MANUAL

ASSESSMENT OF THE FIRE SAFETY OF ONSHORE INSTALLATIONS

DEP 80.47.10.30-Gen.

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DESIGN AND ENGINEERING PRACTICE

PREFACE

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The objective is to set the recommended standard for good design and engineering practice applied by Group companies operating an oil refinery, gas handling installation, chemical plant, oil and gas production facility, or any other such facility, and thereby to achieve maximum technical and economic benefit from standardization.

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

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NOTE: In addition to DEP publications there are Standard Specifications and Draft DEPs for Development (DDDs). DDDs generally introduce new procedures or techniques that will probably need updating as further experience develops during their use. The above requirements for distribution and use of DEPs are also applicable to Standard Specifications and DDDs. Standard Specifications and DDDs will gradually be replaced by DEPs.

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1. INTRODUCTION

1.1 SCOPE

This DEP specifies requirements and gives recommendations for the determination and selection of fire protection measures for optimising the fire safety of onshore plants.

This DEP is a revision of the DEP of the same number dated April 1985, which had the title "Requirements for Fire Protection in Onshore Oil and Gas Processing and Petrochemical Installations".

This DEP is applicable both to new projects and to the modification and extension of existing plants.

This DEP does not include the detailed design and engineering requirements of the selected method; these are covered by the following DEPs:

Fire, gas and smoke detection systems	DEP 32.30.20.11-Gen.
Drainage and primary treatment systems	DEP 34.14.20.31-Gen.
Fire hazards and fireproofing/cold splash protection of steel structures	DEP 34.19.20.11-Gen.
Fire-fighting agents	DEP 80.47.10.10-Gen.
Active fire protection systems and equipment for onshore facilities	DEP 80.47.10.31-Gen.
Portable and mobile equipment for fire-fighting	DEP 80.47.10.32-Gen.
Fire-fighting vehicles and fire stations	DEP 80.47.10.33-Gen.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by SIOP and SIEP, the distribution of this DEP is confined to companies forming part of the Royal Dutch/Shell Group, and to Contractors nominated by them (i.e. the distribution code is "C", as defined in DEP 00.00.05.05-Gen.).

This DEP is intended for use in oil refineries, chemical plants, gas plants, oil and gas production facilities, and supply/marketing installations.

If national and/or local regulations exist in which some of the requirements may be more stringent than in this DEP 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, environmental, economic and legal aspects. In all cases, the Contractor shall inform the Principal of any deviation from the requirements of this DEP 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 DEP as closely as possible.

1.3 DEFINITIONS AND ABBREVIATIONS

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 and abbreviations

active fire protection — a "dormant" system that requires to be activated in order to perform its function.

assessment — the process of analysing and evaluating hazards. It involves both causal and consequence analysis and requires determination of likelihood and risk.

aqueous film forming foam — a synthetic foam consisting of fluorochemical and hydrocarbon surfactants combined with high boiling solvents.

classification of fires — in accordance with NFPA, as follows:

class A fires — fires in ordinary combustible materials such as wood, cloth, paper, rubber and many plastics.

class B fires — fires in fires in flammable liquids, oils, greases, tars and flammable gases.

classification of crude oils and derivatives — in accordance with the IP Code Part 3, as follows:

class 0 products — Liquefied Petroleum Gases (LPG).

class I products — liquids which have flash points below 21 °C

class II (1) products — liquids which have flash points from 21 °C up to and including 55 °C, handled below flash point.

class II (2) products — liquids which have flash points from 21 °C up to and including 55 °C, handled at or above flash point.

class III (1) products — liquids which have flash points above 55 °C up to and including 100 °C, handled below flash point.

class III (2) products — liquids which have flash points above 55 °C up to and including 100 °C, handled at or above flash point.

class 1A products — a classification used by NFPA for liquids having flash points below 22.8 °C and having a boiling point below 37.8 °C.

combustible product — The term **combustible product** is not used in this DEP. For this DEP, all liquid hydrocarbon products handled in plants shall be classed as **flammable product**.

NOTE: This DEP does not use the term **combustible product** in order to avoid confusion caused by various codes which define combustible products differently. For example, according to NFPA 30, a combustible product has a flash point ≥ 37.8 °C, whereas other codes define it as a substance having a flash point > 61 °C.

deluge system — a fire protection system where the water supply valve is automatically activated. The water distribution piping is normally equipped with spray nozzles and/or open sprinklers.

escalation — an increase in risk due to increased likelihood and/or severity of consequences.

fire area — a plant area where a sustained intense fire is considered credible. In line with API RP 521, a 2500 square feet (232 m^2) surface on fire can be assumed to be the maximum size of fire to be encountered.

fire control	a reduction in fire intensity of approximately 90%.
fire-hazardous product service	- butane or lighter product - hydrogen plus hydrocarbons when the partial pressure of hydrogen exceeds 0.7 MPa (7 bar abs), and - hydrocarbons at an operating temperature above the auto-ignition temperature.
fire-safe valves	metal-seated valves which provide critical tight shut-off during fire and which remain operable for a period of at least 15 minutes under these conditions.
fire incident	an event or chain of events which has caused or could have caused injury, damage to assets, the environment or third parties. A fire incident involves the release of a hazard.
fire risk	the product of the chance that a specified undesired fire incident will occur and the severity of the consequences of the event.
fire risk rating	an estimated classification of the fire risk.
flammable product	For this DEP, all liquid hydrocarbon products handled in plants shall be classed as **flammable product**. See also **combustible product** and **flammability**. NOTE: This DEP uses the above definition in order to avoid confusion caused by various codes which define flammable products differently. For example, according to NFPA 30, a flammable product has a flash point below 37.8 °C and a maximum vapour pressure of 276 kPa (abs) at 37.8 °C, whereas other codes define it as a substance having a flash point below 61 °C.
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 range	the range of flammable vapour or gas-air mixture between the upper and lower flammable limits. Also, incorrectly, referred to as Explosive Range.
fluoroprotein foam	a protein based foam with selected fluorinated surfactants which are loosely bonded to the protein to provide the foam with fuel resistance properties.
hazard	the potential to cause harm, including ill health and injury, damage to property, plant, products or the environment; production losses or increased liabilities.
hazard consequence modelling	Using mathematical models to estimate the effect of explosions, fires and dispersion.
master plan of fire safety systems	a drawing 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.
mitigation	measures taken to reduce the consequences of a fire incident.
passive fire protection	a system that performs its function without relying on the requirement of activation.
prevailing wind	the direction from which the wind is most likely to blow, based on local meteorological observations.
safe	a condition in which all hazards inherent in an operation have either been eliminated or are controlled such that their associated risks are both below a tolerable threshold and are reduced to a level which is as low as reasonably practicable.
semi-subsurface foam injection	the discharge of foam at the liquid surface in a tank by means of a foldable hose, through a rupture disk from an inlet near the bottom of

	the tank to avoid intimate contact between foam and the liquid.
sprayer (spray nozzle)	an open discharge device directing most of the discharged water in a pattern typical for the particular discharge device.
sprinkler	a normally closed discharge device directing most of the discharged water in a downward direction.
sprinkler system	a fire protection system consisting of at least one water supply and a distribution piping system normally equipped with closed sprinklers, the so-called "wet-pipe" system. A closed sprinkler is activated by the heat from a fire melting a frangible bulb element. Also "dry-pipe", "pre-action" and other varieties of the systems are applied.
subsurface foam injection	the discharge of foam into a tank near the tank bottom (above the water layer) allowing the foam to travel through the product to the surface.
unclassified products	liquids with flash points exceeding 100 °C.
water spray	a fire protection system where the water supply valve is manually or automatically activated. The water distribution piping is normally equipped with spray nozzles and/or open sprinklers.

The following abbreviations are used in this DEP. Other abbreviations used in this DEP are defined at the first place of use:

AFFF	Aqueous Film Forming Foam
BLEVE	Boiling Liquid Expanding Vapour Explosion
CCTV	Closed Circuit TeleVision
EDP	Emergency Depressuring
ESD	Emergency Shut-down
FAR	Field Auxiliary Room
FIT	First Intervention Team
FRED	Fire Release Exposure and Dispersion
HCM	Hazard Consequence Modelling
IPF	Instrumented Protective Function
ISGOTT	International Safety Guide for Oil Tankers and Terminals
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
NFPA	National Fire Protection Association (USA)
NGL	Natural Gas Liquids
ROV	Remotely Operated Valve

2. FIRE SAFETY

2.1 GENERAL

The fire safety of a plant is the degree of invulnerability to fire and/or explosion incidents in terms of their probability of occurrence and associated potential damage. This degree is maximised by the integrated application of fire prevention, fire protection and fire-fighting measures.

This is primarily achieved by fire prevention measures, which comprise measures taken to prevent or limit hydrocarbon releases, measures to confine or divert spills and releases, a surface drainage system which suppresses migration of a fire to other plant sections, a well-considered plant lay-out, process control and instrumented safeguarding measures, application of emergency shutdown systems, application of emergency depressuring systems and measures to minimise the probability of ignition of a release.

If, despite the preventative measures, potential fire hazards remain, fire protection measures shall be taken comprising measures to protect personnel, measures to protect the environment, measures to detect fires and releases at an early stage and measures to prevent escalation of a fire incident.

The plant organisation shall be prepared to deploy a fire fighting organisation to control and/or extinguish fires that occur despite the fire prevention and fire protection measures.

The optimum combination of fire prevention, fire protection and fire-fighting measures in terms of reliability and cost-effectiveness shall be based on the quantified consequences of a number of selected fire scenarios for the plants concerned. In order to reduce unscheduled plant down-time, emphasis shall be placed on fire prevention rather than on fire protection and fire-fighting.

The degree of fire safety that is achieved for a particular plant is determined by sound engineering and safeguarding practices reflected in the standards used in equipment design, fail-safe instrumentation and control elements, sealing systems for rotary equipment, rapid detection systems, etc. Therefore, all these safety enhancing features shall be taken into account when determining the fire protection requirements.

The extent of fire protection and fire-fighting measures is related to the operating manpower levels and shall be agreed with the Principal.

For situations not included in this DEP, the NFPA codes shall be consulted.

For new projects and, where applicable, for extensions to existing plants, a **master plan of fire safety systems** shall be prepared. This plan covers the entire installation and shows all fire safety related systems (such as fire, smoke and gas detection systems, location of CCTV cameras, location of sirens and beacons, active fire protection systems, fixed, portable and mobile fire fighting equipment and such) using the graphical symbols and abbreviations given in Appendix 1.

For the phases of design, engineering, construction and commissioning of plants, it shall be clearly defined which party is responsible for fire safety and fire protection.

2.1.1 Determination of fire scenarios

In order to achieve in a cost-effective way an acceptable degree of fire safety of the plant, all aspects contributing to fire safety shall be assessed throughout the development of the project.

During such an assessment all aspects of loss of containment, including the frequency of occurrence and the severity of the consequences of such an incident, the possibility of ignition leading to explosion and/or fire and the potential for escalation shall be considered. In this "hazard identification" stage an analysis is made of all potentially hazardous fuel inventories and/or release sources present in the various defined areas. Account is taken of the type and physical conditions (temperature, pressure) of the fuel. On the basis of credible leak sizes the flows and durations of the potential releases can be calculated.

These elements determine the various consequences in terms of event types, i.e. pool fires, jet (torch) fires, flashfires, auto-ignition fires, vapour cloud explosions (deflagrations or detonations) and BLEVEs. The effects of these incidents in terms of heat radiation and explosion potential should be established by using appropriate state-of-the-art HCM models (such as the Shell proprietary HCM model "FRED" explained in Report MF 94-0215).

The sequential steps to be taken during a fire safety assessment are:

2.1.1.1 Determination of a number of typical flammable product release scenarios

The scenarios to be considered should be confined to those equipment failures which involve the release of flammable product, of which the frequency of occurrence and the severity of the consequences have been taken into consideration and which have a low probability of early detection.

Scenarios meeting the above criteria comprise:

a) Small leaks from process equipment and piping, sampling systems, sight glasses, etc. For calculation purposes an equivalent hole size of 6 mm diameter should be assumed.

b) Small leaks from flange joints. Representative hole sizes are 1 mm diameter for ring type joints, 2.5 mm diameter for spiral wound gaskets and 7 mm diameter for compressed asbestos fibre (CAF) gaskets.

c) Full bore ruptures of process lines up to size DN 20.

d) Pump seal failures. These failures can be represented by assuming equivalent hole sizes of 9 mm diameter.

e) For storage areas, full surface fixed roof tank fire scenarios shall be considered.

NOTE: The gas and liquid flow rates from the holes shall be calculated using HCM.

