 Procurement

To obtain a high quality foam concentrate stock, fully UL 162 approved or listed foam concentrates should be purchased. The requisition shall specify that a certification document is required stating that the particular batch conforms to UL listing. Additionally, the requisition should stipulate that a condensed UL test is to be performed on samples, taken from the manufactured batch, at the moment of delivery. This test shall determine the pH (acidity), viscosity, 25% drainage time and specific gravity. The condensed test shall be performed by the Manufacturer and the results forwarded to the Principal.

The foam concentrate Manufacturer or Supplier shall guarantee that the foam concentrates are biodegradable and non-toxic. For this purpose Manufacturers shall supply data on chemical oxygen demand and biological oxygen demand.

A "return" clause should be included in any purchase order for disposal of redundant/deteriorated foam concentrate stock.

Procuring foam concentrate in bulk quantities will significantly reduce the price.

2.3.3 Safety and environmental effects of foam concentrates

Manufacturer's Material Safety Sheets for each foam concentrate type shall be available. The Manufacturer shall confirm that the product meets the legal requirements of the country of destination.

Normally the various types of foam concentrates are complex mixtures. Foam concentrates can contain phosphates, mercury or other materials identified as contaminants or pollutants. Protein based foams may contain added freezing point depressants and organic and inorganic stabilisers. Synthetic foams may contain freezing point depressants and, in some cases, a surface-active fluorocarbon.

The primary concerns as to the potentially adverse environmental impact of foam solutions discharge relate to fish, toxicity, biodegradability, treatability in wastewater treatment plants, and nutrient loading.

The general belief is that the fire safety advantages of using foam are greater than the risk of potential environmental problems. The use of foam, including use during training and testing, shall be done in an environmentally responsible manner to minimise any associated risk.

In the design of facilities where large quantities of foam could be released, ways to capture and prevent escape to sensitive environments (e.g. lakes, drinking water sources or ecologically vulnerable water bodies) should be considered. During training the foam shall not be allowed to escape to water courses.

2.3.4 Functioning of foam

Foam, when applied continuously at the required foam application rate, establishes and maintains a sealing blanket over a burning or non-ignited material. Foam can only function as a fire extinguishing medium if the vapour release from the liquid is reduced so that the vapour/air mixture becomes leaner than the Lower Flammable Limit (LFL) of the vapour. Foam acts differently on non-ignited and ignited fuels depending on the nature of the fuel.

2.3.4.1 Non-ignited pool of fuel

On a non-ignited pool of fuel a distinction is made between:

- a) hydrocarbon liquid fuels;
- b) refrigerated LNG;
- c) refrigerated LPG/NGL.

- a) Hydrocarbon liquid fuels

Foam reduces the formation of vapour by:

- (1) shielding the liquid surface from the air, thus reducing vapour pick-up;
- (2) forming an insulating layer between any radiation from the environment into the fuel, thus reducing evaporation due to heat ingress;
- (3) producing water (result of foam drainage), which will reduce the temperature of the fuel surface (and adjacent materials) when the liquid fuel is above the water temperature.

- b) Refrigerated LNG

LNG vapour is warmed as it rises through a thick (minimum 1.5 m) layer of foam. The resultant buoyancy of the vapour leads to reduced vapour concentrations downwind at grade level. However water resulting from foam drainage will act as a heat source and it has the undesirable effect of increasing vaporisation.

If high expansion foam (refer to 2.3.6.3), with long drainage time (typically 10 - 15 minutes or more), is used the overall effect on downwind vapour concentration at grade level is favourable.

c) Refrigerated LPG/NGL

Pools of LPG/NGL will be at their (cold) atmospheric boiling point.

Water, resulting from foam drainage, would act as a heat source and it has the undesirable effect of increasing vaporisation. As LPG/NGL vapours remain heavier than air the downwind LPG/NGL concentrations would increase. Therefore foam shall not be applied onto non-ignited pools of LPG/NGL.

2.3.4.2 Ignited pool of fuel

On an ignited (burning) pool of fuel distinction is made between:

- a) hydrocarbon liquid fuels;
- b) refrigerated LNG, NGL and LPG.

a) Hydrocarbon liquid fuels

Foam reduces the formation of vapour and reduces the intensity of the fire by:

- (1) forming an insulating layer between the flames and the fuel, thus reducing the heat ingress, via the liquid surface, into the fuel; this results in a reduction of the flammable vapour release which in turn decreases the size of the fire;
- (2) producing water (result of foam drainage), which will reduce the temperature of the fuel surface (and adjacent materials) when the liquid fuel is above the water temperature;
- (3) water evaporation out of the foam, thus:
 - keeping the temperature at the top of the foam layer to maximum 100 °C, which restricts heat ingress into the fuel;
 - forming steam, lowering the (relative) concentration of fuel vapour which reduces the intensity of the fire, resulting in lower radiation levels.

b) Refrigerated LNG, NGL and LPG

Foam reduces the formation of vapour by forming an insulating layer between the flames and the fuel, thus reducing the heat ingress from the fire, via the liquid surface, into the refrigerated fuel. This results in a reduction of the flammable vapour release which in turn decreases the size of the fire. For this purpose a thick (approximately 1.5 m) foam blanket is required.

Water, resulting from foam drainage, will act as a heat source which will cause some increase in vaporisation. Therefore special high expansion foams (refer to 2.3.6.3) shall be used, having long drainage times (typically 10 - 15 minutes or more), which limit free water resulting in minimum increase of vaporisation.

As long as the foam blanket is present it will result in a smaller fire size (no extinguishment will be achieved) with radiation levels reduced to 10 %.

2.3.5 Limitations

From the foregoing it can be concluded that not all types of fire fighting foams are suitable for all types of fuel fire.

- Foams are not effective in extinguishing three dimensional fires involving jetting or falling fuels and flowing liquid fires.
- A release of pressurised LPG is unlikely to form a liquid pool of more than very brief duration, due to flashing of the liquid. Therefore the use of foam is not effective.
- Foams have a limited throwing distance, due to their low density. Wind force and direction may influence this distance as well.
- Unless specially approved foam is used, the same restrictions as mentioned for water (2.2.5) are valid (foam is in principle water)
- If the bulk temperature of the liquid is high (>100 °C) this will restrict the use of foam, and may even cause violent frothing or slop-over.

- The water required for producing foam should not be contaminated with water miscible components e.g. alcohols etc.

2.3.6 Expansion ratio of foam

Depending on the type of foam concentrate and the foam producing equipment used, the expansion ratio will vary widely. The expansion ratio is also governed by the nozzle pressure and impurities in the fire water. Generally the following terminology is used:

Low expansion foam : up to 20:1; Medium expansion foam: between 20:1 and 200:1; High expansion foam : between 200:1 and 1 000:1.

2.3.6.1 Low expansion foam

Low expansion foam is mostly used in the petrochemical industry. It has a good throwing range due to its density (typically, hand nozzles have a maximum throw of 20 m and monitors have a maximum throw of more than 30 m) and good flowing properties (fluidity). Its expansion ratio varies between 6:1 and 10:1 for over-the-top applications. For subsurface applications the expansion ratio varies between 3:1 and 4:1. Non-aspirated application has a ratio of 2:1.

2.3.6.2 Medium expansion foam

Medium expansion foam has a limited throwing range (approximately 10 m) due to its low density. However with properly designed equipment it is particularly suitable for fires in enclosed or contained locations such as pump rooms and engine rooms.

2.3.6.3 High expansion (hi-ex) foam

Hi-ex foam is a synthetic foam, which has no throwing range due to its very low density. It travels over the fuel by gravity. With properly designed equipment it is suitable for fires in enclosed or contained locations such as buildings and warehouses.

By placing a high expansion foam generator at an opening into a confined space and ensuring that clean air (without smoke particles) is present at the point where air is sucked in, a fire can be brought under control without personnel having to enter a potentially hazardous space.

Hi-ex foam, with an expansion ratio of between 200:1 to 500:1 and with a long 25% drainage time (typically at least 10 min.), is used to cover (non) ignited LNG pools, to minimise vaporisation. It requires foam blankets between 1.5 m and 2.0 m thick. It reduces flame size by approximately 90%.

2.3.7 Travel distance of foam

Travel distance is the ability of foam to flow over a liquid by gravity from the application point over a certain distance. Regardless of continuing foam supply, foam has the property of not travelling (spreading) any further when the maximum travel distance is reached. Travel distance is a function of surface properties, foam expansion ratio, static foam head and viscosity. Foam spread dominates fire control time. Good quality foam will travel up to 25 m over a fuel surface.

2.3.8 Types of foam

In the following sections different types of foams are discussed, in terms of composition, purpose of the foam, application method and price ratio.

The required type of foam shall be selected according to the flammable liquids present at the location. If the majority of these liquids on site are non-water-miscible, which is normally the case, it may be more cost effective to keep different types of foam in stock.

2.3.8.1 Protein foam

Protein foam is mainly manufactured from waste animal material (such as hooves, horns,

skins, blood or fish) or soya beans. Metal salts (such as aluminium, zinc or magnesium) are added to act as the framework for the bubbles (reinforcement).

Protein foam is mainly used for oil spills and tank fires. Foam concentration is normally 3%; it is used as a low expansion foam (2.3.6.1). Because of its poor fuel tolerance, protein foam shall not be used for sub-surface application.

2.3.8.2 Fluoroprotein foam

Although more expensive than protein foam it has far better performance. Fluoroprotein foam is similar to protein foam, but has a fluorinated surfactant added. This gives the foam a higher fluidity without losing the cohesiveness of the foam blanket, i.e. the foam spreads more easily over a surface fire but the resulting blanket is still tough enough to seal objects protruding from the fire. It has an excellent fuel tolerance. It is therefore suitable for subsurface injection. The foam concentrate is normally added to water as a 3 % concentrate; though 5% and 6% concentrates are also available. Mixed with the appropriate amount of air it results in a low expansion foam (2.3.6.1). For rim areas of floating roof tanks it should be applied with an expansion ratio varying between 3:1 and 4:1. This will provide better fluidity around metal obstructions.

2.3.8.3 Film forming fluoroprotein foam (FFFP)

FFFP is essentially a mixture of fluoroprotein foam (FP) and aqueous film forming foam (AFFF). Qualities of FFFP can result in a rapid knock down (AFFF) with good burn-back resistance (FP). As a "hybrid" product it does not necessarily combine all the good properties of both individual FP and AFFF. FFFP has the same expansion ratio as FP.

2.3.8.4 Aqueous film forming foam (AFFF)

AFFF is a synthetic, foaming liquid. This type of synthetic foam consists of fluorochemical and hydrocarbon surfactants, combined with high boiling point solvents. The foam forms an aqueous film on the fuel surface. AFFF has the ability to create a film of solution that floats on top of non-polar flammable liquids. Its high fluidity results in rapid fire knock down. In non-aspirating applications the expansion ratio is typically between 2:1 and 4:1. Normally the concentrate is added as a 3 % concentrate to water. It is also available as a 1.0 % foam concentrate. The latter concentrate has the same expansion ratio as a 3 % concentrate. This is particularly attractive where there are weight/space restrictions, as the storage capacity is reduced to 33%.

2.3.8.5 Alcohol resistant foam concentrate (ARFC)

ARFC is used for fighting fires on water-soluble materials and other fuels destructive to AFFF or FFFP foams, as well as for fires involving hydrocarbons. ARFC is generally used in concentrations of 3 to 10 % solutions depending on the nature of the fire hazard to be protected and the type of concentrate. There are three general types:

- a) Based on water-soluble natural polymers, such as protein or fluoroprotein concentrates, and also containing alcohol insoluble materials that precipitate as an insoluble barrier in the bubble structure.
- b) Based on synthetic concentrates and containing a gelling agent that surrounds the foam bubbles and forms a protective raft on the surface of water-soluble fuels; these foams can also have film-forming characteristics on hydrocarbon fires.
- c) Based on both water-soluble natural polymers, such as fluoroprotein, and containing a gelling agent that protects the foam from water-soluble fuels. This foam can also have film-forming and fluoroprotein characteristics on hydrocarbon fuels.

2.3.8.6 Aqueous film forming foam, alcohol type concentrate (AFFF-AR)

This synthetic foam has water soluble polymers added to it. This foam in contact with a polar solvent forms a cohesive polymeric membrane between the foam and the water soluble fuel. This thick membrane protects the foam and its aqueous layer from breakdown

by polar solvents. If the protective layer is disrupted by agitation or wind, more of the layer is produced by means of a regenerative action known as "self healing".

Most of these foams are a versatile AFFF foam type for the protection of a wide range of Class B (i.e. flammable liquid) hazards. It is available as a UL-listed 6 % concentration for polar solvents. The thick polymeric membrane may block sewers. This type of foam concentrate is a non-Newtonian, jelly type liquid. Behaviour as a Newtonian liquid is only guaranteed above certain minimum flow velocities. Therefore all foam proportioning equipment requires specific calibration. This will avoid proportioning rate errors of up to about 50% (e.g. at a 6% setting the proportioning rate may only be 3%). The foam concentrate shall not remain in permanent contact with mild steel as the presence of iron ions will create a polymer film. The resulting sludge may block filters, inductors etc.

AFFF-AR shall always be applied in a "gentle" manner, to avoid submersion, and to ensure that the already formed film is not disturbed and thus remains effective. This implies that AFFF-AR shall never be applied sub-surface; however it may be used in a semi subsurface application.

AFFF-AR may also be applied to non-water-miscible (non-polar) fuels (e.g. normal hydrocarbons), and as such it is called "**Universal**" type foam. Universal concentrate added as a 6% addition is normally suitable for fires containing polar solvents. It may also be used on non water miscible hydrocarbons, normally added as a 3% concentrate. On hydrocarbons it functions like AFFF.

AFFF-AR, applied in medium and high expansion equipment for e.g. chemical warehouses, shall only be used after actual tests of concentrate, equipment and fuel have proven positive. (Test protocol to be agreed.)

2.3.8.7 Fluoroprotein alcohol resistant foam

This foam type consists mainly of hydrolysed proteins, glycol solvents, fluorosurfactants and polymers. Its resistance against water miscibility is achieved by the formation of a polymeric layer between the foam blanket and the liquid fuel. This foam compound is used as a 6% concentrate with low expansion equipment on water miscible fuels. This type of foam may also be used on non-water-miscible fuels; for low expansion application a 3% concentrate is used, while for medium expansion a 6% concentrate is applied.

2.3.8.8 Synthetic detergent foam

Synthetic detergent foam is manufactured from chemical foaming agents with additional stabilisers (high boiling solvents). These foam concentrates have a high fluidity and are applied in solutions with a typical concentration of approximately 2 %. These foam concentrates can be used to produce low, medium and high expansion foam. The ordinary type has poor burnback resistance and poor fuel resistance and therefore this foam has limited extinguishing properties. It is used for extinguishing fires in buildings, warehouses, etc.

Special Hi-ex foams with a typical expansion ratio of 200:1 and 500:1 may be used for covering LNG spills if approved by the Principal.

2.3.9 Application rate of foam

To be effective, foam must be applied at a rate greater than the "critical application rate" which is the minimum recommended application rate that has been found by laboratory tests to be the most practical in terms of speed of control of the fire and the amount of agent required.

A typical minimum recommended application rate for effective control of non-water-miscible fuel fires for low and medium expansion foam is 4.1 l/min/m² fuel area when using fixed foam systems, however the actual generated application rate when using portable/mobile foam monitors or hand lines is influenced by losses during throw and these losses can be up to 60%. The typical application rate when using portable/mobile foam monitors or hand lines is 6.2 l/min/m². If the system features fixed foam monitors these losses shall also be

taken into account during design.

For application rates of foam systems see PTS 80.47.10.30 Section 5.

Increasing foam application over the minimum recommended rate generally reduces the time required for extinguishment, but greatly exceeding the minimum recommended rate will waste foam supplies without gaining advantage in terms of appreciably shorter extinguishing time. If the application rate is lower than the recommended minimum, extinguishment may not be achieved.

The relation between extinguishing time and application rate depends on fuel, foam type and method of application. For hydrocarbon products a standardised application rate is used. Polar solvents and chemicals require individually confirmed application rates to be obtained from the foam concentrate Supplier.

When foam is used it requires constant supply until:

- the fire is extinguished and the liquid is cooled down to below its flash point, or
- the liquid has totally evaporated or has been transferred (pumped) to another container (tank).

For the application of (low expansion) foam the following aspects shall be observed:

- Plunging of foam into fuel should be avoided to reduce free area of evaporation and breaking the foam blanket. Preferably foam shall be applied against a vertical "wall" or by spreading the foam from the application point.
- Recommended pressure ranges should be observed for all foam making equipment. Foam quality generally deteriorates outside these pressure ranges.

2.3.10 Properties of foam

2.3.10.1 Physical properties

Like all liquids, foam concentrates can be characterised by their physical properties, e.g.: specific gravity, pH, total solids, viscosity, and the minimum use temperature. These absolute values are used in engineering foam systems. These values may change over time, which may adversely affect the properties described in this section.

2.3.10.2 Fuel tolerance

Good foam exhibits a high fuel tolerance; minimising fuel pick-up prevents the foam from emitting fuel vapours and supporting the fire. Fuel tolerance is vital for sub-surface and forceful surface applications. Foam can pick up fuel by two mechanisms:

- low interfacial tension can cause it to mix with the fuel (common with detergent based solutions);
- the combination of surface and interfacial values may cause fuel to spread over the foam bubbles. This is a common problem with protein foams.

2.3.10.3 Burnback resistance

The burnback resistance depends on the chemical make-up of the foam concentrate. Protein based foams leave behind a charred residue which delays their destruction by the fire. Synthetic foams, in general, have a poor burnback resistance.

2.3.10.4 Heat resistance

The degree of heat resistance determines to a certain extent the ability to form an effective seal against hot obstacles protruding through the foam blanket.

2.3.10.5 Drainage time

With time, foam bubbles will collapse, depending upon surface tension characteristics, and foam solution will drop out of the foam. This will cause a considerable reduction of the effective thickness of the aerated foam blanket. Drainage time usually improves with

expansion and viscosity. Obviously, long drainage time is a desirable feature for cold/refrigerated fuels. With film forming foams, a controlled drainage rate is required in order to maintain a well spread film. Sometimes the "50%" drainage time is used for commercial reasons. However, typical minimum 25% drainage times for various types of foam are as follows:

Foam type	Test description	Minimum 25% drainage times
Fluoroprotein	UL 162 test method and a cylinder of one litre with a height of 352 mm	8 min
AFFF	UL 162 test method and a cylinder of one liter with a height of 352 mm	5 min
High Expansion (for standard applications)	200 l container with a height of about 1 m	10 min
High Expansion (for LNG applications)	200 l container with a height of about 1 m	10 min to 15 min

2.3.10.6 Critical shear stress

A foam having a high critical shear stress will be stiff and not flow over a burning fuel surface as readily as one with a low critical shear stress, and therefore it will not exhibit such good fire knockdown properties.

2.3.10.7 Shelf life

Shelf life is the foam concentrate Manufacturer's guaranteed time during which a particular foam concentrate will perform as specified, if applied correctly. Shelf life differs according to each Manufacturer: it should be at least 5 years under the storage conditions at the particular location. Foam concentrate can deteriorate in storage, due to e.g. sludging, oxidation, high storage temperature, loss of stability, dilution, evaporation or contamination. To assist in maintaining and extending shelf life, measures shall be taken to minimise the contact of foam concentrate with air, e.g. storage tanks shall be equipped with domes. High temperatures can be avoided by installing a sun roof. During regular training exercises foam shall be checked for a possible change in performance using a fire tray. In addition stocks shall be checked annually by returning a sample to the Supplier or preferably to an independent laboratory. The Manufacturer of the foam should be consulted about purchasing a proper test kit.

2.3.10.8 Performance and quality

The performance of a foam is influenced by the aforementioned properties. Some of these properties counteract each other. The effectiveness of a good foam blanket in a fire situation will depend upon the type of fuel, quality, quantity and pressure of the fire fighting water, the foam making equipment and the foam concentrate. In order to achieve good extinguishment there are six qualities that a foam must exhibit:

- Cohesion; must be such that the foam bubbles cling together and form a tough cohesive blanket.
- Vapour Suppression; the foam must be capable of suppressing flammable vapours and so minimise the risk of re-ignition.
- Stability/Water Retention; it must have the ability to retain water in order to perform its cooling function.
- Heat Resistance; the foam must be able to resist the destructive effects of heat radiated from any remaining fire or hot objects. In addition, it must be able to form an effective seal against any hot metal surface such as a storage tank wall.
- Flowability; in order to extinguish a fire rapidly the foam must flow freely around any obstructions present in the fire. This property is, of course, particularly important when dealing with crash fire situations; typically at loading stations where personnel may be present.

- Fuel Tolerance; a good foam exhibits a high fuel tolerance.

2.3.11 Compatibility

2.3.11.1 Foam concentrates

Different types of foam concentrate shall not be mixed. Different makes of the same type of foam concentrate or foam solution (premix) shall not be mixed in common storage facilities, unless both Manufacturers guarantee the good performance of their foam concentrate when mixed together. Equally if the concentrates are not compatible, resulting solutions shall not be mixed.

2.3.11.2 Finished foam types

Different makes of the same type of (finished) foams may be used simultaneously on the same fire.

2.3.11.3 Foam and dry chemical powder

Foams have to be tested and specified for their compatibility with dry chemical powder, and vice versa. Some dry chemical powders will destroy the finished foam, e.g. when the last flames are treated with dry chemical powder.

2.3.12 Quantity of foam concentrate required

The following requirements for foam quantities are based on the application of fluoroprotein-foam concentrate. The same guidelines apply to Universal and the fluoroprotein variant of foam concentrate.

The basis for the quantity of foam concentrate shall be that required to extinguish the largest credible fire that could occur in the particular plant, using the most effective equipment available.