2.1.1.2 Assessment of the detection time

Assess how the fire or product release can be detected using fire/gas detectors, CCTV, process instrumentation, detection by personnel patrolling the plant. This allows an estimate to be made of the time elapsed between the onset of the release/fire and the moment operating personnel become aware of the abnormal situation.

2.1.1.3 Determination of the fuel supply reduction measures

Assess the available operational measures to isolate and/or reduce the fuel feeding the fire (manual valves, ROVs, EDP and ESD systems, rapid dumping systems, etc.). Assure the operational measures can be deployed during the emergency.

2.1.1.4 Quantification of the fire / release

The various consequences in terms of event types, i.e. pool fires, jet (torch) fires, flashfires, auto-ignition fires, vapour cloud explosions (deflagrations or detonations) and BLEVEs are calculated using HCM.

The effects of such fire scenarios in terms of heat radiation and overpressure levels to which adjacent equipment may be exposed can be established with acceptable accuracy. They constitute the basis for the quantities of water to be applied, see (3.1.2).

2.1.1.5 Determination of required fire protection measures

The results obtained from the calculations thus performed will reveal which equipment would most likely fail causing further escalation of the fire emergency. This provides the basis for the selection of fire protection measures (water spray systems, fixed fire-water monitors, mobile monitors, manual water application by firemen, passive fire protection, etc.).

Generally, it may be assumed that steel equipment will not require protection when exposed to a heat radiation level of 12.5 kW/m^2 or less. At that radiation level the unprotected metal temperature stabilises at about 300 °C, which is in itself harmless.

However, at a heat radiation level of 32 kW/m^2 unprotected steel equipment will quickly exceed the critical metal temperature (just above 400 °C) , which could result in the equipment losing its mechanical integrity and causing escalation of the fire emergency.

2.2 FIRE PREVENTION MEASURES

Fire prevention measures are to a large extent an integral part of the design, engineering and construction of plants.

During the process and engineering design phases a large number of proven guidelines are applied which, together with good engineering practice, should result in processing facilities with a high degree of reliability and consequently a low probability of loss of containment.

For the various processes Process Guides are available dealing with the process safety aspects. Sound judgement of experienced process engineers is of utmost importance in designing safe and operable processing facilities.

Proper application of the appropriate DEPs for equipment, interconnecting piping and fittings should result in facilities with a very low probability of uncontrolled loss of containment.

Additional measures to decrease the probability that explosion and fire incidents could occur comprise:

- measures to prevent hydrocarbon releases;
- measures to minimise release quantities; and
- measures to minimise the probability of ignition if a release should occur.

2.2.1 Measures to prevent hydrocarbon releases

The piping arrangement shall be designed such that the probability of a release is minimised.

The number of flanged connections shall be minimised, particularly in sections with high pressures, sections containing hydrogen, light hydrocarbons or chemical products, and sections containing hot products at or above their auto-ignition temperature.

Critically examine the need for small bore process piping. Delete when not strictly required. When the piping is required, design it properly and protect it against mechanical failure as a result of vibration, collision, freezing or over-pressuring of blocked-in pipe sections.

Pay attention to the fail-safe position of instrumentation and final control elements.

Conventional level gauges are relatively weak and therefore vulnerable. Consider to delete level gauges where not essential for the safe operation of the facilities. In particular for level gauges installed on high pressures equipment, on equipment containing hydrogen, light hydrocarbons or chemical products and containing hot products at or above their auto-ignition temperature it can be considered to install blow-out preventers (excess flow valves) on the isolating valves between the processing equipment and the level gauge. It shall be noted that blow-out preventers are more likely to remain effective when applied in clean product service. Where level gauges in this service are essential, it should be considered to install high integrity level indicators of the magnetic type.

The shaft sealing systems for rotating equipment shall be designed with the aim to reduce the probability of product release when seal components fail.

Redundant process and equipment monitoring alarms are highly effective in protection against malfunctioning process instrumentation and runaway of process conditions. Early detection of extreme temperatures, pressures, levels, etc. can prevent serious incidents.

2.2.2 Measures to minimise hydrocarbon release quantities

During the process and engineering design phases, a number of specific measures can be taken aimed at segregation of particular sections of the plant, rapid dumping of parts of the plant inventory, and provision of rapid detection facilities to alert the operator as quickly as possible that loss of containment has taken place.

These measures are aimed at a reduction of the quantities of fuel that can be consumed in case of fire. These fuel quantities determine the size and duration of a fire which provide the basis to estimate the consequences of the credible fire incidents, on the assumption that the probability of escalation is minimised by the fire protection measures.

To restrict or reduce the quantity of flammable product feeding the fire, isolating valves which are accessible and operable during a fire incident can be incorporated. In case the manual isolation valve will not be accessible during a fire emergency, installation of an ROV should be considered.

Typically ROVs have been installed in the suction line of pumps when the upstream system contains:

- more than 4 m^3 of butane or more volatile product;
- more than 10 m^3 of hydrocarbon liquids handled above its auto-ignition temperature.

Critical isolating valves shall be specified fire safe when installed in locations where it is likely that the valve will be engulfed in flames during a fire emergency.

Use of wafer-type valves in hydrocarbon service is not allowed as per 'piping' DEP. Where in existing plants such valves are installed in areas where pool fires can occur, the external long tensioning bolts shall be fire proofed.

For plants with a significant inventory of light hydrocarbons or toxic material an ESD system should be considered, which can shut down a total plant or individual plant sections. The sections are selected on the basis of the location of the equipment, the lay-out of the plant section, and on the quantity of hydrocarbons contained per section.

Pressure vessels can be provided with EDP facilities to enable controlled process pressure reduction, thus disposing of part of the inventory in a safe manner. Liquid drop-out facilities can be applied when rapid disposal of the liquid inventory is required.

Instrumented detection is essential if detection by personnel or by other means is likely to be too late to prevent escalation of the incident.

2.2.3 Measures to minimise the probability of ignition of hydrocarbon releases

In the design the lay-out shall be optimised to reduce to an acceptable level the probability of coincidence of a flammable vapour-air mixture and known electrical or other sources of ignition. For the lay-out requirements SIOP/SIEP generally applies the IP Codes of Practice and the IEC electrical safety codes.

The overall area lay-out in combination with the surface drainage arrangement should result in minimising the probability of creating large pools of fuel under or in the vicinity of equipment containing flammable liquids or vapours. In case of loss of containment the spill will thus be confined to a small and safe area. In case of ignition of the spill the probability of escalation will then be low.

The equipment lay-out should enhance natural ventilation thus avoiding accumulation of an explosive mixture which on ignition could result in a devastating semi-confined vapour cloud explosion. Fire decks, i.e. impermeable concrete floors in plant structures, inhibit natural ventilation and shall therefore not be applied.

Noisy equipment or equipment requiring frequent opening up may have to be equipped with noise hoods respectively weather protection. In case the need for enclosures for such equipment cannot be avoided otherwise, special attention shall be paid to the ventilation of these enclosures.

A piping model should be used to optimise the lay-out and to evaluate all safety-related aspects.

Where flanges in insulated pipelines in hydrocarbon service have to be opened more frequently than during major shutdowns only, the cladding of the insulation shall be installed such that spillage of hydrocarbon into the insulation material is prevented.

2.3 FIRE PROTECTION OBJECTIVES AND PRINCIPLES

2.3.1 General

Lay-out and distances between fire-hazardous equipment shall be arranged such that in the event of a fire the probability of escalation is minimised. However, since within an operational complex it is not always feasible to achieve complete separation of individual pieces of equipment, additional precautionary fire protection measures may be necessary.

The basic objective of fire protection is to limit or prevent the escalation of a fire, to avoid risk to life and to minimise material damage. The requirements of this DEP are based on the postulation that in a plant complex only one major fire will occur at one time.

Where feasible, passive fire protection measures shall be provided. Active fire protection shall be provided where passive measures are not feasible.

Prompt detection of a fire or hydrocarbon release in its earliest stage of development is a crucial factor for active fire protection systems to be effective. Detection can take place by personnel or by an instrument. Plants with low manpower levels shall consequently have to rely more on instrumented detection systems.

Active fire protection systems in plants mainly comprise water spray systems and fire water monitors.

Sufficient access shall be provided for manual fire-fighting operations. For areas requiring protection but where access is considered inadequate and cannot be improved, fixed exposure protection systems, which remain in operation until the fire brigade has arrived to determine the appropriate method of attack, shall be provided.

2.3.2 Passive fire protection

Passive fire protection performs its function without relying on activation. The prime function of passive fire protection is to retard the rate of temperature increase of a given substrate. It provides protection only for a limited period of time and is only effective if adequate active fire protection and fire-fighting capabilities can be deployed before the system loses its protective properties.

2.3.2.1 Passive fire protection for structural steel

In cases where liquid flammable product can collect under or in the vicinity of supporting steel structures, passive fire protection shall be considered. Passive fire protection (fire-proofing) is applied to all steel supporting structures whose sudden failure would lead to danger for personnel, escalation of the incident or unacceptable environmental pollution. It offers protection for a limited period and a limited degree of exposure, i.e. until the full fire-fighting capabilities can be deployed. Such fire-proofing shall be resistant to fire for 30 minutes.

It is also applied as cold splash protection to supporting structures near equipment containing liquefied cryogenic gases which upon release to atmosphere would exert an intense cooling effect resulting in embrittlement and consequent fractural failure of the structure.

2.3.2.2 Passive fire protection for process equipment

Vital equipment which can be exposed to fire and which is required to maintain its functionality during a fire, such as remotely operated shut-off and depressuring valves and actuators, critical power supply cabling and instrument cables serving safeguarding systems as well as BLEVE-prone vessels shall be protected against the effects of fire.

The degree of required fire resistance is dictated by operability requirements. If active fire protection systems also covering the area where this equipment is located are not expected to give timely and adequate protection, passive fire protection shall be provided

2.3.2.2.1 Valves and valve actuators

In all cases where valves can be engulfed in fire or exposed to high radiation fluxes as a result of a fire, the fire-safe requirements of the valve shall be determined. The exposure of the valve to fire shall not result in escalation of the fire emergency by leakage of product via the gland to atmosphere or leakage through the valve possibly feeding the fire.

Two categories of valves can be identified, i.e. those which are fire safe by nature (all- metal design) and those designed to reduce a fire risk and which are tested as such (e.g. soft seated valves tested according to BS 6755).

ROVs and depressuring valves plus their actuators plus the actuating system shall remain operable for at least 15 minutes. This can be achieved by locating the valves plus components outside the fire area. In case they have to be located in the fire area, continued operability can for instance be achieved by means of fire proofing the actuator assembly, by applying fire resistant cables or by putting the whole assembly in a fire resistant enclosure.

2.3.2.2.2 Cabling

Critical instrument and electric cabling shall be installed in such a way that they are protected against direct heat radiation and flame impingement. If this is not possible special fire-resistant cables shall be used, which have a minimal 30 minute fire rating.

2.3.2.2.3 Process vessels, storage vessels and piping

In exceptional cases, where activation of active systems is expected to be too slow or inadequate to avoid escalation, vessels and piping shall be equipped with passive fire protection. An example of such a case is found in parts of large propane refrigerant systems, where the probability of a BLEVE caused by a jet fire can be reduced by means of passive fire protection. The required fire resistance shall be determined by taking into consideration the expected response time of the fire brigade.

The material to be used for this application shall be an epoxy-based intumescent or an epoxy-based subliming coating. This type of material is suitable only if the normal operating temperature of the substrate is permanently between ambient and 60 °C.

Although the fire protection properties of the epoxy-based fire proofing materials suitable for process and storage vessels are very good, there is not yet much experience with these materials over longer periods of time and there is concern about the lack of cost-effective non-destructive inspection methods for the outer surface of the substrate. The Principal shall be contacted for advice in case passive fire protection is considered the most appropriate protection for the hazard concerned.

Combined cold insulation / fire proofing is applied on cryogenic equipment. It consists of a layer of urethane foam, a layer of cellular glass and steel jacketing and provides immediate protection for a limited period of time.

2.3.3 Active fire protection

An active fire protection system is a dormant system that requires to be activated in order to perform its function.

Active fire protection systems comprise water spray systems, deluge systems, sprinkler systems, fire-water monitors and steamrings around flanges. Such systems are activated once the information is received from the scene of the fire that protection is required. Their function is to provide protection against escalation of the fire emergency pending the arrival of the fire brigade.

2.4 FIRE FIGHTING ORGANISATION AND FACILITIES

2.4.1 General

Despite the degree of reliability of process equipment, process control and safeguarding systems and optimum application of fire prevention and fire protection measures, occasional fire incidents will continue to occur.