Storage tanks equipped with a fixed subsurface foam extinguishing system, for instance, require $4.1 \text{ dm}^3/\text{minute}$ foam solution per m^2 burning surface. With 3% foam concentrate, the available quantity thereof shall allow:

- 55 minutes of uninterrupted foam application;
- 100 % extra capacity as spare.

NOTE: This 100% extra capacity shall be strictly adhered to at plants where replenishing the foam stocks may require more than a few days. Mutual aid arrangements or foam suppliers may be able to guarantee replenishment of stocks within hours, in which case the 100% extra capacity requirement may be relaxed.

Therefore, for tanks of diameter D in metres:

- the required solution rate is $\pi/4 * D^2 * 4.1 \text{ dm}^3/\text{min}$;
- the required foam concentrate for a 3% agent is $0.03 * \text{solution rate in dm}^3/\text{min}$.

The required quantity of foam concentrate for 55 minutes including 100% spare capacity would thus be $\pi/4 * D^2 * 4.1 * 0.03 * 55 * 2 \text{ dm}^3$, with a minimum of 24 m^3 for a typical refinery.

For specific foam application rates and durations for other types of extinguishing system and for mobile application NFPA 11 shall be used for guidance.

As the above calculation is based on the largest fire scenario, the foam quantity is also adequate for extinguishing all other fires in the plant complex.

2.3.13 Storage of foam concentrate

2.3.13.1 General

Foam concentrate shall be stored in a dedicated storage, manufactured of a suitable

material tank (see PTS 80.47.10.31 section 5); or in the Manufacturer's non-metallic drums. The Manufacturer of the foam concentrate shall be consulted for suitable foam concentrate resistant material.

2.3.13.2 Foam sampling

Annually at least one bottom sample of foam concentrate shall be examined and tested (to determine specific gravity, pH and viscosity at 20°C) to verify the quality of the foam concentrate and the produced foam. The following collection schemes may be used for foam concentrate sampling:

- | | |
|------------------------|--|
| Collect one sample; | bottom only (minimum requirement); |
| Collect two samples; | one top, one bottom; |
| Collect three samples; | one top, one bottom, one middle (recommended); |
| Collect one sample; | after recirculating contents. |

Care shall be taken with bottom samples, with allowance being made for sediments such as layers of dirt and degradation products. When samples contain rust or scale, the contaminated concentrate shall be drained and filtered. Samples of about one litre shall be representative of the bulk stock and they shall be sealed in clean non-metallic containers, accompanied by a label stating type and history.

2.4 DRY CHEMICAL POWDER

2.4.1 Specification, testing and procurement of powder

2.4.1.1 Standards

Available standards are:

USA Federal specification O-D-1407 for potassium bicarbonate
and

USA Federal specification O-F-371B for sodium bicarbonate.

The use of other standards for dry chemical powders requires the approval of the Principal.

2.4.1.2 Testing

Independent testing authorities, such as Underwriters Laboratories Inc. (UL), are the customer's assurance that the Manufacturer of Dry Chemical Powder (systems) has demonstrated through extensive fire testing and evaluations that the product complies to the rigid requirements and specifications of the testing authority. In addition, a UL-listed Manufacturing source will be checked at regular intervals to confirm production quality in the factory. Any deviation from UL standards can lead to the Manufacturer being removed from the UL approval list. When witnessing Manufacturers' tests, the Dry Chemical Powder shall be applied with standard equipment, i.e. with mass-produced equipment which is generally available to the Principal.

2.4.1.3 Procurement

High quality, fully (e.g. UL-) approved or listed dry chemical powders should be procured from reliable and reputable dry chemical powder system Manufacturers. The requisition shall specify that a certification document is required stating that the particular batch is suitable for the intended system. Only dry chemical powder with a test certificate (e.g. UL 299, Part 47: "Extinguishing agent test"), shall be accepted. Such tests shall be performed by suitable, independent testing laboratories.

2.4.2 Functioning of powder

The detailed mechanisms by which dry chemical agents extinguish fires have not been completely determined. However, it is generally accepted that the primary extinguishing mechanisms include:

- interruption of the chain reaction sequence in chemical reactions;
- reduction of liquid fuel evaporation rates by reduction of flame radiation at the liquid surface;
- inert effects due to reduction of oxygen concentration within the active fire zone.

Secondary extinguishing mechanisms may include:

- heat absorption effects (particularly at high dry chemical concentrations);
- cooling effects, due to the formation of water vapour by the pyrolysis processes, in the flame, (this reduces the heat radiated back into the product on fire);
- additional inert effects due to the formation of carbon dioxide by the pyrolysis of the dry chemical;
- fire retardant effects due to surface coatings.

The effectiveness of the chemical reaction mechanisms differs with each chemical agent and is believed to be the primary reason for the differences in overall effectiveness of the different agents at critical extinguishing flow rates. The physical mechanisms, such as reduction of oxygen concentrations, are significantly influenced by dry chemical concentrations in the flame zone as well as the dry chemical agent's physical properties.

2.4.3 Advantages and limitations of powder

Dry chemical powders give an instantaneous extinguishment of the flames of a fire. The agent gives very rapid fire control and it is particularly useful against running flammable liquid fires, which foam cannot readily extinguish. Dry chemical powders are highly efficient in extinguishing fires, provided they can reach all areas of the fire without interruption.

The use of dry chemical agents shall not be considered satisfactory protection for the following:

- chemicals containing their own oxygen supply, such as cellulose nitrate;
- combustible metals such as sodium, potassium, magnesium, titanium, and zirconium;
- deep seated fires in ordinary combustibles where the dry powder cannot reach the point of combustion.

Although dry chemical powders are electrically non-conductive, they should preferably not be used on instrumentation and electrical equipment, due to the corrosion such equipment may suffer after being exposed to moisture. Their use in fixed installations requires specialist designs. They shall be designed according to NFPA and the Manufacturer's specifications. Dry chemical powders do not cover and cool oil surfaces and therefore do not provide any post-fire security.

Dry chemical powders have limitations in extinguishing performance. Therefore the appropriate powder shall be used for a particular fire (see 2.4.4).

Dry chemical powders do not cool the product on fire. After extinguishment a flash fire may occur instantly; this can only be avoided by cooling with water. If flammable liquids are involved and a spill fire occurs, foam should be used instead of water.

2.4.4 Types of dry chemical powder

The common dry chemical powders are listed below. These materials are treated to improve their flow and to provide resistance against packing and moisture absorption (caking). The type of dry chemical powder used is one of the factors determining the fire extinguishing rating as described in UL 711 and EN 3-1.

2.4.4.1 Sodium bicarbonate

Sodium bicarbonate is a basic dry chemical powder extinguishing agent. It consists of small particles which do not penetrate deeply into the fire. It is suitable for use on all types of hydrocarbon flammable liquid and gas fires (Class B) and also for fires involving energised electrical equipment (Class C). It is not recommended for Class A fires. A fire extinguisher rating of 60 (based on UL 711) is typical for 12 kg of sodium bicarbonate for class B and C fires.

2.4.4.2 Potassium bicarbonate

Potassium bicarbonate consists of larger particles which penetrate deeper into the fire. As a result it has a better UL rating than sodium bicarbonate. A UL 711 rating of 120 is typical for 12 kg of potassium bicarbonate for class B and C fires. It is suitable for use on all types of flammable liquid and gas fires (Class B) and also for fires involving energised electrical equipment (Class C).

Generally dry chemical powders, based on salts of potassium, are not recommended for Class A fires.

2.4.4.3 Ammonium phosphate

This agent consists of a mixture of ammonium phosphate (min. 40%) and ammonium sulphate. Mono-ammonium phosphate powders, referred to as multi-purpose powders, are suitable for Class A, B and C fires. The agent, when heated, decomposes to form a molten residue which will adhere to heated surfaces. Therefore it is less appropriate for processing and storage facilities. On combustible solid surfaces (Class A), the molten residue excludes the oxygen necessary for propagation of the fire. As a result it has a good extinguishing

effect in Class A fires.

2.4.4.4 Urea-based potassium bicarbonate

This material is denser than sodium bicarbonate. Due to the resulting improved throw, urea-based potassium bicarbonate has a better fire penetration capability in all types of flammable liquid and gas fires (Class B) and also in fires involving energised electrical equipment (Class C). As a result the fire extinguishing rating is better than that of potassium bicarbonate. Urea-based potassium bicarbonate particles have a larger volume than potassium bicarbonate particles. The filling ratio of urea-based potassium bicarbonate to potassium bicarbonate is 0.7. A nominal 12 kg portable extinguisher filled with 8 kg urea-based potassium bicarbonate has the same extinguishing rating for B and C fires as when filled with 12 kg potassium bicarbonate. Though more expensive, urea-based potassium bicarbonate is the most powerful dry chemical powder on a weight basis and therefore the preferred powder for use in Group installations.

Urea-based dry chemical powders are not recommended for the extinguishment of Class A fires.

2.4.4.5 Special powders for chemical or metal fires

These dry chemical powders are generally based on sodium chloride, graphite or sodium bicarbonate. Standard types of dry chemical powders should not be used to extinguish chemical or metal type fires because in most cases there is danger of increasing the intensity of the fire due to chemical reaction between some extinguishing agents and the burning chemical or metal. When special powders are used on chemical or metal fires, special safety equipment, including breathing apparatus, may be required to protect operators. With these special powders care should be taken to use the appropriate type of dry chemical powder for the particular type of fire.

2.4.5 Application rate

Dry chemical powder is used to achieve fast extinguishment of any fire which may occur in the protected area.

The application rate of dry chemical powders specified according to:

- the flow characteristics of the particular dry chemical powder,
- and
- the equipment used in the system.

The following minimum application rates for dry chemical powders may be used for guidance:

- sodium bicarbonate	:	1.1 kg.s ⁻¹ m ⁻² .
- potassium bicarbonate	:	1.1 kg.s ⁻¹ m ⁻²
- urea-based potassium bicarbonate	:	0.8 kg.s ⁻¹ m ⁻² .
- ammonium phosphate	:	1.6 kg.s ⁻¹ m ⁻² .

Typical discharge time is at least 30 seconds.

Performance rating of an extinguisher is typically expressed as a fire area which can be extinguished under test conditions e.g. a UL 711 rating of 60 indicates a test area of 14 m².

2.4.6 Properties of powder

2.4.6.1 Flowability

In this context flowability is the ability of the dry chemical powder to pass through piping systems (incl. hoses, fittings and nozzles) without blocking the extinguishing system.

2.4.6.2 Hygroscopic behaviour

Dry chemical powder has the tendency to absorb moisture; this is called hygroscopic behaviour. Most powders have a silicone coating which may resist absorption. If the moisture content is too high, the dry chemical powder will cake. The moisture content shall not exceed 0.2%.

2.4.6.3 Resistance to packing

Dry chemical powder particles should be resistant to packing if stored in sacks or in fire-fighting vehicles. The storage of sacks shall not exceed a height of 1.2 m. The silicone coating, which is on most powders, may be broken by crushing; this will cause the extinguishing performance of the dry chemical powder to deteriorate.

In portable, wheeled, mobile and fixed systems powders may be subject to vibration. Therefore provisions shall be made to fluidize the powder upon pressurisation.

2.4.6.4 Particle size

The particle size of dry chemical powders is important for their extinguishing performance. The smaller the particle size, the greater the relative particle surface and the lighter the particle. The lighter the particle the lower the throwing capacity. Particles smaller than 14 mm are too light for sufficient throwing capacity.

2.4.7 Compatibility

2.4.7.1 Compatibility of powder types

Dry chemical powders shall not be mixed. Mixtures of certain dry chemicals may generate dangerous pressures and the mixtures may form lumps. If dry chemical powders of the ABC type (ammonium phosphate) are mixed with dry chemical powders of the BC type (potassium or sodium bicarbonate), ammonia and carbon dioxide gases will be released.

2.4.7.2 Compatibility of powder and foam

Dry chemical powders shall only be used with foam if the Manufacturer of the dry chemical powder provides proof, by an independent testing authority, that the powder is compatible with the particular foam type. Generally, silicone-coated dry chemical powders are compatible with foam.

2.4.7.3 Compatibility of powder and water

At the moment of application of the dry chemical powder the fire fighting water shall not interfere with the cloud of powder.

Special branch pipes and monitors where powder is injected in a water stream, thus allowing the powder to be applied from a greater distance without the water obstructing the functioning of the powder, are available on the market.

2.4.8 Quantity required

To determine the amount of readily available dry chemical powder, fire plans shall be established. Based on a risk-based incident scenario approach, the amount of dry chemical powder to be available for immediate use shall be determined. The fact that dry chemical provides no post-fire security shall be taken into account when determining the maximum scenarios where dry chemical powder is used for extinguishment.

A 100 % spare capacity shall be kept in stock.

2.4.9 Storage of powder

2.4.9.1 Storage conditions

Stocks of dry chemical powder shall be stored in a permanently dry area. Dry chemical

powders are unaffected by temperature extremes. Dry chemical powder shall be shipped/stored in containers which will prevent the entrance of moisture. For stacking see (2.4.6.3).

2.4.9.2 Periodic inspection

At regular intervals, dry chemical powder stocks should be inspected for flowability and caking. They shall be laboratory-tested in accordance with UL 299. Powder contained in portable, wheeled and mobile units shall be checked regularly to ensure it is still free-flowing.

2.5 GASEOUS EXTINGUISHING AGENTS

2.5.1 Halon compounds

In support of the Montreal Protocol, **halons shall not be used** as fighting agents except in exceptional cases (called "Essential Uses") where they have been permitted under the Protocol for situations where protection by means of a gaseous extinguishing system is essential and there are no suitable alternatives. These exceptional cases mainly involve major life safety issues and other than aircraft protection they do not apply to manufacturing and E&P process operations within PETRONAS.

2.5.2 Carbon dioxide

Carbon dioxide is a colourless, odourless, electrically inert gas. It acts as a fire suppressor by reducing the oxygen-fuel ratio below the level necessary to support combustion. Particularly in enclosed areas, as a gas it will penetrate and spread to all parts of the hazard (e.g. gas turbine enclosure).

Carbon dioxide is a gas present in the air at an average concentration of about 0.03 % by volume. Carbon dioxide gas has 1.5 times the density of air.

2.5.2.1 Advantages

Carbon dioxide is used as an inerting agent in specific hazards or equipment and in areas/enclosures where an inert electrically non conductive medium is essential and where clean-up of other agents presents a problem.

Some types of hazards and equipment that carbon dioxide gas may protect are electrical hazards, rotating equipment and electronic equipment, engines utilising gasoline and other flammable liquid fuels, unmanned computer rooms, and ordinary combustibles such as paper, wood and textiles.

2.5.2.2 Restrictions

The discharge of liquid carbon dioxide can produce electrical charges which, under certain conditions, could create sparks. In addition, vaporising carbon dioxide (atmospheric boiling point minus 79 °C) may damage sensitive equipment through cold shock on direct impact.

2.5.2.3 Safety

Carbon dioxide cylinders shall not be exposed to direct sunlight as the vapour pressure rises sharply under rising temperature.

In enclosed areas the concentration of carbon dioxide as discharged from fixed carbon dioxide systems or even fire extinguishers may create serious hazards to personnel, such as suffocation and reduced visibility during and after the discharge period. A concentration of 30 % is needed for fire extinguishing, while a 12 % concentration creates a risk to personnel.

Other personnel hazards are noise and cold burn.

For precautions to be taken against these hazards, reference is made to NFPA-10, NFPA-12 or equivalent standards.

2.5.2.4 Storage

Carbon dioxide shall be stored in rechargeable containers designed to hold pressurised carbon dioxide in liquid form at atmospheric temperatures corresponding to a vapour pressure of 58.6 bar (ga) at 21 °C. Containers for transport purposes, up to 130 litres, shall comply with required codes as stipulated by the country of destination.

2.5.3 Clean agents

Clean agents can be used for fixed extinguishing installations and some of them may also

be used in portable extinguishers.

2.5.3.1 Functioning of clean agents

Halocarbons:

The chemical mechanism by which halocarbon agents extinguish a fire is based on a chemical reaction affecting the process of the fire "anti-catalytically". Finely-distributed halocarbons interrupt the radical chain and branching reactions which maintain combustion. The extinguishing effect due to cooling or dilution of oxygen or fuel vapour concentration is minor. Examples are hydrofluorocarbons (HFCs), hydrochlorofluorocarbons (HCFCs), perfluorocarbons (PFCs or FCs), and fluoriodocarbons (FICs). Examples of brand names of agents commonly used are FM-200, FE-13, CEA-410, CEA-614, FE-25, and TRIODIDE.

Inert gas agents:

Inert gas agents act as a fire suppressor by reducing the oxygen-fuel ratio below the level necessary to support combustion. Examples are Argon (ARGOTEC), a mixture of Argon and Nitrogen (ARGONITE), or a mixture of Argon, Nitrogen and Carbon Dioxide (INERGEN).

For guidance on their applicability, use and limitations, safety aspects and environmental aspects, PTS 80.47.10.30, NFPA 2001 or equivalent standards and the E&P Forum report numbers 6.32/195, 6.39/214, 6.45/227 and 6.60/259 shall be consulted.

2.6 STEAM

Steam extinguishes fire by exclusion of air or reduction of the oxygen content of the atmosphere in a manner similar to carbon dioxide or other inert gases. Steam is generally used for fire fighting purposes in areas where it is readily available in large quantities such as furnaces. The advantage of using steam in fighting furnace fires is that it generates no cold shock. Steam can be applied with the use of a steam lance in furnace crossover header boxes etc. Sometimes steam rings are used around flanged connections, e.g. in hydrogen service.

Possible injury from burns to personnel should be considered when steam is used. The use of steam as a fire fighting agent has often been unsuccessful due to failure to understand that its purpose is to prevent the supply of oxygen.

3. MOVABLE FIRE FIGHTING EQUIPMENT

Most fires in plants start small and are extinguished by personnel using an appropriate fire extinguisher. Provided all personnel dealing with hydrocarbons and ignition sources in a plant receive regular training to maintain their skill in controlling small fires, these small fires can often be prevented from escalating into large fires.

The need for and extent of movable fire-fighting equipment are determined during the risk assessment process. During this process the fire and release scenarios per plant area are determined. After fire prevention and fire protection measures are taken a residual fire risk remains. Depending on the extent and nature of that fire risk the appropriate extinguishing medium shall be selected, refer to PTS 80.47.10.30

Movable fire-fighting equipment as applicable may have to be readily available in process and storage areas, on jetties, and in buildings, offices, laboratories and warehouses. Alternatively it may best be stored at 'Fire-points' or in the Fire Station.

Fire-fighting vehicles are equipped with selected types of portable fire-fighting equipment, refer to PTS 80.47.10.33

For new projects, a drawing showing the location of all portable and movable fire-fighting equipment shall be prepared. A list shall be prepared which shall quantify and state the location of the various types of equipment, including hose boxes and fire points, and shall be approved by the Principal. This drawing together with drawings showing fire alarm call points, location of detection equipment, water spray systems, fire water monitors, firewater distribution system, firewater pumps, foam systems and so on form the **master plan of fire safety systems**.

3.1 PORTABLE AND WHEELED EXTINGUISHERS

3.1.1 General requirements

Fire extinguishers shall be provided at every plant section in such numbers and at such locations that at least one extinguisher is readily accessible from any part of the facility.

Each extinguisher provided shall be of a type suitable for use in fighting a fire of the kind which is most likely to occur in the vicinity in which it is placed.

Portable extinguishers are intended to provide a 'first-aid' or 'incipient' fire-fighting facility for dealing with small outbreaks of fire. Wheeled extinguishers are of a larger capacity and are suitable for dealing with larger fires.

Portable and wheeled fire extinguishers shall, as far as practicable, have a uniform method of operation.

Portable and wheeled fire extinguishers shall be available for immediate use. Brackets for hand-held extinguishers shall be of such a design that the extinguisher can be readily removed from the bracket.

The colour and marking of extinguishers should comply with local authority requirements. In the absence of local requirements a consistent colour coding shall be selected and applied.

3.1.2 Design

In the absence of statutory requirements and/or local standards, extinguishers shall be approved and tested in accordance with a specific design and performance standard such as EN 3, ISO/DIS 11601, the appropriate UL standard or another recognised standard approved by the Principal.

Extinguishers shall be suitable for long term exposure to the prevailing environmental conditions at the location of use. The bodies, brackets and other metal parts shall be treated by the Manufacturer to ensure the required degree of corrosion resistance.

Portable extinguishers may be of the stored pressure type or of the type which needs to be pressurised at the time of use

For new projects and when existing extinguishers are replaced, preference should be given to extinguishers of the stored pressure type. The advantage of stored pressure extinguishers is that any sub-standard maintenance of these extinguishers is self revealing.

Poor maintenance of a cartridge-type extinguisher only comes to light when the unit is being pressurised. This has caused fatalities in the past. Cartridge type extinguishers may however be safely used if correctly maintained.

The extinguisher shell shall have a large filling opening to allow quick recharging.

Components of extinguishers shall be made of metal or a suitable synthetic material. All metal components such as clips and clamps shall be of stainless steel or non-ferrous metal. The extinguisher should have a bottom skirt and shall be suitable for wall mounting.

The hoses shall be made of neoprene or an equivalent reinforced synthetic material and be of a quality which remains flexible under the prevailing environmental conditions.

All extinguishers shall be marked and painted in the colour prescribed by the local standard or alternatively as specified by the Principal. The marking should include a simple pictorial operating instruction, type of extinguishing agent used, capacity in kilograms, hazard identification and statement of type approval. The language used for nameplates shall be English unless otherwise specified.

3.1.3 Inspection, maintenance and care

All fire-fighting equipment needs regular inspection and maintenance. Fire extinguishers in particular require periodic attention to assure that each unit is fully charged and operable.

The efficiency of visual inspections is improved by using extinguishers equipped with seals, pressure gauges or other types of indicators.