The probability of occurrence of these incidents constitutes the residual fire risk, i.e. the risk that remains after all normal prevention and protection measures have been taken.

Plants should be provided with adequate first-aid fire-fighting equipment (hand-held extinguishers, small foam units, hose reels, steam lances) and well-trained plant personnel able to handle the small fire incidents with confidence.

It should further be able to mobilise large fire-fighting equipment (firetrucks, foam transport vehicles, auxiliary vehicles) within a reasonable time after outbreak of a major fire and should have an organisation in place able to manage the large fire and explosion emergencies, possibly in collaboration with external fire brigades.

2.4.2 Organisation

The optimal structure of the emergency organisation should be decided upon considering the following site-specific factors:

- The size, location and complexity of the installation(s).
- The available own manpower (around-the-clock manning level, number of men that can be freed immediately to assist in or manage fire-fighting operations, level of training of these persons).
- The local fire regulations in force.
- The authority, technical capabilities (manual and mobile equipment) and expected response time of municipal fire brigades.
- Possible legal requirements for an emergency centre, including medical services.
- Mutual aid arrangements in the region.

A prerequisite for such an organisation to act effectively is the existence of well-prepared pre-fire plans, based on well-defined scenarios. These scenarios, see (2.1.1), may best be generated by a study team consisting of operations, process, hardware and safety specialists.

The fire-fighting functions in the organisation have to be covered by competent, experienced and fully trained personnel. The positions to be filled comprise the fire-fighting commander, drivers/operators of the fire fighting vehicles and a number of hose teams. The number of persons assigned to these hose teams depends on the overall manpower situation, complexity of plants, the fire prevention and fire protection measures in place and lay-out of the site.

This personnel may be drawn partly from a permanent fire brigade. The remaining positions are in most cases taken by shift operators and maintenance personnel.

At the onset of a fire the shift supervisor assumes the duty of fire-fighting commander and co-ordinates the activities of a nominated First Intervention Team (FIT). This FIT consists of a number of men available on the site at any one time to operate the fire truck(s) and to man the hose teams. The shift supervisor remains in charge of both the operational and fire-fighting activities until he is relieved from this duty by the Fire Chief. Depending on the site-specific organisation, stand-by teams may be formed from other personnel not normally engaged in operational or maintenance activities. In plants with very low manning levels it may be impossible to form an effective FIT. In case external fire-fighting support is also not available at short notice, the low manpower situation shall be compensated by putting more emphasis on the provision of ESD and extensive fire protection and fire extinguishing systems.

2.4.3 Facilities

2.4.3.1 Communication

The speed and effectiveness of the various actions to be taken is also dependent on the availability of a reliable communications system. This system serves to receive messages from the plant via telephone, radio and alarm systems. It is used to call out duty personnel, fire-fighting personnel, the municipal fire brigade, the police and if necessary, ambulances. It is also used to inform key personnel of the development of the incident.

2.4.3.2 Fire-fighting vehicles

The required number (n) and capacity of the fire-fighting vehicles shall be based on the largest determined fire scenario, which dictates the foam generating capacity and the number of personnel available for fire-fighting operations.

As fire-fighting is a vital service in a plant, the number of foam generating vehicles shall be n + 1, since it cannot be excluded that one vehicle may fail to perform its duty during a crucial fire.

Acquisition of a foam transport vehicle shall be considered.

A general purpose vehicle for transport of protective clothing, additional hoses, additional portable monitors and tools shall also be considered.

2.4.3.3 Mobile foam monitors

For backing-up the sub-surface and semi-sub-surface foam injection systems on fixed roof storage tanks an adequate number of portable or wheeled foam monitors shall be available with adequate capacity.

2.4.3.4 Fire station

The provision of a fire station shall be considered to park the vehicles, to provide a maintenance workshop for fire-fighting equipment, storage space for fire-fighting agents, training space for fire-fighting instruction and office space for full-time fire brigade personnel. If there is a foam storage tank it shall be located in the vicinity of the fire station. See also (4.2.2).

2.4.3.5 Fire training ground

Subject to permission by the local Authorities to make open fires, a training ground shall be provided.

First aid fire-fighting training shall be given to all personnel involved in handling flammable products and to personnel handling ignition sources. This training concerns the use of portable and wheeled dry chemical extinguishers and small foam carts. For this type of training a facility as described in Standard Drawing S 88.030 should be provided.

Hose team training is required for the FIT and back-up teams. The fires to be lit shall be large enough to be realistic. Authority permission is specifically required for the larger fires before training facilities are built. For this type of training a facility as described in Standard Drawing S 88.031 should be provided. If the size of the groups which can be mobilised for the training sessions is too small (less than 10 people) it may be more efficient and cost effective to send personnel to external fire training courses.

3. ACTIVE FIRE PROTECTION SYSTEMS AND FACILITIES

3.1 FIRE WATER SUPPLY SYSTEM

3.1.1 General

Water (either as such or as a foam solution) is the most commonly used agent for cooling of equipment and for controlling and/or extinguishing the fire. It also provides protection for fire-fighters and other personnel in the event of fire. Water shall therefore be readily available at all the appropriate locations, at the correct pressure and in the required quantity. Fire water shall be considered a vital utility.

Fire water should not be used for any other purpose. If under non-fire conditions the water mains system has to be used for service water, the take-off connection shall be of a size smaller than the nominal size of the hydrant valve and be provided with a restriction device or pressure reducing valve, to ensure that the required water flow can be supplied without causing the main fire-water pumps to start automatically as a result of pressure loss in the mains. These flow limiting devices also serve to protect the hose handler against a sudden pressure increase.

3.1.2 Fire water flow rates

The radiation levels to which the various pieces of equipment may be exposed, as calculated during the fire safety assessment process (see Section 2.1.1), form the basis to determine the quantities of fire-water required for exposure protection.

These quantities (Q, dm^3/minute) are related to the radiation flux levels (W, kW/m^2) as follows:

1) for process areas, etc. which are not too windy, including 25% losses, use:

- for $W \leq 25$ kW/m^2 : $Q = 2$ dm^3/minute per m^2 exposed area
- for $W > 25$ kW/m^2 : $Q = 1.2 + (0.033 * W)$ dm^3/minute per m^2 exposed area

2) for areas which are very windy, including 50% losses, use:

- for $W \leq 15$ kW/m^2 : $Q = 2$ dm^3/minute per m^2 exposed area
- for $W > 15$ kW/m^2 : $Q = 1.4 + (0.04 * W)$ dm^3/minute per m^2 exposed area

The above formulae are used to calculate water requirements for three-dimensional areas, such as:

- the general process areas;
- atmospheric product storage tanks;
- pressure storage tanks (LPG, etc.);
- steel-walled and roofed refrigerated storage tanks (LNG, etc.).

For two-dimensional areas, like:

- oil movements pumping stations, manifolds, in-line blenders, etc.;
- jetty manifolds;
- product loading / unloading facilities.

general water application figures ranging from 6 to 10 dm^3/minute per m^2 of ground surface, depending on the products handled, can be applied.

Typical water application rates, for general use, that in general will provide adequate protection are given in (3.3.1).

Select on the plot plan a few fire areas with a high density of equipment and where a pool fire could occur. Determine the 12.5 kW/m^2 radiation contour. Calculate the water quantity required to provide adequate exposure protection to the equipment located within the radiation contour.

In addition to the water requirements for exposure protection, water may be required to generate foam to extinguish a fire. Particularly for atmospheric storage tanks, exposure protection may be required for adjacent tanks while foam has to be generated to extinguish the tank fire itself.

Note that a full surface tank bund fire shall not be considered for the water quantity calculation, since experience indicates that such bund fires are not likely to occur with well maintained and operated storage tanks.

Storage tanks equipped with a fixed subsurface foam extinguishing system, for instance, require 4.1 dm^3/minute foam solution per m^2 burning surface. The foam solution contains 97% water, when using a 3% foam concentrate.

See NFPA 11 for specific foam application rates and durations for other types of extinguishing systems.

The largest of the above quantities thus found, usually the amount required to protect adjacent storage tanks against radiation from a full fixed roof tank fire and to extinguish the tank on fire, is taken as the design basis for the capacity of the fire-water pumps. This capacity is the basis of design of the mains system, which however shall never be less than 720 m^3/h, unless specifically agreed otherwise by the Principal.

3.1.3 Fire-water supply quantity and quality

Based on the fire scenarios both the required flow rate and duration of supply can be determined. Where possible, fire water should be supplied from open water, in which case the availability of the supply is unlimited.

To meet the fire-water requirements of a plant, fresh water with a low biological activity is preferred. Where the required quantity and quality are not available at acceptable cost, water storage facilities shall be provided.

The capacity of the storage facilities shall be sufficient for the expected duration of the fire. In climates where freezing occurs, provisions shall be made to prevent stored water from freezing, e.g. by circulation or by heating. Alternatively, the storage capacity can be increased to compensate for the ice layer.

Considering periodic maintenance requirements on the fire-water storage facilities and available reliable replenishment rates during fire-water consumption at maximum flow rate, the storage capacity can be determined.

Resources that may be considered for replenishment are plant cooling water, open water or well water, subject to economic evaluation. If during an emergency a normally fresh water filled system has to be replenished with more corrosive water, the system can still be considered a fresh water system, assuming that prompt flushing takes place after emergency use to replace the corrosive water in the system.

In cases where the fire scenarios are not clear or where a longer duration fire cannot be excluded a minimum of 6 hours uninterrupted water supply at maximum required rate shall be provided.

It shall be considered to install fire-water import facilities. For instance, where reliable fire boats are available they can be used to pump water into the fire-water distribution system.

3.1.4 Fire-water pumping arrangement

Fire water is considered a vital utility for a plant. Fire-water shall be provided by at least two identical pumps, each of which is able to supply the largest required flow rate to the fire-water ring mains system. An alternative with a higher reliability is the installation of three identical pumps, each able to supply 60% of the largest required flow rate.

The fire-water pumps shall be of the submerged vertical type when taking suction from open water, and of the horizontal type when suction is taken from a storage tank.

The fire-water pumps shall be installed at a location which is considered to be safe in case of fire anywhere in the plant, where it is unlikely to be engulfed in an explosive vapour cloud originating in the plant, and where it is unlikely to be damaged by collision with vehicles and/or ships.

3.1.5 Selection of fire-water pump drivers

Pumps may be driven by electric motors, steam turbines, gas turbines or internal combustion engines according to application, location, fuel availability and economics.

The selection of the pump drivers shall be governed by the requirement of maximum reliability of the overall system. This is directly related to the reliability of the associated utility systems (power, steam and fuel supply) and the instrumentation system.

In plants, both those relying on imported electric power as well as those generating their own electric power, the standard arrangement is that diesel engine driven pumps are able to provide the fire-water at the required flow rate. In a two pump arrangement, one is electric motor driven and the other is diesel engine driven. In a three pump arrangement, one pump is electric motor driven while the two other pumps are diesel engine driven.

Rather than providing the infrastructure for permanently installed back-up fire-water pumps, it shall be considered to provide a number of standard diesel driven portable, submersible pumps. When needed they can be mobilised within half an hour. A suitable water source, e.g. cooling water basin, shall be available. The pumps deliver the water via hydrant connections into the firewater main. They are normally stored in a warehouse and shall be tested regularly.

3.1.6 Fire water distribution system

3.1.6.1 Fire-water ring mains system - General

Fire-water shall always be able to be provided at the required flow rate in all plant sections under all circumstances. Non-availability of a section of the fire-water main shall not affect the fire-water availability anywhere in the plant. The ring main shall be provided with block valves such that sections can be isolated for maintenance.

For the safety of personnel involved in manual fire fighting operations, facilities shall be provided enabling full control of the firewater pressure in all plant sections under all circumstances.

Fire-water ring mains of the required capacity shall thus be laid to surround all processing units, storage facilities for flammable liquids, loading facilities for road vehicles and rail cars, bottle filling plants, warehouses, workshops, utilities, training centres, laboratories and offices. Large areas shall be sub-divided into smaller sections, each enclosed by fire-water mains equipped with hydrants and block valves.

A full bore flushing connection is only required if the fire-water quality could result in settlement of silt in the piping, in case marine growth is likely and in cases where corrosion (rust flakes) or erosion (cement particles) products can be formed.

A single fire-water pipeline is acceptable for the non-critical fire-fighting training ground.

On the basis that non-availability of the fire-water supply to jetties could be caused by corrosion to the piping or major damage to the jetty caused by a ship, supply of a "ring" main on the jetty will not provide the reliability of supply on a jetty. The corrosion problem can be solved by proper material selection. It is thus acceptable that fire-water may be supplied by a single pipeline. In some cases back-up can be provided via a separate pipeline supplying water spray systems from the foot of the jetty.