Fire extinguishers shall be designed so that they can be readily maintained and serviced. This shall include easy removal and refitting of any parts which may require replacement.

Maintenance shall be carried out in accordance with local regulations if applicable. The frequency shall be never less than once a year to provide assurance that extinguishers will operate effectively and safely when required. Proper maintenance records shall be kept. See also EN 3 and NFPA 10.

Extinguishers should be protected from the weather while ensuring that they can still be used quickly in an emergency. For instance, this can be achieved by covering them with a disposable plastic bag, by protecting them under a durable canvas-type cover or by storing them in a dedicated box with perspex door.

3.1.4 Extinguisher rating systems

The rating of an extinguisher is an indication of its extinguishing performance when used by non-expert personnel. A number of rating systems are in use. In the list below only the European CEN and the American UL ratings for class B fires are given.

3.1.4.1 CEN rating

This rating system is intended for small extinguishers only and is related to the duration of the discharge and the surface area of a heptane fire in a circular tray.

An extinguisher receives its rating when at least two test fires out of three are extinguished.

The lowest "B" rating extinguisher, i.e. 34B, can extinguish a 1.07 m² fire.

The highest "B" rating extinguisher, i.e. 233B, can extinguish a 7.32 m² fire.

3.1.4.2 UL rating

The UL 299 rating system is related to the duration of the discharge and the surface area of a heptane fire in a square tray.

The number designating the rating of the extinguisher represents the fire area that the non-expert operator can expect to extinguish. This is always 40 % of the fire area the expert operator at UL must extinguish consistently. For example A 40-B rating extinguisher in the hands of the non-expert operator will be able to extinguish a 40 ft² (4 m²) fire consistently. The expert UL operator can expect to extinguish a 9.3 m² fire with the same extinguisher.

3.2 TYPES AND SELECTION OF EXTINGUISHERS

3.2.1 Dry chemical extinguishers

The stored pressure type extinguishers shall incorporate a pressure gauge showing the normal, minimum and maximum allowable pressure. The gauge shall have a colour-coded pressure range and be located at the top of the extinguisher.

Wheeled extinguishers are pressurised at the time of use. They shall be equipped with a rupture disc to prevent ingress of moisture into the dry chemical powder.

3.2.1.1 BC-type dry chemical powders are most effective in extinguishing hydrocarbon and other flammable product fires. They can be urea-based potassium bicarbonate (e.g. Monnex), sodium bicarbonate, potassium bicarbonate or potassium chloride-based powders.

In view of its large extinguishing power per unit weight, urea-based potassium bicarbonate is the preferred powder.

Dry chemical BC powder extinguishers are the recommended type of standard extinguisher for a petrochemical plant (see 3.2.1.2 for disadvantages of ABC powder).

They shall be installed in all plant areas, on elevated floors in multi-storey structures, at rail and road loading/discharge facilities and at jetties.

For a typical onshore installation portable dry powder extinguishers with a capacity of about 9 kg and a minimum effective discharge time of 20 seconds (CEN rating 233B; UL rating 120-B) shall be used.

For a typical onshore installation wheeled units with filling weights ranging from 35 to 70 kg (UL rating 240-B) shall be used.

3.2.1.2 Multipurpose dry chemical powder, called ABC, can extinguish A-type fires (wood, paper, rubber) and to a lesser extent BC-type fires (hydrocarbons and flammables).

The most widely used 'ABC' powder is mono-ammonium phosphate-based.

Dry chemical ABC powder extinguishers may be used in offices and stores to extinguish fires involving combustible materials such as wood and paper and flammable liquids. For this purpose 'ABC' powder shall be used.

The advantage of this type of extinguisher is its large extinguishing power compared to that of a water or foam/spray extinguisher. Disadvantages of 'ABC' powder are that it leaves a glassy deposit on hot surfaces which always makes thorough cleaning and/or salvage necessary after the event. BC powder does not leave this glassy deposit which makes it easier to remove and reduces the salvage costs.

Portable ABC extinguishers have a slightly lower rating per unit weight than comparable BC extinguishers.

3.2.2 Carbon dioxide extinguishers

These extinguishers are constantly pressurised by CO₂ vapour pressure.

The body of the container shall be made of aluminium or steel, both protected externally with an epoxy paint system.

The design of all carbon dioxide extinguishers shall include a control device to enable the extinguisher discharge to be interrupted freely by the operator.

The discharge horn shall be of dielectric material.

CO₂ extinguishers shall be used for fires on electrical and/or electronic equipment.

This is the recommended type of extinguisher for use in locations such as switch houses, computer rooms, control rooms with auxiliary equipment rooms, analyser buildings and laboratories and areas where food is handled.

For a typical onshore installation portable CO₂ extinguishers shall have a filling weight of

about 5 kg (CEN rating 34B; UL rating 10-B).

Portable extinguishers shall comply with EN 3-1, EN 3-2, EN 3-4 and EN 3-5, or with UL 154.

3.2.3 Water extinguishers

Water extinguishers shall be of the stored pressure type. Various additives can be incorporated to allow low temperature operation, or to improve spread and penetration (wetting agents).

They shall incorporate a pressure gauge showing the normal, minimum and maximum allowable pressure. The gauge shall have a colour-coded pressure range and be located at the top of the extinguisher.

Water extinguishers are only suitable for use on Class A fires and particularly for extinguishing smouldering fires of wood or paper. They shall not be used on electrical equipment, metal fires, or water reactive products. Their use is restricted in areas where freezing can occur.

The capacity of portable water extinguishers shall be 9 litres of filling volume (CEN rating 13A; UL rating 2-A).

3.2.4 Pre-mix foam extinguishers

These extinguishers shall be of the stored pressure type. The type of foam, suitable for the most likely kind of fire, shall be indicated on the extinguisher label. These extinguishers produce low expansion foam.

They shall incorporate a pressure gauge showing the normal, minimum and maximum allowable pressure. The gauge shall have a colour-coded pressure range and be located at the top of the extinguisher.

Pre-mix foam extinguishers may be used in locations where small hydrocarbon spill fires are the most likely fire to occur and where the use of a dry chemical powder extinguisher would cause too much damage in addition to the fire damage. They have a limited extinguishing capacity.

This type of extinguisher shall not be used on electrical fires. Their use is restricted in areas where freezing can occur.

The capacity of portable extinguishers shall be 9 litres of filling volume (CEN rating 144B; UL rating 20-B).

Large capacity pre-mix foam extinguishers (size up to 75 litre) may be used for identified minor-to-moderate spill fires when the use of foam carts (3.2.6) is not an option.

3.2.5 Foam spray extinguishers

These extinguishers shall be of the stored pressure type, containing a pre-mix of water and AFFF and equipped with a special nozzle. These extinguishers produce a finely divided foam spray.

They are particularly suitable for extinguishing the type of fires likely to occur in office spaces and are certified safe for the operator to use on typical electrical office equipment, including personal computers.

As a consequence of the fine spraying of the foam, the damage caused by the foam is slight.

They shall incorporate a pressure gauge showing the normal, minimum and maximum allowable pressure. The gauge shall have a colour-coded pressure range and be located at the top of the extinguisher.

Foam spray extinguishers are the recommended type of extinguisher for use in an office-type environment.

They are not suitable for areas where freezing can occur.

The capacity of these extinguishers is 9 kg filling weight (CEN rating 144B; UL rating 20-B).

3.2.6 Foam carts

Foam carts are self-contained foam production units equipped with an eductor, a foam branch pipe and interconnecting hoses. They need to be connected to a suitable pressurised water supply. In practice this means that a fire water system with hydrants is required. The typical foam agent content of a foam cart is 120 litres.

Foam carts are easy and quick to operate, can be operated by one person and have a considerable fire extinguishing power. They shall be the main 'first-aid' or 'incipient' fire fighting tool for larger spill fires in hydrocarbon processing units and on jetties.

Foam carts should have a large wheel size so that the wheels will not sink into soft surfaces.

The units can proportion up to 450 l/min of foam solution, which produces just over 2 m³ /min of low expansion foam. At this flow rate they can operate for 9 min without refilling.

This is the recommended type of extinguisher for plant areas where spills of flammable products are likely to occur.

3.2.7 Steam lances

Steam may be used to smother small fires caused by leakage from pumps, coolers, columns, furnaces, heat exchangers and valve manifolds handling flammable products.

In process plant areas where small fires are likely to occur and where low pressure steam is available the provision of a number of 15 m steam hoses with steam lances shall be considered. If required, the hoses may be permanently connected to the LP steam utility connections.

For details of a steam lance, see Standard Drawing S 88.005.

3.3 LOCATION / DISTRIBUTION OF EXTINGUISHERS

3.3.1 Process plant and storage/loading areas

3.3.1.1 Portable dry chemical extinguishers

This equipment should be distributed throughout the plant so that anywhere in the plant where there is flammable product, a person cannot be further away than 15 m from the nearest extinguisher. In this case hand-held extinguishers with a UL rating of 120-B or higher shall be used. When the exact location of the extinguisher is determined, the potential fire area and radiant heat levels should be considered.

For fire-fighting at higher elevations in multi-storey structures, portable dry chemical extinguishers shall be provided at each level.

For compressors handling flammable gas, at least one extinguisher shall be provided within 5 m of the equipment at each floor level. This to extinguish potential lube oil fires or minor (residual after depressuring) gas flames.

Their distribution throughout the plant shall be logical and practical, so that extinguishers are available along all access routes.

3.3.1.2 Wheeled dry chemical extinguishers

Wheeled units shall be located in areas with a high fire risk where a hand extinguisher would not be expected to have sufficient capacity. The units shall also be distributed at ground level throughout process plants, loading/discharge facilities and jetties in addition to hand-held extinguishers. The travel distance to a wheeled unit should range between 30 m and 50 m depending on the expected fire hazard.

3.3.1.3 Foam carts

Foam carts shall be provided at grade in the vicinity of plant areas where larger spills of flammable products are likely to occur. They should be stationed so that they do not have to be pushed or pulled through shingle, pebbles, stones or sand.

A firewater hydrant should be available within a distance of 50 m.

They should be protected against the weather, e.g. by storing them under a durable canvas-type cover or by storing them in fire points (3.3.1.4). It should be easy to remove the weather protection cover to ensure rapid operation.

3.3.1.4 Fire points

Fire points can be created to back up the distributed extinguishers as described above. Based on the results of the risk based fire safety assessment, a number of open sheds may be provided containing a selection of fire extinguishing equipment (large, small, dry chemical, foam, carbon dioxide, portable, wheeled). The advantages of fire points are that the personnel only need to remember a small number of locations instead of the locations of many single extinguishers throughout the plant and that the best suited extinguishing medium is more likely to be available in them.

Fire points shall only be provided in and around processing areas.

They shall be open for ease of accessibility and shall have a roof for weather protection.

Unless otherwise specified by the Principal each fire point shall contain:

- two to four x 50 kg capacity, wheeled dry chemical powder units;
- four to eight x 9 kg capacity, dry chemical powder hand extinguishers;
- one 120 dm³ capacity foam cart.