The fire-water pipelines to the jetty shall be provided with isolating valves at the foot of the jetty which can be closed in the event of serious damage to the jetty.

3.1.6.2 Fire-water ring mains/network design

The fire-water mains network pipe sizes shall be calculated using an approved state-of-the-art computer program. The calculations shall be based on the design rates at a pressure of 10 bar(ga) at the take-off point under the most unfavourable water supply conditions.

3.1.6.3 Fire-water mains - Installation and material selection

To reduce the probability of losing the fire-water supply as a result of an explosion the fire-water ring main shall be laid underground within the 0.15 bar over-pressure contour in plant areas where explosions cannot be excluded. Over-pressures can be calculated using HCM. As a general and conservative guideline it can be stated that within a radius of 100 m from process plant equipment and pressurised storage tanks the fire main shall be laid underground.

In all low risk areas fire-water mains can be laid above ground.

In areas where the ambient temperature can drop below 0 °C for longer periods, the fire water mains shall be buried not less than 0.3 m below the frost line.

The selection of materials for the fire-water piping shall be based on the predominant water quality and the choice of piping being routed above or below ground.

3.1.6.4 Hydrants

Fire-water mains shall be provided with permanent hydrants, located in strategic positions around processing units/areas, loading/unloading facilities, LPG bottle filling plants, storage facilities for flammable liquids and LPG/LNG, and on jetty heads/berths.

When selecting the type of hydrant coupling consideration shall be given to the coupling type in use by other fire brigades in the area. Alternatively appropriate adapters shall be provided enabling interchange of equipment with the others.

3.2 FIRE WATER DISPOSAL FACILITIES

In general plant design, fire-water is normally discharged via the plant drainage system. In order to avoid flooding of plant areas, which would entail the danger of a fire spreading, it should be ensured that the drainage capacity of a plant section always exceeds the maximum fire-water demand to control the fire scenario in the plant section concerned.

The floor in the various plants sections should be profiled such that the maximum travel distances of burning liquid pools are limited and that burning spills will flow away from equipment, thus reducing the probability of escalation.

For on-plot drainage networks two main segregated systems can be found: an accidentally oil-contaminated (AOC) system and an oil drip/drain collection network. Fire-water is disposed of via this AOC system.

The AOC drainage network in new plants comprises a sump-free paved area with surface water run-offs being collected in perimeter drain channels and routed via flooded underground headers to end-of-pipe treatment. In existing plants, drainage generally takes place via underground flooded pipelines.

The AOC systems will generally discharge to a holding basin or oil trap. Contaminated fire-water shall not be discharged directly to public water. Buffering facilities are provided to retain fire-water to allow inspection and analysis for decision making with regard to treatment requirements. The capacity of the buffering facility is determined by the fire scenarios. The buffering facilities are, where practical, an integral part of the controlled discharge facility for rain water effluents.

3.3 EXPOSURE PROTECTION SYSTEMS

These systems use water to suppress a fire by converting water to steam inside the flame, thus partly reducing the oxygen supply to the fire. The water consumes part of the heat generated by the fire, thus reducing the quantity of heat available to overheat and damage adjacent equipment.

The temperature for failure of structural steel is generally taken at 538 °C. For pressurised vessels 250 to 300 °C is taken as maximum, and for cabling a maximum temperature between 100 and 150 °C is taken.

By maintaining a water film on the exposed equipment its surface temperature is kept at or below 100 °C, thus avoiding escalation of the fire as a result of further damage to equipment. The preferred way of applying water onto equipment surface is by spraying it on the section concerned. Applying the water at higher elevations and relying on rundown of the water easily leads to damage to the water film because of uneven surface of the equipment or disturbance of the film by wind or updraught.

Exposure protection can be provided by water spray systems, deluge systems or fire-water monitors. Exposure protection shall preferably be provided by means of fire-water monitors.

3.3.1 Water application rates

Where the fire scenarios indicate that exposure protection is required, section 3.1.2 gives guidance on the required water application rates.

As a rough guideline, the following typical application rates will in general provide adequate protection:

3.3.1.1 Pumps

For conventional pumps handling LNG, LPG and products near their auto ignition temperature, the pump and a border of 1.2 m around the pump shall be wetted. Directly over the pump, a rate of 40 dm^3/minute/m^2 of ground surface shall be applied, around the pump, 20 dm^3/minute/m^2 of ground surface shall be applied.

For pumps and equipment in congested areas (where a chimney effect may occur) or when installed under air-cooled heat exchangers, water shall be applied at 20 dm^3/minute/m^2 of ground surface.

3.3.1.2 Compressors

For compressors, 40 dm^3/minute/m^2 of ground surface shall be applied.

For water fog systems installed above lube oil/seal oil tanks, 8.5 dm^3/minute/m^2 equipment surface shall be applied.

3.3.1.3 Static equipment

For vessels, columns and heat exchangers holding a liquid volume of 5 m^3 or more of butane or lighter products, the application rate shall be 8.5 dm^3/minute/m^2 equipment surface. Wetting shall be provided up to a height of 9 m above the potential source of the fire.

3.3.1.4 Storage tanks

For the roof of cone roof tanks spaced in accordance with the IP Code Part 3, 1.7 dm^3/minute/m^2 of surface area shall be applied.

For tanks spaced in accordance with the IP Code, 17 dm^3/minute/metre of tank circumference shall be applied to the part of the tank circumference that is potentially exposed to an adjacent fire.

For pressure storage of butane and lighter hydrocarbons, 8.5 dm^3/minute/m^2 equipment surface shall be applied.

3.3.1.5 Jetties

For jetty structures, support legs, manifolds and gangways, 20 dm^3/minute/m^2 equipment surface shall be applied.

3.3.2 Water spray systems

Water spray systems are engineered systems applying water at a pre-determined application rate onto the equipment and the surrounding area to be protected. The advantage is their correct water dosage. Disadvantages are high installation and maintenance costs. For congested areas, in most cases these systems are the only way to provide adequate protection.

In most cases, a few minutes delay to evaluate the situation after receipt of a fire alarm can be tolerated before activating the water spray system. This approach minimises the number of nuisance activations of spray systems, subject to the availability at short notice of sufficient operating manpower to carry out the evaluation.

A maximum of four pieces of equipment may normally be sprayed by one system. If two adjacent systems are likely to operate simultaneously, the total water flow shall not exceed 50% of the fire-water capacity supplied to the area using the normal pumps.

3.3.3 Automatic water spray ("deluge") systems

Automatic water spray systems are systems where the supply valve is activated automatically by a detection system installed in the same area. These systems are applied when delay in activating the water spray system is unacceptable in view of the immediate danger of escalation. The disadvantage is that nuisance activation of the system may occur. In cases where nuisance activation of the system is undesirable a double detection system shall be considered subject to classification according to DEP 32.80.10.10-Gen.

Automatic water spray systems are also called "water deluge systems".

3.3.4 Fire water monitors

Fixed manually adjustable and operated water monitors with adjustable nozzles shall be installed at strategic points around and inside areas where fire hazards have been identified. Accessibility and prevailing wind directions shall be taken into account to arrive at the optimum positions.

Fire water monitors have relatively low installation and maintenance costs and provide very effective and flexible means to provide exposure protection.

The standard monitor has a water capacity of 120 m^3/h at a working pressure of 10 bar(ga). However, monitors with a different capacity may be necessary for particular applications.

For congested plant sections where fixed ground level mounted water monitors may be less effective because of obstructions, elevated fixed adjustable water monitors operated manually from grade level shall be considered.

In case exposure protection is provided by means of fire-water monitors only, back-up protection by another monitor fed from another branch of the fire-water main shall be available. Monitors shall be located in a safe location considering the area they should cover.

Where exposure protection is provided by monitors, detection systems may still be required to alert operating personnel of the abnormal situation.

Portable or wheeled monitors carried by fire brigade vehicles provide additional flexibility.

3.3.5 Water fog systems

Water fog systems apply water at a pre-determined application rate onto the equipment and the surrounding area. These systems are applied in situations where water damage to the equipment during testing and inadvertent actuation is to be avoided. This is achieved by accurate dosing of small water droplets into the flames. In case of fire the droplets vaporise immediately. During testing the droplets are so small that they do no harm. Disadvantages are high installation and maintenance costs.

A typical application is protection of luboil and seal oil tanks in congested areas. The delicate dosing of water prevents water from entering the tank via the vent.

In most cases, a few minutes delay can be tolerated to evaluate the situation after receipt of a fire alarm before activating the water fog system. This approach minimises the number of nuisance activations of the systems, subject to the availability at short notice of sufficient operating manpower to carry out the evaluation.

3.3.6 Water curtains

Water curtains are not effective in providing protection to equipment. They separate sections from each other, thus preventing to some extent escalation from one section to the other, but do not prevent escalation in the section where the fire takes place.

3.4 SPRINKLER SYSTEMS

A wet-pipe sprinkler system is a permanently filled and pressurised water distribution piping system fitted with normally closed sprinkler nozzles. A frangible glass bulb keeps the nozzle closed by means of a plug. When exposed to a certain heat input the bulb fractures and the plug is pushed out by the water pressure. Also "dry-pipe", "pre-action" and other varieties of the systems are applied.

Such systems only spray water via the activated nozzle. For a typical hydrocarbon plant situation, the protection they provide is insufficient as both the area they cover and the water application rate are far too small to have the desired protection effect.

Sprinkler systems are widely applied in buildings to extinguish class A fires.

Design requirements shall be in accordance with NFPA 13.

3.5 DETECTION, ALARM, AUTOMATIC CONTROL AND MONITORING SYSTEMS

3.5.1 General

Prompt detection at the onset of a fire or hydrocarbon release anywhere in the plant and an immediate warning to operational and fire-fighting personnel are crucial factors in the basic concept of fire protection.

Detection of a fire in its earliest stage of development is essential if remedial actions are to be effective. Fire detection signals can be initiated either by personnel or by an instrument.

Instrumented detection is essential if delayed detection of a fire could lead to a fire size beyond the extinguishing capabilities available, if leakage of material to the atmosphere results in a large flammable gas cloud, if the material is above its auto-ignition temperature and if release of a toxic substances would immediately endanger personnel.

Typical examples are instrumented detectors in the seal areas of floating roof tanks, in gas turbines enclosures, in air intakes of control rooms, in unmanned computer rooms and in fire-hazardous material stores.

3.5.2 Detector type selection

3.5.2.1 Detection by persons

Personnel detecting loss of containment, smoke or fire gas release shall be given efficient means to alert other personnel or call for assistance to deal with the incident.

Means to alert others are a personal radio link with the control centre, manual call points and direct telephone links.

It may be considered not to install manual call points in the plant on the basis of widespread use and availability of other means of communication between field and control centre.

Fire alarm call points in buildings shall be provided when required by NFPA 101, unless local regulations are more stringent.

3.5.2.2 Heat detectors

Heat detectors should be applied for the detection of fires which are expected to build up quickly and generate much heat. They have a low spurious alarm rate, but are slow in detecting fires. Since the heat generated by small fires tends to dissipate fairly rapidly, heat detectors shall be installed close to the hazard where the fire is expected.

Heat detectors can be of the point/spot (frangible bulb) type, can be linear (polyethylene tubing) detectors or can be space detectors.

3.5.2.3 Fire detectors

IR (infra red) fire detectors should be applied only where fast detection of a hydrocarbon fire is of prime importance. The design is based on the flame-flicker principle, i.e. the detector recognises the flickering of most hydrocarbon fires. Because they will react to any radiation in the same sensitivity range they are liable to give false alarms. They are spatial coverage devices (seeing a cone volume) and can be used outdoors. They will not detect low temperature smouldering fires.

UV (ultraviolet) fire detectors are also very fast in detecting fire. They should not be applied in a dusty or otherwise dirty environment as fouling of the lens will affect the performance of the detector. They are subject to interference from welding arcs, sunlight and lightning. They are more suitable for use indoors.

3.5.2.4 Smoke detectors

Conventional smoke detectors function by sensing visible or invisible products of combustion. Some types are not suitable for fires involving materials which do not produce smoke particles. All smoke detectors are liable to produce false alarms due to emissions from normal operations, such as dust and exhaust gases.

Ionisation-type smoke detectors make use of a small radioactive source, which could mean that their application is restricted in some countries. This type of smoke detector should be applied in combination with heat detection to detect smouldering fires in buildings. Used detectors shall be disposed of in a controlled manner.

Scattered light-type detectors are the preferred type and should be used as an alternative in countries where use of the ionisation-type detector is restricted.