3.3.2 Plant buildings

3.3.2.1 Laboratories

Work benches in laboratories shall each be provided with a carbon dioxide extinguisher.

3.3.2.2 Analyser buildings and enclosed gas metering stations

Analyser buildings and gas metering stations shall each have two carbon dioxide extinguishers positioned on the outside of the building near each entrance. Extinguishers may be required inside the building as well if the travel distance exceeds 20 m.

3.3.2.3 Product warehouses and flammables stores

Warehouses and enclosed flammables stores shall each have two dry chemical ABC powder extinguishers positioned on the outside of the building near each entrance. Extinguishers may be required inside the building as well if the travel distance exceeds 20 m.

3.3.2.4 Auxiliary rooms and switch houses

Rooms with electrical/electronic control equipment shall each have two carbon dioxide extinguishers located on the outside of the room near each entrance. Additional extinguishers may be required inside the room as well if the travel distance exceeds 6 m.

3.3.3 Office buildings and general stores

The travel distance to extinguishers located in offices and stores shall not exceed 30 m. Depending on the fire hazard in the office space concerned a carbon dioxide extinguisher or a foam spray extinguisher shall be selected. For general fire-fighting, hose reels shall be provided (see 4.1).

4. WATER-BASED MOVABLE EQUIPMENT

4.1 HOSE REELS

Firewater hose reels are intended for indoor use. They are simple to use and are ready for immediate use since they are permanently connected to a domestic water source. The inlet valve to the hose shall be clearly marked.

The hose reel shall not be connected to the fire water system in view of the possibility of large pressure fluctuations and surges.

Hose reels shall be installed in corridors near entrances, positioned so that each individual space in the building is well within reach of one or more nozzles.

Hoses should be $\frac{3}{4}$ " diameter with a length of 20 m. The nozzle shall be a combination nozzle adjustable from shut-off through spray to jet. The minimum reach in jet mode shall be 10 m.

See EN 671 for details on hose reels.

4.2 FIRE HOSES AND ASSOCIATED EQUIPMENT

4.2.1 Fire hoses

For supply of fire water to handlines, movable fire fighting equipment such as monitors and foam carts, fire-fighting vehicles, and dry risers, fire hoses are used. Fire hoses are also used to convey fire water over large distances.

Fire hoses for supplying water to handlines shall have a diameter of 40 or 65 mm. They are typically 25 m long and fitted with a Storz, Instantaneous or other type of coupling.

The hoses shall be in accordance with EN 671, BS 6391 type 3 or equivalent, with couplings secured to the hoses with stainless steel binding wire. The hoses shall be suitable for a working pressure of 15 bar (ga) and a test pressure of 25 bar (ga).

For high rates of supply of fire water to monitors, to fixed or mobile equipment or to 40 mm handlines, 65 mm diameter or greater hoses should be used to minimise pressure losses.

40 mm diameter hoses should be used for the last downstream section(s) of handlines. The reduced flow rate results in a smaller reaction force to be coped with by the nozzle men; the pressurised hose will remain relatively flexible so that the nozzle men can manoeuvre it more easily.

75 mm, 100 mm and 150 mm diameter hoses are the most common types for conveying fire water over long distances, but even larger diameters are available for this duty.

40 mm, 65 mm and 75 mm diameter hoses shall be equipped with the same size of coupling, normally the nominal 65 mm size. Larger sized hoses have their own typical coupling size.

150 mm diameter hoses and greater should have a locking device at the couplings to secure the connections which otherwise tend to unlock easily while being handled or pressurised.

4.2.2 Coupling types

The type of hydrant coupling shall be selected with account being taken of the coupling type in use by other fire brigades in the area. Alternatively, appropriate adapters shall be provided enabling interchange of equipment with other fire brigades.

Storz couplings should be used. Instantaneous couplings may be used with the approval of the Principal or shall be used where required by local authorities.

The number of types and sizes of couplings used at a site shall be kept to a minimum.

4.2.3 Hose interconnecting components

Hose interconnecting components, such as collecting and dividing breechings and adapters, are mainly used in major fire hose operations involving the plant fire brigade and are consequently part of the inventory of fire-fighting vehicles.

The need for these components shall be determined by the local fire fighting specialist. They shall be suitable for a working pressure of 15 bar (ga) and a test pressure of 25 bar (ga).

The material of construction shall have adequate corrosion resistance for the environmental conditions and fire water quality used.

Weight considerations may influence the material selection, as the total weight shall not exceed 30 kg.

4.2.4 Pressure reducers

If a pressure greater than 8 bar (ga) can be generated in the firewater main **and** it is unavoidable that firewater will be used for cleaning or other purposes, pressure reducers shall be installed between the hydrant valve and the consumer.

The objective of the reducer is to protect the branch pipe nozzle operator from the reaction of the hose and nozzle to the sudden increase of pressure in the firewater main.

This device is a self regulating flow limiter and shall be sized to control the flowing pressure to 7 bar (ga) for the adopted size of hand-held branch pipe nozzle.

The reducer shall be constructed of metal with adequate corrosion resistance for the environmental conditions and fire water quality used.

4.2.5 Back flow protection

When it is unavoidable that firewater will be used for cleaning or other purposes, product shall be prevented from flowing back into the fire-main system.

4.3 WATER BRANCH PIPES (NOZZLES) AND MONITORS

4.3.1 Hand-held water branch pipes (nozzles)

The branch pipe:

- shall have either a separate shut-off valve and spray angle adjustment with clear marking of the setting;
- or shall be of the "close-fog-jet" type with a single control device with a clear marking of the setting.

The components upstream of and including the shut-off valve shall be suitable for a maximum pressure of 15 bar (ga).

The materials used for the branch pipe shall have adequate corrosion resistance for the environmental conditions and fire water quality used.

A nominal 500 l/min branch pipe, connected to a 40 mm hose with a 10 bar (ga) water supply pressure, can be easily and safely operated by one person.

Larger capacity hand-held branch pipes, up to 1 000 l/min, should only be used when sufficient trained fire fighting manpower is available.

4.3.2 Portable water monitors

Portable monitors are typically used to provide back-up for fixed systems, for protection of process equipment which is not protected by fixed systems and to relieve personnel undertaking prolonged and arduous fire fighting operations.

After being placed in position and directed they shall be capable of being left unattended in

operation during the incident. They shall be equipped with suitable feet to permit safe operation on concrete paving. The monitor shall be of such a design that the hydraulic forces, including the pressure shock at the start, are absorbed.

Each water inlet to the unit shall be equipped with a spring loaded non-return valve to ensure continued operation in case a supply hose fails.

Portable monitors should be equipped with a nozzle with a variable flow between 1600 and 2400 l/min and the nozzle shall have an adjustable stream pattern.

At 7 bar (ga) inlet pressure the water jet at 30° elevation shall reach 50 m. The footprint shall be 4 m x 6 m. 80 % of the total water flow shall reach the footprint.

At 7 bar (ga) inlet pressure the water fog at 30° elevation and 30° nozzle position shall reach 18 m. The footprint shall be 7 m x 8 m. 80 % of the total water flow shall reach the footprint.

Since portable monitors often have to be transported over obstacles and sometimes over considerable distances they shall not be heavier than 30 kg. It shall be possible for two fire fighters to place a monitor into position.

The materials of construction shall have adequate corrosion resistance for the environmental conditions and fire water quality used. Weight considerations may influence the material selection.

The monitors shall have a horizontal traverse of 180° and a vertical elevation of 30° minimum and 80° maximum. It shall be possible to lock the traverse and elevation in any chosen position.

The capacity of the monitors should be typically 2 000 l/min, at a working pressure of 10 bar (ga). They shall not have a shut-off facility. The maximum operating pressure shall be 15 bar (ga).

4.3.3 Wheeled water monitors

Wheeled monitors shall be of the hand-down type, able to be manoeuvred by one man over uneven terrain. They should be stationed so that they do not have to be pushed or pulled through shingle, pebbles, stones or sand. They shall be equipped with two or four solid rubber wheels and be provided with a facility to store two fire hoses.

After being placed in position and directed, they shall be capable of being left unattended in operation during the incident. They shall be equipped with lockable wheels and/or adjustable drop-legs to permit safe operation on concrete paving. The monitor shall be of such a design that the hydraulic forces, including the pressure shock at the start, are absorbed.

Each water inlet to the unit shall be equipped with a spring loaded non-return valve to ensure continued operation in case a supply hose fails.

Wheeled monitors should be equipped with a nozzle with a variable flow between 1 600 and 2 400 l/min and the nozzle shall have an adjustable stream pattern.

At 7 bar (ga) inlet pressure the water jet at 30° elevation shall reach 50 m. The footprint shall be 4 m x 6 m. 80 % of the total water flow shall reach the footprint.

At 7 bar (ga) inlet pressure the water fog at 30° elevation and 30° nozzle position shall reach 18 m. The footprint shall be 7 m x 8 m. 80 % of the total water flow shall reach the footprint.

The materials of construction shall have adequate corrosion resistance for the environmental conditions and fire water quality used.

The monitors shall have a vertical elevation of 30° minimum and 80° maximum. It shall be possible to lock the elevation in any chosen position.

The capacity of the monitors should be typically 2 000 l/min, at a working pressure of 10 bar (ga). They shall not have a shut-off facility. The maximum operating pressure shall be 15

bar (ga).

4.3.4 Trailer type water monitors

Trailer type water monitors should be considered where there may be a need for water monitors to be deployed anywhere on site.

They shall be equipped with two or four pneumatic wheels, a height-adjustable small front steering wheel, a towing pole, suspension, a mechanical hand brake, an overrun brake, drop-legs, road illumination, reflectors and an open storage locker with four fire hoses.

After being placed in position and directed they shall be capable of being left unattended in operation during the incident. The adjustable drop-legs shall permit safe operation on concrete paving. The monitor will be of such a design that the hydraulic forces, including the pressure shock at the start, are absorbed.

Each water inlet to the unit shall be equipped with a spring loaded non-return valve to ensure continued operation in case a supply hose fails.

This type of monitor should be equipped with a nozzle with a variable flow and the nozzle shall have an adjustable stream pattern.

At 7 bar (ga) inlet pressure the water jet at 30° elevation shall reach 50 m. The footprint shall be 4 m x 6 m. 80 % of the total water flow shall reach the footprint.

At 7 bar (ga) inlet pressure the water fog at 30° elevation and 30° nozzle position shall reach 18 m. The footprint shall be 7 m x 8 m. 80 % of the total water flow shall reach the footprint.

The materials of construction shall have adequate corrosion resistance for the environmental conditions and fire water quality used.

The monitors shall have a horizontal traverse of 180° and a vertical elevation of 30° minimum and 80° maximum. It shall be possible to lock the traverse and elevation in any chosen position.

The capacity of the monitors should have a minimal capacity of 2 000 l/min, at a working pressure of 10 bar (ga). They shall not have a shut-off facility. The maximum operating pressure shall be 15 bar (ga).

Note: A number of Manufacturers market combined water and foam monitors on trailers. A two-way valve directs the flow to either the water nozzle or the foam barrel.

5. FOAM-BASED MOVABLE EQUIPMENT

5.1 IN-LINE FOAM INDUCTORS

If foam needs to be produced and a fire fighting vehicle, a foam station or a foam cart is not available, the use of in-line foam inductors shall be considered.

Their basic function is to proportion foam concentrate with water. They shall be equipped with a foam pick-up tube, a filter element and a 1.5 m long hose.

In-line foam inductors may take suction from 25 litre cans, 200 litre drums or larger containers. Higher capacity inductors may consequently require many cans or drums to be handled.

Firewater of about 10 bar is required for in-line inductors to perform well. Another pre-requisite for good performance is that the capacity of the inductor shall match that of the connected foam application device.

5.2 LOW EXPANSION FOAM EQUIPMENT

5.2.1 Hand-held low expansion foam branch pipes

Foam branch pipes shall be specified for use with premix foam solution. The foam branch pipes receive the ready made foam solution from a fire-fighting vehicle, in-line variable foam inductor or fixed foam station.

Foam branch pipes produce aspirated foam with an expansion factor of between 6 and 8.

Foam branches shall have a shut-off valve to ensure flexible fire-fighting.

The materials of construction shall have adequate corrosion resistance for the environmental conditions, the foam solution concerned and the fire water quality used.

The most commonly applied hand-held low expansion foam branch pipes have capacities of in between 400 and 800 l/min foam solution at a working pressure of 7 bar (ga). At that pressure the reach shall be more than 25 m.

5.2.2 Portable low expansion foam monitors

These monitors are typically used to cover large areas with foam during fires or hydrocarbon spills in plants.

After being placed in position and directed by fire fighters they shall be capable of being left unattended in operation during the incident. They shall be equipped with suitable feet to permit safe operation on concrete paving. The monitor shall be of such a design that the hydraulic forces, including the pressure shock at the start, are absorbed.

Each foam solution inlet to the unit shall be equipped with a spring loaded non-return valve to ensure continued operation in case a supply hose fails.

Foam monitors shall be specified for use with premix foam solution. The monitor receives the ready made foam solution from a fire-fighting vehicle, in-line variable foam inductor or fixed foam station.

Portable monitors shall be of the aspirated type and produce foam with an expansion factor of between 6 and 8.

The barrel should be equipped with an adjustable "blabbermouth" spray device.

At 7 bar (ga) inlet pressure the foam jet at 30° elevation shall reach 50 m. The footprint shall be 4 m x 6 m. 80 % of the total foam flow shall reach the footprint.

Since portable monitors often have to be transported over obstacles and sometimes over considerable distances they shall not be heavier than 30 kg. It shall be possible for two fire fighters to place a monitor into position.

The materials of construction shall have adequate corrosion resistance for the

environmental conditions, the foam solution concerned and the fire water quality used. Weight considerations may influence the material selection.

The monitors shall have a horizontal traverse of 180° and a vertical elevation of 30° minimum and 80° maximum. It shall be possible to lock the traverse and elevation in any chosen position.

The capacity of the monitors should be typically 2 000 l/min, at a working pressure of 10 bar (ga). They shall not have a shut-off facility. The maximum operating pressure shall be 15 bar (ga).

5.2.3 Tripod mounted low expansion foam monitors

These monitors are typically used to deliver foam onto large tanks.

After being placed in position by fire fighters they shall be capable of being left unattended in operation during the incident. They shall be equipped with suitable feet to permit safe operation on concrete paving. The monitor shall be of such a design that the hydraulic forces, including the pressure shock at the start, are absorbed.

Each foam solution inlet to the unit shall be equipped with a spring loaded non-return valve to ensure continued operation in case a supply hose fails.

Foam monitors shall be specified for use with premix foam solution. The monitor receives the ready made foam solution from a fire-fighting vehicle, in-line variable foam inductor or fixed foam station.

This type of monitor shall be of the aspirated type and produce foam with an expansion factor of between 6 and 8.

In view of its intended use the reach shall be as large as possible. There is thus no need for an adjustable "blabbermouth" spray device on the barrel.

At 7 bar (ga) inlet pressure the foam jet at 30° elevation shall reach 50 m. The footprint shall be 4 m x 6 m. 80 % of the total foam flow shall reach the footprint.

The materials of construction shall have adequate corrosion resistance for the environmental conditions, the foam solution concerned and the fire water quality used. Weight considerations may influence the material selection.

Once put into operation neither the horizontal traverse nor the vertical elevation can be subsequently adjusted. This is a major drawback of this type of monitor.

The capacity of the monitors at a working pressure of 10 bar (ga) could be up to 4 500 l/min. The required capacity shall be based on a scenario based assessment. They shall not have a shut-off facility. The maximum operating pressure shall be 15 bar (ga).

Tripod foam monitors can be useful for fighting tank fires but the logistics of supply and resources need to be carefully considered when the need for these monitors is determined.

5.2.4 Trailer type low expansion foam monitors

Trailer type foam monitors should be considered where there may be a need for very large capacity low expansion foam monitors for deployment anywhere on site. The size and quantity of trailer mounted monitors shall be based on a scenario based assessment.

The trailer can be of the tank trailer type with the foam monitor mounted on top of the foam tank (typical content 2 000 l of foam concentrate).

They shall be equipped with two or four pneumatic wheels, a height-adjustable small front steering wheel, a towing pole, suspension, a mechanical hand brake, an overrun brake, drop-legs, road illumination, reflectors and an open storage locker with four fire hoses.

After being placed in position and directed they shall be capable of being left unattended in operation during the incident. The adjustable drop-legs shall permit safe operation on concrete paving. The monitor shall be of such a design that the hydraulic forces, including the pressure shock at the start, are absorbed.

Each foam solution inlet to the unit shall be equipped with a spring loaded non-return valve to ensure continued operation in case a supply hose fails.

Foam monitors shall be specified for use with premix foam solution. The monitor receives the ready made foam solution from a fire-fighting vehicle, in-line variable foam inductor or fixed foam station.

The monitors shall be of the aspirated type and produce foam with an expansion factor of between 6 and 8.

The barrel should be equipped with an adjustable "blabbermouth" spray device.

The required throw range should be specified according to a scenario based approach. It need to be such that it can reach the fire area under the expected site-specific conditions. At 7 bar (ga) inlet pressure the foam jet at 30° elevation shall reach the specified throw range. The footprint shall be 4 m x 6 m. 80 % of the total foam flow shall reach the footprint.

The materials of construction shall have adequate corrosion resistance for the environmental conditions, the foam solution concerned and the fire water quality used. Weight considerations may influence the material selection.

The monitors shall have a horizontal traverse of 180° and a vertical elevation of 30° minimum and 80° maximum. It shall be possible to lock the traverse and elevation in any chosen position.

The capacity of the monitors should be typically in between 2 000 l/min and 6 000 l/min, at a working pressure of 10 bar (ga), however in some situations monitors with a larger capacity may be needed. Monitors with a capacity of over 16 000 l/min are available on the market. The monitors shall not have a shut-off facility. The maximum operating pressure shall be 15 bar (ga).

The logistics of supply and resources need to be carefully considered when the need for these very large monitors is determined.

5.2.5 High back-pressure low-expansion foam generators

Where it is not possible to generate expanded foam at the location where it has to be applied and where the back pressure on the generator exceeds 2 bar, high back pressure foam generators (HBPG) shall be used. The maximum allowable back pressure shall not exceed 40 % of the inlet pressure.

This type of equipment is used to aspirate air into the foam solution. The aspirated foam (expansion ratio between 1:3 and 1:4) is further transported through the piped system to where the expanded foam is ultimately released.

In hydrocarbon processing plants they are used for the generation and supply of foam to either subsurface or semi-subsurface foam injection systems on fixed roof storage tanks. They may also be used to supply foam to rim seal foam pourers on floating roof tanks.

A high inlet pressure is required for foam generation by this type of equipment, since the pressure loss over the high back pressure foam generator is relatively high. However the pressure loss across the generator should not exceed 70% of the inlet pressure.

The capacity of the generator shall be matched to that of the foam inlet device to ensure proper operation.

The materials of construction shall have adequate corrosion resistance for the environmental conditions, the foam solution concerned and the fire water quality used.

One size of HBPG should be selected as standard (typically 900 l/min) and multiple units should be used if required.

5.3 MEDIUM EXPANSION FOAM EQUIPMENT

5.3.1 Hand-held medium expansion foam branch pipes

Where fire-fighting access is poor (e.g. complex hydrocarbon containing equipment in a pit) and where the use of conventional fire fighting methods is not likely to be successful, the use of medium expanded foam to smother the fire should be considered.

Hand-held medium expansion foam generators shall be specified for use with premix foam solution. Foam concentrate normally used for low expansion foam generating equipment is also suitable for generating medium expansion foam. The foam branch pipes receive the ready made foam solution from a fire-fighting vehicle, in-line variable foam inductor or fixed foam station.

Foam branch pipes produce aspirated foam with an expansion factor of about 50.

The branch pipe shall be of the constant flow type and shall be equipped with a shut-off valve.

The materials of construction shall have adequate corrosion resistance for the environmental conditions, the foam solution concerned and fire water quality used.

The most commonly applied hand-held foam branch pipes have capacities of around 500 l/min foam solution at a working pressure of 7 bar (ga). At that pressure the reach shall be at least 8 m.

5.4 HIGH EXPANSION FOAM EQUIPMENT

High expansion (between 1:500 and 1:1000) foam generators may be used to control fires in enclosed spaces like warehouses, tunnels, ships' holds and basements.

Controlling these types of fires is beyond the normal duties of a typical hydrocarbon processing plant fire brigade.

The use of mobile high expansion foam generators shall therefore be left to specialist fire fighters, like the municipal fire brigades.

Fixed high expansion (between 1:200 and 1:500) foam generators may be used to control LNG fires.

Because of the very limited reach of this foam, the generators are not safely accessible during a fire or a major spill. They are consequently not considered a movable device.

6. LOCATION / DISTRIBUTION OF WATER- AND FOAM-BASED MOVABLES

Lining up the components of water-and foam-based movables requires considerable time and manpower. In hydrocarbon processing installations with low operating manpower levels, the use of this type of labour intensive water-and foam-based equipment for first-aid or incipient fire fighting is therefore no longer considered a feasible option. Only fire protection and fire fighting equipment which can be quickly deployed shall be used for this purpose. The further fighting of larger fires shall be left to the trained fire responders of the site and/or other fire-brigades.

6.1 HOSES / MONITORS / FOAM GENERATORS

6.1.1 Movables located in the plant

Wheeled water monitors are typically provided in plants to protect process equipment which is not protected by fixed systems. They are easy and quick to operate, require minimal manpower and are a very flexible means of protection. Once installed, they relieve manpower.

They shall be protected against the weather, e.g. by storing them under a durable canvas-type cover or in fire points.

6.1.2 Movables located on board fire-fighting vehicles

Fire hoses and associated equipment, hand-held water and foam branch pipes, portable water and foam monitors as well as tripod mounted foam monitors shall be carried on board the fire-fighting vehicles or dedicated trailer units. Spares shall be stored in the fire station.