Ultra-sensitive smoke detectors which monitor the air inside buildings for minute smoke particles give a very early warning of overheating of cables and electronic components. These systems are particularly useful in high density instrument and electronic equipment areas where very early detection of malfunctioning equipment will provide time to correct the situation and prevent damage to vital instrumentation.

3.5.2.5 Flammable gas detectors

In open process plants, the hydrocarbon-containing equipment is so designed that, should leakages of flammable material occur, they are not very likely to escalate into fires or explosions within the confines of the plant. Early warning of an unplanned leak which might quickly lead to an unacceptably hazardous situation or which might threaten the safety of personnel or the public, however, may be essential.

Gas detectors can be classified as follows:

A)	Infrared absorption-type detectors	These are the preferred type and are available both as line-of-sight and point detectors. Line-of-sight detectors require an unobstructed view and are very suitable for area and perimeter monitoring.
B)	Catalytic combustion-type detectors	These are point-type detectors and are the most widely used type and are economically priced. They require regular testing to ensure proper functioning. They are not failure-revealing.
C)	Semiconductor detectors	These should not be used for flammable gas detection.

For an overview of typical applications of fire, smoke and flammable gas detection see Appendix 2. The associated cause and alarm/action matrix is shown in Appendix 3.

3.5.3 Alarm presentation and location

A dedicated emergency annunciation panel shall be provided to give an overview of all emergency related information, such as the status of the fire-water supply, gas, smoke and fire alarms, wind speed and direction, road blockages, activated fire alarm call points etc. This display shall be installed in continuously manned building in the plant. Slave displays may be installed at other locations where the occurrence of a fire needs to be known, e.g. the general control centre, the fire station and the gatehouse entrance to the plant.

3.5.4 Closed circuit television monitoring systems (CCTV)

Closed circuit television systems may be installed to provide additional supervision to compensate for low operating manpower levels. CCTV can assist Operations in surveying potentially fire-hazardous areas and to enable them to take appropriate action when fire, smoke or gas is detected.

In particular areas which are less frequently patrolled by personnel, where the situation cannot be observed from a distance because of obstructions or where there is an interface with frequently changing non-Company personnel, CCTV should be considered.

Cameras can be installed in a fixed position focused on high risk areas or may permanently scan large areas.

Typical locations may be pump floors in process and oil movements areas, road/rail car loading areas, jetties and inside plant buildings that contain process equipment.

Monitors shall be installed in the nominated control room close to the gas/fire/smoke detection presentation panel. Upon receiving a gas or fire alarm the cameras can be directed at the area concerned to complement or confirm the information provided by the detection system.

3.5.5 Systems to alert personnel

Toxic and explosive gas mixtures may pose an immediate danger to personnel. Alerting personnel to this danger in and around the area concerned shall be provided by audible and visual means.

In process buildings, sirens and beacons shall be installed which may signal automatically on leakage of flammable and toxic gases, or on the outbreak of a fire.

Evacuation alarm bells in office buildings shall be provided when required by NFPA 101.

Based on the availability of alternative means of communications and to prevent nuisance to the public, the Principal may decide not to install site-wide fire sirens.

4. FIRE-FIGHTING AGENTS, SYSTEMS AND EQUIPMENT

4.1 WATER

Water is the most appropriate extinguishing agent for Class A fires. It has limited use on Class B fires.

However, if properly applied on a fire of flammable product with a flash point above 40 °C, it is able to cool the surface of the product to below its flash point, thereby extinguishing the fire.

4.2 FIRE-FIGHTING FOAMS

4.2.1 Selecting the type of foam concentrate

The type of foam concentrate to be selected shall be based on the type of flammable liquids stored within the plant complex and the professionalism of the fire emergency control organisation. The aim shall be to use as few types of foam as possible to avoid confusion under the generally stressful fire emergency situations and to attempt to have some uniformity with outside fire brigades.

The recommended foam concentrate for use throughout a plant storing normal hydrocarbon products is 3% fluoro-protein. If the plant also produces or stores MTBE (methyl tertiary butyl ether), an adapted 3% fluoro-protein foam should be used.

For plants processing and storing polar solvents and/or alcohols, 3 or 6% Universal foams shall be used. These foams are also suitable to extinguish conventional hydrocarbon fires.

The specialised use of high and medium expansion foam compound and AFFF is addressed in (4.2).

4.2.2 Foam storage capacity

The following requirements for foam compound facilities are based on the application of fluoro-protein foam concentrate. The same guidelines apply to Universal and the Fluoro-protein variant foam concentrate.

The basis for the storage capacity for foam concentrate shall be the quantity 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 dm^3/minute foam solution per m^2 burning surface. When using 3% foam concentrate the available foam concentrate quantity shall allow:

- 55 minutes uninterrupted foam application;
- one hundred percent extra capacity as spare.

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

Therefore, for tanks of diameter D in metres:

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

The required quantity of foam concentrate for 55 minutes including 100% spare capacity would thus be $\pi/4 * D^2 * 4.1 * 0.03 * 55 * 2$ 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 see NFPA 11.

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

The storage of the foam concentrate can be mobile, i.e. in the tanks of the various fire-fighting vehicles, in which case the non-availability of one vehicle shall be taken into consideration. If the mobile stock is insufficient, a fixed foam storage tank is required.

If plant complexes cover large areas, it may be considered to provide more than one fixed foam compound storage facility, installed strategically in the vicinity of the main hydrocarbon storage tank and/or the jetty where large quantities of foam will be required in the event of a fire.

4.3 FOAM SYSTEMS

Foam systems are required when foam application by means of hand lines or foam monitors is not feasible (e.g. the size of the fire may be too large or the time required to line up the manual systems may be too long).

4.3.1 Low expansion foam systems

Low expansion foam can be used to extinguish fires on hydrocarbons ranging from crude oil to flammable liquids with a flash point up to 60 °C. These systems are typically provided for storage tank protection and for remote and inaccessible areas like jetty manifolds.

Depending on the product in the storage tanks and the size of the tanks either subsurface or semi-subsurface foam injection systems are applied.

Depending on accessibility of the fire area and the affordable time delay before foam has to be applied, foam can be provided via a fire-fighting vehicle or via a dedicated foam station.

Generally for hydrocarbons the minimum required foam application rate is 4.1 dm^3/minute per m^2 burning surface.

For hydrocarbons with a flash point below 23 °C and a boiling point below 38 °C the minimum foam application rate shall be 6.0 dm^3/minute/m^2 burning surface.

4.3.2 Medium expansion foam systems

Medium expansion foam can be used on refrigerated LPG and LNG fires. The thick foam blanket acts as a radiation shield reducing the vaporisation of the fuel, thus reducing the quantity of fuel feeding the fire and consequently the fire intensity. The objective of this type of system is to control the burning rate and not to extinguish the fire These systems are typically provided for potential LPG/LNG spill areas such as pump floors and manifold areas.

Foam concentrate for LNG shall be approved by the Principal, shall take into consideration that the maximum travel distance of expanded foam is 20 m, shall have a foam blanket thickness of 1.5 to 2 m, shall have an expansion ratio between 250 (for windy locations, as specified by the Principal) or 500 (for normal locations) and shall be operated remotely and intermittently.

The average foam application rate shall be 3.2 dm^3/minute/m^2 ground surface. Because of the intermittent operation the foam generating capacity shall be between 4.8 and 6.4 dm^3/minute/m^2 burning surface.

4.3.3 High expansion foam systems

High expansion foam can be used to extinguish fires in enclosed spaces such as warehouses, gas turbine installations etc.

4.3.4 Special foam systems

Special AFFF foam systems, generating non-aspirated foam are applied in situations where the immediate objective is to save human lives. Non-aspirated AFFF very quickly knocks down spill fires. The minimum application rate is 6.5 dm^3/minute/m^2 equipment surface.

4.4 GASEOUS SYSTEMS

Only extinguishing agents which do not have a negative impact on the environment shall be applied in the systems.

4.4.1 Carbon dioxide systems

Carbon dioxide extinguishes a fire by lowering the oxygen concentration to a level where fire can no longer be sustained. Such an environment is fatal to humans.

Carbon dioxide systems are designed for total flooding of enclosures such as those of gas turbines. The systems are automatically activated by fire or gas detection and have extensive safeguards built in to ensure the safety of personnel present in the enclosure.

4.4.2 Inergen systems

Inergen is a gaseous fire-fighting agent composed of nitrogen, argon and carbon dioxide. After complete release of the agent the oxygen concentration is too low to sustain a fire but is sufficient for humans to survive and function in a normal manner. The argon and carbon dioxide stimulates respiration to the extent that humans can easily survive in such a low oxygen environment. Inergen can be used for total flooding of enclosed spaces, for instance as a replacement for Halon systems or for new systems.

The advantage of Inergen is that it can be released as soon as the fire is detected. The generation of toxic combustion products and oxygen depletion action by the fire is considerably reduced by early release of the extinguishing agent, thus increasing the chance of survival of injured / immobilised personnel in the enclosure.

Inergen systems are applied for the total flooding of enclosures such as those of gas turbine installations and other normally unmanned areas where loss of the equipment would have a severe impact on the continued operation of the plant. The system is automatically activated by fire or gas detection.

4.4.3 Inert gas systems

The purpose of inert gas systems is to prevent the creation of flammable conditions inside equipment normally containing flammable product, such as the vapour space of storage tanks.

4.4.4 Steam Systems

Steam can be used to smother fires, to dilute gas/air mixtures in enclosed areas, to control flange fires in plants in hydrogen service and on equipment handling flammable products on or above their auto-ignition temperature.

Examples of fixed steam systems for these purposes are smothering steam systems on furnaces and boilers and steam ring systems on inaccessible flanges of plants in hydrogen service.

4.5 DRY CHEMICAL POWDER SYSTEMS

A number of dry chemicals can inhibit the oxidation process within the flame but their application is effective only when the chemical is applied in the diffusion zone of the fire.

However, slight malfunctioning of such a system may result in partial extinguishment followed by immediate reignition, which in itself can be hazardous. Such systems should therefore not be used.

4.6 PORTABLE AND MOVABLE FIRE-FIGHTING EQUIPMENT

4.6.1 General

The vast majority of fires in plants start small and are extinguished by the person detecting the fire using a portable or wheeled dry chemical or foam extinguisher. Provided all personnel dealing with hydrocarbons and ignition sources in a plant are given the opportunity to maintain their skill in handling extinguishers, the number of small fires escalating into large fires can be kept low.

4.6.2 Distribution

Distribution of this equipment in the plant should be such that, anywhere in the plant, any person requiring an extinguisher is no further than 15 m away from the nearest one for high hazard areas. See NFPA 10 for further guidance.

An alternative is to create fire points, e.g for each 1500 m^2 an open shed is provided which contains a selection of fire extinguishing equipment (large, small, dry chemical, foam, carbon dioxide). The advantage is the smaller number of areas to be remembered and the higher probability that a more appropriate extinguishing medium is selected.

Either of the above methods is acceptable, provided uniformity is applied throughout the plant complex.

Hose boxes shall be installed containing initial fire-fighting equipment such as fire-water hoses, water and foam branch pipes, foam compound pick-up tube assemblies and foam compounds in containers. Hose boxes shall only be provided in remote areas where response by the fire brigade to provide fire hoses is expected to be too slow. They shall be positioned near hydrants in the vicinity of areas where fires may occur. Hose boxes may be up to 150 m apart.

Steam lances can be used to smother small fires caused by leakage from equipment handling flammable products at or above auto-ignition temperature. Where low pressure steam is available it shall be considered to provide a number of off-take connections equipped with steam lances.

For fire-fighting at higher elevations in multi-storey structures, portable dry chemical extinguishers shall be provided at each level. Dry risers shall be provided to pipe water to the higher elevations.

5. FIRE SAFETY REQUIREMENTS FOR SPECIFIC AREAS AND EQUIPMENT

5.1 GENERAL

The optimum inherently safe state in a plant is achieved when there is a proper balance among all factors contributing to safety. Reliability and correct functioning of safety enhancing hardware systems shall be ensured by means of good safety management. The focus shall be on built-in safety rather than add-on safety.

As an example, preference shall be given to mounded pressurised storage over above-ground pressurised storage. Despite add-on fire and gas detection and exposure protection systems on the above-ground storage facility, the overall situation has a lower degree of inherent safety than the mounded storage situation.

This section describes the standard equipment arrangements, the corresponding fire hazard, the probability of occurrence of a fire and the standard fire protection measures.

The standard arrangement is based on a well-designed, maintained and operated plant, on continuous manning of the plant (i.e. in case of an emergency, an operator can be on the scene within 5 minutes and effective fire-fighting operations are started within 10 minutes), regular inspection rounds by operators, good equipment lay-out, proper application of area classification guidelines, adequate process control and safeguarding facilities, etc. The description of the standard arrangement includes the fire protection measures.

Based on the standard arrangement, the fire scenario being considered and the estimated probability of occurrence, the adequacy of the fire protection facilities are given.

Subsequently, measures and factors which change the overall fire safety situation and possibly affect the extent of fire protection measures are discussed.

NOTES:
1) In case of inadequate equipment supervision (low operating manpower, remote location of the equipment, absence of sophisticated process and equipment performance monitoring and CCTV) it may be considered to increase the degree of detection facilities compared to the standard situation.
2) In case of complete unattended operation of equipment it may be considered to provide automatic shutdown systems acting on equipment malfunction. This could include a fire extinguishing system.
3) In case of slow response to fire emergencies (low manpower and an expected slow start of fire-fighting operations) more automatic exposure protection systems shall be considered.

5.2 FIRE SAFETY FACILITIES FOR ROTATING EQUIPMENT

5.2.1 Pumps

5.2.1.1 Standard arrangement

The overall objective in designing pump line-ups and lay-outs is to ensure that, in case of a pump failure, the resulting spill/fire and consequential damage will be small.

The majority of pumps are spared, are equipped with efficient shaft sealing systems, can be safely isolated on the suction side either by manipulating a manual valve or by means of an ROV, are not located in congested areas where escalation can easily take place, are not installed underneath pipe racks and air coolers, and are accessible for fire-fighting operations.

Pumps in **fire-hazardous product service** are spared, are equipped with a sophisticated double shaft sealing system, can be safely isolated on the suction side either by manipulating a manual valve or by means of an ROV, have a manual discharge valve and a non-return valve in the discharge, are equipped with simple lubricating systems, have no remote equipment performance monitoring facilities, are accessible for manual fire-fighting operations and are equipped with fire detection and exposure protection systems.

The fire hazard for such a pump is an ignited, relatively small release via a damaged seal.

The probability of occurrence of such a fire is very small as seals of a double arrangement are equipped with an instrumented alarm which operates when the seal fails. Only gross neglect can result in a fire.

A seal fire shall be addressed by closing the pump suction valve and by extinguishing the fire with dry chemical or steam.

The standard fire detection system is installed to detect a fire in the seal area.

For pumps handling butane and lighter products, point gas detectors are installed near the pump seals.

The exposure protection system provides protection to the pump in case of a fire on adjacent equipment and provides protection to adjacent equipment if the pump is on fire. The exposure protection system should be provided by means of fire water monitors.

The fire risk rating is LOW.

Pumps in **other product** service are usually spared, are equipped with efficient single shaft sealing systems, have a manual suction and discharge valve and a non-return valve in the discharge, are equipped with simple lubricating systems, have no remote equipment performance monitoring facilities, are accessible for manual fire-fighting operations and are not equipped with fire protection systems.

The fire hazard for such a pump is an ignited, relatively small release via a damaged seal.

The probability of occurrence of such a fire is small as the released product is not easily ignitable.

A seal fire can be extinguished by using dry chemical or steam.

The fire risk rating is LOW.

Sophisticated expensive pumps, such as hydrocracker feed pumps, are not spared for economic reasons, are equipped with a sophisticated double shaft sealing system, have a remotely operable suction valve, a manual discharge valve and a non-return valve in the discharge, are equipped with sophisticated lubricating systems, have remote equipment monitoring facilities, are accessible for manual fire-fighting operations and are equipped with fire protection systems.

The fire hazard for such a pump is an ignited, relatively small, release via a damaged seal. If not extinguished in time, such a fire could escalate into the lubricating system.

The probability of occurrence of such a fire is very small as seals of a double arrangement are equipped with an instrumented alarm which operates when the seal fails. Only gross neglect can result in a fire.

A seal fire shall be addressed by closing the pump suction valve and by extinguishing the fire with dry chemical or steam.

The standard fire detection is installed to detect a fire in the seal area.

The water spray system provides protection to the pump in case of an external fire and provides protection to adjacent equipment if the pump is on fire.

The fire risk rating is LOW.

5.2.1.2 Deviations / options

If loss of a non-spared pump would have serious consequences for the continued operation of the plant it may be considered to maximize the protection on the unit, for instance by installing an automatic water spray system, with the objective to reduce the probability of losing the pump for mechanical or fire reasons.

Shaft seal systems remain the most vulnerable component of pumps. Given proper care during design, maintenance and operation, seal systems are reliable. In case of too high a failure rate, resulting in too frequent loss of containment via the defective seal, it may be considered to provide fire or gas detection (whichever is the more appropriate considering the process conditions) in the seal area or alternatively to provide higher quality seals.

If the product supply to a pump cannot be isolated under fire emergency conditions it shall be considered to provide either an ROV or an additional manual valve accessible under pump fire conditions.

If access for manual fire-fighting operations or effective use of fire water monitors is limited it shall be considered to install a water spray system. If the situation is very congested and in cases where pumps are located underneath pipe racks or air coolers, which could quickly lead to escalation, it shall be considered to install an automatic water spray system.

For groups of pumps with sophisticated shaft seal systems and consequently a very low probability of seal fires, it shall be considered to provide one fire detection system covering a number of pumps in the area.

For pumps in butane and lighter product service with sophisticated shaft seal systems and consequently a very low probability of release of product via the seal, a point gas detection system should not be installed. Instead, it should be considered to provide an area gas monitoring system for groups of pumps

Small bore and/or screwed connections on pumps (which are prohibited by other DEPs) increase the fire risk.

5.2.2 Compressors

5.2.2.1 Standard arrangement

The overall objective in designing compressor line-ups and lay-outs is to ensure that, in case of a compressor failure, the resulting vapour cloud/fire and consequential damage will be small.

The majority of **reciprocating compressors** are spared, are equipped with a conventional seal system on the shaft, have a dedicated lubricating system for the entire unit, are equipped with equipment monitoring equipment, can be isolated by manipulating manual valves in suction and discharge, are located in the open air where escalation is unlikely to take place and are accessible for fire-fighting operations. The gas supply to the typical compressor fire is already reduced considerably by just tripping the compressor. Exposure protection by means of fire-water monitors is provided.

The fire hazard for such a reciprocating compressor is an ignited, relatively small release at the top of the seal vent pipe at safe location. The release originates from a leaking packing box seal. Escalation of such a fire to other parts of the compressor arrangement is unlikely.

A seal fire can be addressed by tripping the compressor and by extinguishing the fire with dry chemical or steam.

The objective of the fire-water monitor is to provide cooling to the equipment during the period while the compressor is running down and the fuel supply to the fire is being shut off.

The fire risk rating is LOW.

The majority of **centrifugal compressors** are normally not spared, are equipped with high quality shaft sealing systems, have a dedicated lubricating system with back-up for the entire unit, are equipped with equipment monitoring facilities, are equipped with a non-return valve in the discharge, can be isolated by an ROV in the suction and a manual valve in the discharge, are equipped with a remotely operable depressuring facility, are located in a naturally ventilated compressor house where escalation is unlikely to take place and are equipped with water spray, gas and fire detection systems.

The gas supply to the fire can be isolated by tripping the compressor, by closing the suction ROV and by manual depressuring. For compressors in toxic and hydrogen service, a discharge ROV and EDP shall be provided. Large lubricating and seal oil tanks are located close to the compressor and contain the major quantity of flammable products in the area. The hazard of seal oil tanks, i.e. ignition of gas contaminated seal oil, is reduced by permanent inerting of the vapour space. The hazard of the luboil tank, i.e. ignition of luboil mist by static electricity, is also reduced by permanent inerting of the vapour space. A fire in the vicinity may escalate to the tanks.

Although the residual fire hazard for a well-operated compressor installation is low, the consequences of losing the installation are serious. A fire detection system covering tanks and pumps shall be installed. Fire protection shall therefore be provided focusing on containing a seal oil tank fire, thus avoiding escalation to the luboil unit and the compressor itself. This can be achieved by a manually-activated water fog system on the seal oil tank and pumps and an exposure protection system for the compressor.

For additional supervision CCTV shall be considered inside the compressor house.

The fire risk rating is LOW.

Rotary compressors are most often used in intermittent service and are thus not spared. The more sophisticated machines are equipped with high quality shaft sealing systems, have a dedicated lubricating system for the entire unit, are equipped with equipment monitoring facilities, can be isolated by manipulating manual valves in suction and discharge, are located in the open air where escalation is unlikely to take place and are accessible for fire-fighting operations. The gas supply to the typical compressor fire is already reduced considerably by just tripping the compressor. Exposure protection by means of fire-water monitors and gas and fire detection for the seal areas is provided.

The fire hazard for such a positive displacement compressor with a relatively large number of shaft seals is an ignited, relatively small release via a damaged seal. If not extinguished in time, such a fire could escalate into fire of the lubricating system.

The probability of occurrence of such a fire is very small as compressors in hydrocarbon service are equipped with seals, including a back-up seal, and an instrumented alarm which operates when the primary seal fails. Only gross neglect can result in a fire.

A seal fire shall be addressed by tripping the compressor and by extinguishing the fire with dry chemical or steam. The objective of the fire-water monitor is to provide cooling to the equipment during the period while the compressor is running down and the fuel supply to the fire is being shut off.

The fire risk rating is LOW.

5.2.2.2 Deviations / options

If loss of a non-spared compressor would have serious consequences for the continued operation of the plant it may be considered to maximize the protection on the unit with the objective to reduce the probability of losing the compressor for mechanical or fire reasons.

Shaft seal systems remain the most vulnerable component of compressors. Given proper care during design, maintenance and operation seal systems are reliable. In case of too high a failure rate, resulting in too frequent loss of containment via the defective seal, it may be considered to provide fire or gas detection (whichever is the more appropriate considering the process conditions) in the seal area or alternatively to provide better seals.

If the product supply to a compressor cannot be isolated under fire emergency conditions it shall be considered to provide in the suction either an ROV or an additional manual valve accessible under fire conditions.

If compressors are installed in enclosures and access for manual fire-fighting operation is limited it shall be considered to install a water spray system. If the situation is very congested, which could quickly lead to escalation, it shall be considered to install an automatic water spray system and to provide fire and gas detection.

If centrifugal compressors are located in the open air or where access for manual fire-fighting operation is good, it shall be considered to provide exposure protection by means of water monitors rather than a more expensive water spray system.

For compressors with sophisticated shaft seal systems and a consequently very low probability of seal fires, it shall be considered to provide one fire detection system covering all seals.

For compressors with sophisticated shaft seal systems and a consequently very low probability of release of product via the seal, a point gas detection system should not be installed. For compressors in enclosures it shall be considered to provide an area gas detection system only.

5.2.3 Gas turbines

5.2.3.1 Standard arrangement

The majority of **gas turbines** are not spared for economic reasons, have a dedicated lubricating system with back-up for the entire unit, are equipped with equipment performance monitoring equipment, are equipped with an emergency shutdown system, are located in a tight, mechanically ventilated, noise-abating enclosure and are not accessible for fire-fighting operations.

The fuel supply to the installation is stopped when the turbine is tripped. The fuel supply station is often located inside the turbine enclosure. Large lubricating oil tanks form part of the foundation of the turbine installation. In case of a fire the luboil supply has to be kept in operation to prevent irrepairable damage to the turbine. The luboil system contains the major quantity of flammable product in the installation. The main fire hazard is a luboil leak resulting in a pool fire or a luboil jet projecting onto the uninsulated hot turbine surface.

Although the residual fire hazard for a well-operated gas turbine installation is low, the consequences of losing the installation are serious. Fire protection shall therefore be provided focusing on detection of fire and gas inside the enclosure and on a gaseous extinguishing system.

The fire risk rating is VERY LOW.

5.2.3.2 Deviations / options

If the gas turbine is located in the open air and access for manual fire-fighting operation is good it is recommended to provide exposure protection by means of water monitors only. Fire and gas detection is then not required.

The fire risk rating improves when the fuel supply station is located outside the turbine enclosure.

If the gas turbine can also run on a liquid fuel, the possibility of a pool fire of this fuel shall be considered.

5.2.4 Steam turbines

5.2.4.1 Standard arrangement

The majority of **steam turbines** are not spared for economic reasons, have a dedicated lubricating system with back-up for the entire unit, are equipped with equipment performance monitoring equipment, are equipped with an emergency shutdown system, are located in a naturally ventilated "compressor house" and are not accessible for fire-fighting operations.

Large lubricating oil skids form part of the turbine installation. In case of a fire the luboil supply has to be kept in operation to prevent irrepairable damage to the turbine. The luboil system contains the major quantity of flammable product in the installation. The main fire hazard is a luboil leak resulting in a pool fire, a luboil jet projecting onto an uninsulated part of the hot turbine surface or autoignition of luboil-soaked insulation.