6.1.3 Movables located in the fire station

Trailer-type water and foam monitors are typically stationed in the fire station and are towed by a vehicle to the location where they are to be deployed.

Where there is an obvious need for a trailer type foam monitor but no obvious need for a trailer type water monitor, the use of the foam monitor for water as well should be considered. A foam monitor used in water service will give at least the same volumetric throwing capacity as a water monitor, but has limited control over the jet and thus less throwing distance.

6.2 HOSE BOXES

Only in exceptional cases shall hose boxes be provided in plant areas. If a plant or external fire brigade is not available or if response by the fire brigade is expected to be too slow and if fire control/extinguishing capacity cannot be provided by other means, the provision of hose boxes may be required. They shall be positioned near hydrants in the vicinity of areas where fires may occur. Hose boxes may be up to 150 m apart.

If hose boxes are provided in accordance with a risk-based fire safety assessment, they shall typically contain 2 standard length fire-water hoses (40 mm diameter), 1 water branch pipe (400 l/min), 1 foam branch pipe (400 l/min at 7 bar(ga)) with a built-in inductor, 40 litres foam compound in containers and 2 coupling spanners. When fire hoses are installed in hose boxes to supply water to a dry riser they shall have a minimal diameter of 65 mm.

Hose boxes shall be made of materials with adequate corrosion resistance for the environmental conditions. The hose box shall be closed by a door or a cover which can be opened by one person. The door or cover shall be sealed with a lead seal or similar device making pilfering or tampering evident but still making it possible to easily open the box if required.

7. PERSONAL PROTECTION

7.1 FIRE PROTECTIVE CLOTHING

All fire responders who will be engaged in aspects of fire fighting which will expose them to hazardous radiant heat levels or close flame proximity shall be equipped with appropriate personal protective equipment.

This PTS only provides guidance on Personal Protective Equipment (PPE) to be used during normal fire-fighting operations. The PPE Guide issued by the HSE Committee shall be used for guidance to determine the most practical and cost effective way to protect the fire-fighters against direct, chemical, physical and biological hazards during their operations.

For hygiene reasons it should be considered to provide all potential fire fighters with their own personal protective equipment for fire fighting operations. The alternative is to clean all PPE thoroughly after each use.

7.1.1 Body protection

A one piece or two piece suit shall provide protection against radiated heat and flame lick. The suit shall be designed for extended periods close to heat sources without hazard to the wearer. In the design of the suit a balance shall be found between protection against external heat and ventilation to dispose of excess body heat. It shall be designed to be worn with a fire helmet with visor.

The jacket shall have a high collar to protect the chin, neck and throat. The length of the jacket shall be adequate to prevent access of flame between jacket and trousers.

The trousers shall be provided with adjustable braces. The leg length shall be sufficient for the trouser leg bottoms to fit over boots.

The suit shall be lined with inherently fire resistant material. It shall be fire resistant and shall meet EN 469, NFPA 1971 or equivalent. The suit shall be tested in accordance with EN 469, NFPA 1971 or equivalent.

7.1.2 Hand and arm protection

Fire-fighter's gauntlets shall protect the hand and arms, with a minimum overall length of 30 cm from fingertip to cuff.

The material shall be inherently fire resistant and shall have been tested in accordance with EN 659, NFPA 1971 or equivalent.

7.1.3 Foot protection

Fire-fighter's boots shall protect the feet against the various hazards which may be encountered during fire fighting operations.

The design shall include a steel toe cap, a steel plate inner sole and a non-conductive sole with adequate tread to give good grip. Boots shall conform to NFPA 1971 or equivalent.

7.1.4 Head protection

Fire-fighter's helmets shall be manufactured from glass reinforced plastic or other approved material with impact and bump resistance conforming to EN 443, NFPA 1971 or equivalent. The resistance to elevated temperatures shall conform to EN 443, NFPA 1971 or equivalent.

The helmet shall be equipped with a clear transparent full face pivoted visor of the tilt-up/tilt-down type.

Special fire-fighting helmets with an integrated device for quick connection of dedicated face masks are available on the market. Disadvantage of these helmets is that they have to be adjusted to suit the wearer's head size. These helmets shall only be used where every fire-fighter has his own dedicated personal protection gear.

7.2 SELF CONTAINED BREATHING APPARATUS

For fire fighting operations inside buildings or confined spaces or in toxic atmospheres respiratory protection shall be provided to the fire fighters.

Self contained breathing apparatus shall provide 30 to 45 minutes of nominal protection.

The design of the apparatus shall enable the wearer to breathe air on demand from a high pressure air cylinder via a demand valve connected to the face mask. The exhaled air shall pass from the face-mask through a non-return valve to the atmosphere.

The apparatus shall be designed and constructed to prevent ingress of the external atmosphere. It shall operate on Automatic Positive Pressure mode.

The design shall conform to EN 137 or an equivalent standard approved by the Principal.

The total mass of the apparatus should not exceed 16 kg.

The storage capacity of the compressed air cylinder(s) attached to the apparatus and carried by the wearer shall be 1800 litres of free air, which is sufficient for 45 minutes based on an estimated consumption of 40 litres per minute.

There shall be an audible warning when 80% of the usable capacity has been consumed.

Lightweight composite cylinders of a spun metal/carbon fibre type may be used only if approved by local regulations.

8. MISCELLANEOUS

8.1 SAFETY SHOWERS / EYE WASH STATIONS

Safety showers shall be provided in areas where flammable products are handled and personnel may be exposed to the product (on fire). Safety showers shall be positioned not more than 15 m away from the potential hazard.

For situations where personnel can be exposed to corrosive materials, safety showers shall be combined with eye wash stations.

Safety showers and eye wash stations shall be supplied with potable fresh water at a temperature between 15 °C and 36 °C.

Water supply to the safety shower shall be activated by a pull-rod or a step-on platform. For the safety shower, approximately 190 l/min at 4 bar (ga) shall be supplied.

If the supply pressure may fluctuate widely the water supply to the eye wash shall be provided with a regulating valve. The eye wash station shall use nozzles which aerate the water. Water supply to the eye wash station shall be activated by a hand or elbow operated spring loaded quarter turn valve. The water rate for the eye wash station shall be approximately 30 l/min.

The safety shower shall be fitted with a device which is activated when the shower is being used and which will raise an alarm in the control room.

8.2 MOVABLE DIESEL DRIVEN GENERATOR SETS AND FLOOD LIGHTS

For sites which are not adequately illuminated the provision of movable power generator units shall be considered, providing power for emergency lighting of the scene of the fire.

Each unit shall include at least 4 telescopic lamp posts and heavy duty tripods to reach a height of 2.5 m, with explosion proof lamp fittings each of 1 000 W.

The generator shall have a continuous operational capacity of 10 kW, and be equipped with explosion proof sockets, a spark arrestor in the exhaust and an automatic shutdown valve in the air intake of the diesel engine for protection against flammable gas clouds.

8.3 MOVABLE DIESEL/ELECTRICAL DRIVEN PUMPS

Portable lightweight pumping units shall be considered for process plants where the plant drainage system has insufficient capacity to handle the normal firewater water quantities used in the event of a fire.

Portable pumps can also be used to lift static water supplies for fire fighting purposes.

Pumping units shall comply with the specifications given in PTS 80.47.10.33 Pumps portable by two persons typically have a capacity of 2 500 l/min at a discharge pressure of 7 bar (ga), with a suction lift of 3 m of water.

9. REFERENCES

In this PTS, reference is made to the following publications:

NOTE: Unless specifically designated by date the latest issue of each publication shall be used (together with any amendments/supplements/revisions thereto).

PETRONAS STANDARDS

Index to PTS publications and standard specifications	PTS 00.00.05.05
Index to standard drawings	PTS 00.00.06.06
Assessment of the fire safety of onshore installations	PTS 80.47.10.30
Active fire protection systems and equipment for onshore facilities	PTS 80.47.10.31
Fire-fighting vehicles and fire stations	PTS 80.47.10.33
Personal protective equipment guide	HSE Committee
Guidance on the selection of halon replacements and alternative fire extinguishing agents	E&P Forum Report No. 6.32/195
Guidance on halon free fire protection	E&P Forum Report No. 6.39/214
Halon-like agents	E&P Forum Report No. 6.45/227
Inert gas fire extinguishing agents	E&P Forum Report No. 6.60/259

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25/28 Old Burlington Street
London W1X 1LB
UK

STANDARD DRAWINGS

Steam lance	S 88.005
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AMERICAN STANDARDS

Standard for portable fire extinguishers	NFPA 10
Low expansion foam	NFPA 11
Carbon dioxide extinguishing systems	NFPA 12
Guide to fire hazard properties of flammable liquids, gases, and volatile solids	NFPA 325
Standard system for the identification of the hazards of materials for emergency response	NFPA 704
Protective ensemble for structural fire fighting	NFPA 1971

Clean agent fire extinguishing systems

NFPA 2001

Issued by:
National Fire Protection Association
One Batterymarch Park
PO Box 9101
Quincy, MA 02269-9101
USA

Carbon-dioxide fire extinguishers

UL 154

Foam equipment and liquid concentrates

UL 162

Dry chemical fire extinguishers

UL 299

Fire extinguishers, Rating and Fire Testing of

UL 711

Issued by:
Underwriters Laboratories incorporated
333, Pfingsten Road
Northbrook, IL 60062
USA.

Fire extinguisher agent - Potassium bicarbonate
dry chemical

O-D-1407

Fire extinguisher agent - Sodium bicarbonate dry
chemical

O-F-371B

Issued by:
Federal Specifications
Superintendent of Documents
U. S. Government Printing Office
Washington DC, 20402
USA

BRITISH STANDARDS

Non percolating layflat delivery hoses and hose
assemblies for fire fighting purposes

BS 6391

Issued by:
British Standards Institution
389 Chiswick High Road
London W4 4AL
UK

EUROPEAN STANDARDS

Classification of fires

EN 2

Portable fire extinguishers

EN 3

Part 1- Description, duration of operation Class A
and B fire test

EN 3-1

Part 2 - Tightness, dielectric test, tamping test,
special provisions

EN 3-2

Part 4 - Charges, of minimum required fire

EN 3-4

Part 5 - Specification and supplementary tests

EN 3-5

Respiratory protective devices; self-contained
open-circuit compressed air breathing apparatus;
requirements, testing, marking

EN 137

Helmets for fire fighters

EN 443

Protective clothing for fire fighters - Requirements
and test methods for protective clothing for fire
fighting EN 469

Protective gloves for fire fighters EN 659

Fixed fire fighting systems - Hose systems EN 671

Issued by:
Secrétariat Central
Rue de Stassart 36
B-1050 Brussels
Belgium

*Copies can also be obtained from national standards
organisations*

INTERNATIONAL STANDARDS

Fire protection equipment - Wheeled extinguishers
- Performance and construction requirements ISO/FDIS 11601

Issued by:
International Organisation for Standardisation
1, Rue de Varembe
CH-1211 Geneva 20
Switzerland.

*Copies can also be obtained from national standards
organisations.*