Although the fire hazard for a well-operated steam turbine installation is very low, the consequences of losing the installation are serious. Fire protection shall therefore be provided focusing on detection of fire and exposure protection of the luboil skid.

The fire risk rating is VERY LOW.

5.2.4.2 Deviations / options

If the steam turbine is located in the open air and access for manual fire-fighting operation is good, it is recommended to provide exposure protection by means of water monitors only. Fire detection is only required when the likelihood of early detection of a fire by personnel is low.

5.2.5 Turbo expanders

Turbo expanders are generally not spared for economic reasons, and share a luboil system and an emergency shutdown system with the other power recovery elements (compressor, steam turbine) in the installation. They are equipped with performance monitoring facilities, are equipped with an emergency shutdown system, are located in a tight, mechanically ventilated enclosure and are not accessible for fire fighting operations. The main fire hazard is a luboil leak resulting in a pool fire or a luboil jet projecting onto the uninsulated hot expander casing.

Fire protection shall be provided focusing on detection of fire inside the enclosure and on a gaseous extinguishing system. Because of the possible presence of carbon monoxide gas inside the enclosure, appropriate gas detection shall be considered to protect personnel entering the enclosure.

Although the residual fire hazard for a well-operated installation is low, the financial consequences of losing it are serious.

The fire risk rating is VERY LOW.

5.3 FIRE SAFETY FACILITIES FOR FIRED EQUIPMENT

5.3.1 Furnaces

5.3.1.1 Standard arrangement

Area classification and sound safety distance criteria determine the location of furnaces and their air intake. Advanced burner safeguarding prevents release of unburnt fuel into the combustion chamber. Optimum selection of the material of furnace piping reduces the probability of tube bursts.

The main fire hazard to be considered for a furnace is a tube burst.

Furnaces shall be provided with a system of smothering steam lines to control fires inside the furnace. Separate smothering steam lines, operable from a safe distance from the hazard, are to be installed in each radiant section of heaters, in individual header boxes and in the air duct downstream of the damper or air preheater.

To protect fired equipment against the effect of an external pool fire, the steel supporting structures shall be fireproofed. The fire will be extinguished by manual fire-fighting action.

The fire risk rating is LOW.

5.3.1.2 Deviations / options

If only gaseous fuels are burnt in the furnace and gaseous hydrocarbons are heated in the furnace tubes it can be considered to delete the fire proofing of the supporting structure. In case of gas-only fired furnaces the smothering steam to the air ducting can be omitted.

5.3.2 Steam boilers

5.3.2.1 Standard arrangement

Area classification and sound safety distance criteria determine the location of boilers and their air intake. Advanced burner safeguarding prevents release of unburnt fuel into the combustion chamber.

Boilers shall be provided with a system of smothering steam lines to control the fires inside the air duct downstream of the damper or air preheater.

To protect fired equipment against the effect of an external pool fire, the steel supporting structures shall be fireproofed. The fire will be extinguished by manual fire-fighting action.

The fire risk rating is VERY LOW.

5.3.2.2 Deviations / options

If only gaseous fuels are burnt in the boiler it can be considered to delete the fire proofing of the supporting structure and to delete the smothering steam to the air ducting.

5.4 FIRE SAFETY FACILITIES FOR STATIC EQUIPMENT

5.4.1 Columns and vessels

5.4.1.1 Standard arrangement

Columns and vessels are designed according to well-proven codes. Piping is subjected to stress calculations and is generally connected to this type of equipment by means of flanges. Level instrumentation often obviates the need for level glasses. The vessels are protected against overpressure. Emergency depressuring facilities are provided if the vessels normally hold a liquid volume of more than 5 m^3 of butane and lighter products. Vessels in vacuum service are equipped with steam supply lines to break the vacuum.

The fire hazard to be considered for vessels is an external pool fire which may weaken the supporting structure of the vessel as well as the vessel itself. The pool fire could damage a level glass, resulting in escalation.

Supporting structures for vessels and columns shall be fire proofed. Exposure protection systems shall be provided for all non-fire proofed sections of columns and vessels normally holding a liquid volume of more than 5 m^3 of butane and lighter products. The area to be wetted typically extends to 9 m above the hazard level, subject to HCM.

The fire risk rating is LOW.

5.4.1.2 Deviations / options

Escalation as a result of damage to level glasses can be reduced by installing blow-out preventers in the glasses or by using magnetic type level gauges instead.

If the formation of a pool fire near or under the vessel is unlikely as a result of the slope of the plant floor, it can be considered to provide general exposure protection by means of fire-water monitors.

For congested areas where water monitors may be less effective in providing adequate exposure protection, water spray systems shall be installed.

5.4.2 Heat exchangers

Heat exchangers are designed according to well-proven codes. Piping is subjected to stress calculations and is connected to this type of equipment by means of flanges. Individual exchangers are only protected against thermal over-pressure.

5.4.2.1 Standard arrangement for steel heat exchangers

This type of heat exchanger is located on grade or in a process structure and usually operates at elevated temperatures.

The fire hazard to be considered for this type of equipment is an external pool fire which may weaken the supporting structure and the exchanger itself. The pool fire could affect the tightness of the many flanged connections thus causing escalation.

The supporting structure shall be fire proofed as per DEP 34.19.20.11-Gen.

Exposure protection shall be provided for all heat exchangers holding a liquid volume of more than 5 m^3 of butane and lighter products.

Flanges around heat exchangers containing hydrogen-rich products above auto-ignition temperature such as those found in hydro-processing units are further protected by permanently installed steam rings which are manually activated in case a flange leak develops.

The fire risk rating is VERY LOW.

5.4.2.1.1 Deviations / options

In case the formation of a pool fire near or under the heat exchanger is unlikely as a result of the grading of the plant floor it can be considered to provide general exposure protection by means of fire-water monitors only.

For congested areas where water monitors may be less effective in providing adequate exposure protection, water spray systems shall be installed.

5.4.2.2 Standard arrangement for aluminium heat exchangers

This type of heat exchanger is located on grade or in a process structure and operates at ambient and cryogenic temperatures.

The fire hazards to be considered for this type of equipment are pool fires and jet fires. Both types of fires may very quickly damage the exchanger itself. The pool fire may also weaken the supporting structure and could affect the tightness of the many flanged connections, thus causing escalation.

The supporting structure shall be fire proofed as per DEP 34.19.20.11-Gen.

Because of their vulnerability to flame contact, exposure protection shall be provided for all heat exchangers irrespective of the volume they hold. Passive fire protection shall be applied on the sections of the heat exchanger which are affected by the pool fire and on the sections which can be affected by a jet fire. Active fire protection measures shall be provided for the other sections of the exchanger.

The fire risk rating is LOW.

5.4.2.2.1 Deviations / options

Due to the service this type of equipment is used for, cryogenic-type insulation is normally provided. As insulation may also have fire protection properties, the actual fire protection measures may be relaxed to some extent.

In case the formation of a pool fire near or under the heat exchanger is unlikely as a result of the grading of the plant floor it can be considered to provide active fire protection only.

For congested areas where water monitors may be less effective in providing adequate exposure protection, water spray systems shall be installed.

5.4.2.3 Standard arrangement for air-cooled heat exchangers

This type of heat exchanger is located at higher elevations beyond the reach of pool fire flames. It operates at moderate to high temperatures.

The fire hazard to be considered for this type of equipment is an external pool fire which may weaken the supporting structure of the exchanger itself.

The supporting structure shall be fire proofed. This applies to all heat exchangers containing more than 1 tonne of flammable product or having a total mass exceeding 2.5 tonnes.

Flanges around heat exchangers containing hydrogen-rich product above auto-ignition temperature such as those found in hydro-processing units are further protected by permanently installed steamrings which are manually activated in case a flange leak develops.

The fire risk rating is LOW.

5.4.2.3.1 Deviations / options

In case the formation of a pool fire near or under the supporting structure of the heat exchanger is unlikely as a result of the grading of the plant floor it can be considered to provide general exposure protection by means of fire-water monitors.

5.4.3 Slug catcher areas

5.4.3.1 Standard arrangement

NGLs may collect at the lower end of slugcatchers. Slugcatchers are equipped with remotely operable inlet and outlet valves and a low-rate manual depressuring valve. The liquid collection header is equipped with level glasses. A level control valve maintains a level in the header.

The fire hazard to be considered is an ignited liquid release from a flange connection. Escalation can take place when level glasses are damaged.

General exposure protection measures in the form of fire-water monitors able to cover the entire slugcatcher shall be provided.

The fire risk rating is LOW.

5.4.3.2 Deviations / options

Escalation as a result of damage to level glasses can be reduced by installing blow-out preventers in the glasses or by installing magnetic type level gauges.

If the low end of the slug catcher is installed in a pit below grade, gas detection shall be installed inside the pit to provide early warning of loss of containment.

5.5 FIRE SAFETY FACILITIES FOR PRESSURISED STORAGE VESSELS AND STORAGE TANKS

5.5.1 Pressurised storage vessels

5.5.1.1 General

Pressurised storage vessels (spheres, bullets) normally holding a liquid volume of more than 5 m^3 butane or lighter products shall be protected against radiation from a fire on the storage vessel itself or from a fire in the close vicinity of the vessel, thus minimising the probability of an ensuing BLEVE.

Quantitative Risk Assessment studies have shown that a mounded storage vessel constitutes a considerably lower risk of being involved in a BLEVE than an above ground storage vessel equipped with a conventional active protection system. Mounded storage is therefore the preferred option.

5.5.1.2 Above ground storage vessels - standard arrangement

Above ground pressurised storage vessels (spheres, bullets) normally holding a liquid volume of more than 5 m^3 butane or lighter products are not equipped with emergency depressuring facilities, have no flanged connections below the liquid level in the vessel, are equipped with a remotely operable isolating valve in the bottom outlet line, have redundant level instruments and redundant level alarms. They are equipped with an overfill relief valve venting to safe location and a fire relief valve venting via a tailpipe to atmosphere. The vessels are located on a well compacted and smooth sloping floor to minimise the probability of having a pool fire underneath the vessel. The area lay-out enhances natural ventilation. Fire and gas detection and manually activated water spray systems are provided.

The fire hazards to be considered are ignition at the outlet of a tailpipe of a passing relief valve and ignition of a leak from a flange connection on top of the vessel. The probability of both incidents is considered low. A fire originating from adjacent areas may be possible, depending on the situation. Normally applied safety distances minimise the effect of such a fire on the vessel.

The fire and gas detection focuses on leaks and fires around the flange connections and tailpipes on top of the vessel. In case of a tailpipe or flange fire the water spray system shall be activated to protect the vessel from overheating. Manual fire-fighting actions are required to extinguish the fire.

The fire risk rating is VERY LOW.

5.5.1.3 Deviations / options

In tropical areas the likelihood of collecting a pool of LPG and having pool fires underneath the vessel, caused by a leak of the vessel concerned, is insignificant. It can therefore be considered to delete the sloping floor and the liquid collecting trench.

For stand-alone pressurised storage vessels in tropical climates it can be considered to delete the bottom half of the water spray system.

For storage vessels with potential leak sources on the bottom side of the vessel it shall be considered to provide gas detection near the source and to provide water spray nozzles at the potential leak source, which are able to quickly dilute leaking product to below the lower flammable limit.

It shall be considered to provide exposure protection by means of water monitors rather than a more expensive water spray system. The monitors shall cover all areas to be protected at the same time. Water to the monitors shall be supplied via an easily operable common valve.

If the relief valve outlets are piped to a remote safe location and an ignited release has no noticeable effect on the vessel itself it shall be considered to delete the top half of the water spray system. Due to potential leaks from the flange connections on top of the vessel it shall be considered to provide gas detection near the potential leak source and water spray nozzles aimed at the flange connection, which are able to dilute leaking product to below the lower flammable limit.

If local regulations do not accept exposure protection by means of water, then passive fire protection shall be applied.

It may be considered to delete the gas and fire detection facilities from the standard arrangement. The level of safety without these instruments can be considered adequate.

5.5.1.4 Mounded storage vessels - standard arrangement

Mounded pressurised storage vessels, normally containing a liquid volume of more than 5 m^3 butane or lighter products, are not equipped with emergency depressuring valves, have no flanged connections below the liquid level in the vessel and are equipped with a submerged pump mounted in a well. They have redundant level instruments and level alarms. They are equipped with an overfill relief valve venting to safe location and a fire relief valve venting via a tailpipe to atmosphere. They are entirely covered with soil except for the part of the dome and pump-well which protrude through the mound and except for appurtenances. The mound is protected against erosion. Fire and gas detection is provided. A manually activated water spray system shall be provided to protect the exposed parts from overheating.

The fire hazards to be considered are ignition at the outlet of a tailpipe of a passing relief valve and ignition of a leak of a flange connection on top of the vessel. The probability of both incidents is considered low. A fire originating in adjacent areas may be possible, but is not expected to have an effect on the storage vessel.

The fire and gas detection focuses on leaks and fires around the flange connections and tailpipes on top of the vessel. In case of a tailpipe or flange fire the mound protects the vessel from overheating. The water spray system shall be activated to protect the exposed parts from overheating. Manual fire-fighting actions are required to extinguish the fire.

The fire risk rating is VERY LOW.

5.5.1.5 Deviations / options

Consider to delete the gas and fire detection facilities from the standard arrangement. The level of safety without these instruments can be considered adequate.

5.5.2 Fixed roof storage tanks

5.5.2.1 Standard arrangement

Fixed roof tanks are normally used to store Class II (1), Class III (1), Class III (2) and Unclassified products. IP intertank spacing criteria are applied. Tanks storing Class III (2) and lighter products are located in a bund with adequate capacity. Separate High-High level alarms are installed to prevent overfill. The vapour space is not inerted and vents to the atmosphere via a P-V valve.

For tanks over 15 m in diameter and height storing Class II (1) or Class III (2) products, foam extinguishing systems are installed. Fires on smaller tanks shall be extinguished using the available mobile equipment.

For tanks up to 40 m in diameter storing Class III (1) and Unclassified products no fixed foam extinguishing systems are installed. For these products, the risk of ignition is low, due to the low product volatility. Should the tank catch fire it shall be extinguished using the available mobile equipment.

Fixed roof tanks over 40 m in diameter storing Class III (1) and Unclassified product are equipped with fixed foam extinguishing systems as there is in the Industry no hard evidence that full surface fires in tanks with such a diameter or larger can be successfully extinguished with mobile equipment.

Tanks containing non-water miscible products shall be equipped with a subsurface foam injection system. Subsurface foam injection systems are not suitable for products having a viscosity above 100 mm^2 (cSt), an operating temperature above 95 °C and Class 1A products (NFPA classification).

Tanks containing polar and/or water miscible flammable products shall be provided with a semi-subsurface foam injection system.

A tank fire which lasts too long may escalate to neighbouring tanks. Depending on the outcome of HCM calculations, exposure protection against heat radiation from fires in adjacent areas may have to be provided.

The fire hazard for a fixed roof tank is an internal explosion, resulting in damage to the roof and escalating into a full surface fire.

The fire risk rating is MEDIUM.

5.5.2.2 Deviations / options

The overall safety of a fixed roof tank can be increased considerably by inerting the vapour space or by vapour balancing with other tanks, thus avoiding pulling in air via the P-V valve when emptying the tank.

If there is poor availability of fire fighting manpower, or a slow response time of the fire brigade, or limited capabilities of the fire brigade, or poor accessibility for fire-fighting operations, it shall be considered also to provide foam systems for tanks smaller than those stated in (5.5.2.1).

In case of excellent fire fighting manpower availability, a good response time of the fire brigade, excellent capabilities of the fire brigade or good accessibility for fire-fighting operations, it shall be considered to rely on extinguishing the fire with mobile equipment and not to install fixed foam extinguishing systems.

5.5.3 Fixed roof tanks equipped with an internal floating cover

5.5.3.1 Standard arrangement

Conventional fixed roof tanks in flammable product service can be equipped with an internal floating cover to reduce excessive vapour emissions.

As the seal of the floating cover is not 100 percent efficient, some hydrocarbons will still enter the space above the floater. Depending on the flash point of the stored product and the prevailing temperature, a vapour/air mixture can be formed in the space.

A variety of types of floating covers can be applied. The non-ferrous types have little resistance to fire. The steel versions stay intact for a longer period under fire exposure.

The fire hazard for this type of tank is an explosion in the space above the floater, resulting in damage to the floater and further escalation into a fire of the non-covered surface of the tank contents.

Because of the uncertain failure mode of the floating cover, this type of tank in general has to be equipped with topside foam application (to extinguish a fire in the event that the floating cover stays virtually intact and afloat) **and** a subsurface foam injection system (to extinguish a fire in case the floating cover partly sinks or disintegrates).

From a fire safety point of view this type of tank is undesirable.

The fire risk rating is MEDIUM.

5.5.3.2 Deviations / options

For tanks with steel floaters equipped with separate sealed floatation compartments, the probability of sinking of the roof is very low, assuming the mechanical inspection schedules are adhered to. In this case it shall be considered to delete the subsurface foam injection system.

To avoid the mixture being in the flammable range, the vapour space can be made free-venting above the floater. The objective is to permanently dilute the mixture to below the lower flammable limit (LFL). The potential for an explosion in the space above the cover is low.

By closing the space and venting it via P-V valves, emissions are reduced further. Depending on flash point of the stored product and the prevailing temperature the vapour/air mixture in the space above the floating cover may frequently pass through the flammable range. The potential for an explosion in the space above the floater is high.

By closing the space and venting it via vapour balancing/recovery systems the vapour in the space is in general always above the upper flammable limit (UFL). Note that with this configuration precautions shall be taken to prevent migration of a fire in one part of the balancing system to an other part. The potential for an explosion in the space above the cover is low.

5.5.4 Floating roof tanks

5.5.4.1 Standard arrangement

Floating roof tanks are normally used to store Class I and Class II (2) products. Intertank spacing according to the IP Code is applied. Tanks storing these products are located in a bund with adequate capacity. Separate High-High level alarms are installed to prevent overfill. Flame retardant rim seals are used. The floating roof is either of the single deck, pontoon type design or of the double deck design. Stainless steel shunt contacts are fitted for earthing the floating roof across the rim space.

Because of the low risk of failure of floating roof tanks, only a fire in the rim seal area shall be considered. Tanks are thus only equipped with a heat detection system in the rim seal area, a foam dam on the roof and foam pourers around the circumference of the tank. Foam solution to the foam pourers is supplied by fire trucks.

A fire in an adjacent area which lasts too long may escalate to the floating roof tank. Depending on the outcome of HCM calculations, exposure protection against heat radiation from fires in adjacent areas may have to be provided.

The fire hazard for a floating roof tank is a rim seal fire.

The fire risk rating is VERY LOW.

5.5.4.2 Deviations / options

For tanks in waxy service the tank wall may become coated with a layer of wax, depending on the pour point of the stored product and the prevailing ambient temperature. A seal fire could then escalate into a brief but intense wall fire. Provided prompt fire-fighting action takes place escalation is unlikely. The best protection against this type of incident is to prevent the formation of a wax layer by externally insulating the tank wall.

Secondary seals reduce vapour emissions and improve the fire risk rating of the tank even further.

For tanks not equipped with fire retardant seals, a seal fire could quickly escalate to the entire seal area. Prompt fire-fighting action is required.

In case of good fire fighting manpower availability, prompt response of the fire brigade, good accessibility for fire-fighting operations and good capabilities of the fire brigade, it shall be considered to provide only one foam pourer near the access stairs platform at wind girder level equipped with two hose connections. Seal fires beyond the reach of the foam pourer shall be extinguished by manual foam application.

If no firetrucks are available or if the foam generating capacity of the truck is inadequate or if fire-fighting manpower is not quickly available, a foam station shall be provided.

Tanks equipped with a one-shot extinguishing system (e.g. a modular foam extinguishing system or a BCF-type extinguishing system) only, are not considered adequately protected. The standard foam pourer system remains required for these tank to achieve an acceptable level of protection.

5.5.5 Atmospheric refrigerated liquefied gas storage tanks

5.5.5.1 Standard arrangement

This type of refrigerated storage tanks are of the full containment type with top entry of all connections and a concrete roof. A number of relief valves vent via a tailpipe to the atmosphere. In the pump discharge manifold there are a number of valve glands and flanged connections. There is a grated floor underneath the manifold. The tank is protected against over- and under-pressure. There are a number of point gas detectors in the manifold area. Delicate equipment, (e.g. pilot-operated relief valves) which can be exposed to high radiation is equipped with an automatic water spray system.

The fire hazard for such a tank is the ignited discharge of the tail pipe of a failed open relief valve. The radiation will in time result in damage to adjacent relief valves. Tail pipes are provided with inert gas connections, operable from a safe distance, to extinguish the fire.

The fire risk rating is VERY LOW.

5.5.5.2 Deviations / options

For tanks with steel roofs and no concrete protection, a full surface fire shall be considered. Depending on the inter-tank spacing and HCM results, exposure protection against heat radiation from fires on adjacent tanks may have to be provided.

LNG and NGL storage tank fires are unlikely due to the inherent safety of the tank design. If they do occur they cannot be extinguished due to the intensity of the fire and consequently a complete burn-out of the tank has to be accepted. Successful attempts to extinguish such a fire will result in a cloud of flammable vapour which is considered a greater hazard than the tank fire itself.

5.6 FIRE SAFETY FACILITIES FOR MISCELLANEOUS EQUIPMENT

5.6.1 Pipe racks and pipe tracks

Precautions shall be taken only in locations in pipe racks and pipe tracks where equipment is installed which could possibly cause spills or fires. In such a case it shall be considered to install spill walls which direct the spill away to a safe area. For refrigerated gases directing the spill to a containment area equipped with a medium expansion foam system shall be considered.

Pipe racks shall be fireproofed if a sustained pool fire is considered possible. The objective is to maintain the mechanical integrity of the pipe rack, thereby continuing to provide proper support for the pipelines in it.

The fire risk rating is VERY LOW.

5.6.2 Off-site pump stations

Off-site pump stations in storage areas are normally unmanned. A wide variety of products is transferred with these pumps. Quantities and pressure can be quite high. In the majority of cases the pumps are spared. Pumps are in general of conventional design. Experience shows that pumps frequently subjected to starting and stopping are less reliable and more often experience seal and bearing damage. Drain sumps shall be provided with high level alarms.

In addition to the fire and gas detection recommendations of (5.2.1) it shall be considered to install CCTV.

In view of the low probability of escalation of a fire to adjacent equipment and the good accessibility fire-water monitors shall be provided in the area. Two separate monitors, each fed from an other branch of the fire-water mains, should each be able to cover the pumps.

The fire risk rating is LOW to MEDIUM.

5.6.3 Effluent treatment areas

In this area some equipment contains appreciable quantities of heavy hydrocarbons. The area is normally manned.

Installation of strategically located fire-water monitors able to cover the equipment concerned shall be considered.

A wheeled foam cart and portable dry chemical extinguishers shall be provided.

The fire risk rating is VERY LOW.

5.6.4 LPG bottling facilities

LPG bottling facilities shall be laid out such that adequate ventilation is obtained. They shall be equipped with gas detection facilities. The installation shall be shut down automatically on confirmed detection of gas or on loss of the ventilation system.

To prevent damage, all delicate equipment shall be water sprayed. The water spray system shall be activated by gas detection, by fire detection and manually.

Portable dry chemical fire extinguishers shall be provided in and around the area.

All fire and smoke detection systems shall be connected to the central fire alarm system.

The fire risk rating is MEDIUM.

5.7 FIRE SAFETY FACILITIES FOR LOADING AREAS

5.7.1 Rail car loading facilities

5.7.1.1 Standard arrangement

Loading facilities for railcars used for transportation of flammable liquid hydrocarbons are equipped with top loading via arms, no vapour return, an interlocking system preventing loading/unloading while the cars are moving, an interlocking system preventing loading/unloading operations when the earthing cable is not connected and an Emergency Shutdown System. It is a manned-only operation and the tankers are filled by volume or weight. The facility is equipped with an automatic water spray system covering the tanker concerned plus half of each adjacent tanker.

The fire hazard for such a facility is ignition of spilled product as a result of overfilling and ignition of a vapour cloud.

In view of the variety of rail tankers and products and the frequency of coupling and uncoupling operations the probability of occurrence of a spill/fire is quite high.

Depending on the product the fire can be extinguished with water, dry chemical or foam.

The fire risk rating is MEDIUM to HIGH.

5.7.1.2 Deviations / options

The possibility of fire caused by release of vapour from the railcar vent is small when systems are equipped with vapour return facilities.

The possibility of fire caused by overfill is small when systems are equipped with bottom loading.

For systems using loading hoses the increased probability of spilling product due to hose failure or mishandling shall be taken into consideration. A spill containment area and foam system shall be considered.

5.7.2 Road car loading facilities

5.7.2.1 Standard arrangement

Loading facilities for road cars used for transportation of flammable liquid hydrocarbons are equipped with bottom loading via arms with dry-break couplings, vapour return, an interlocking system preventing loading/unloading while the cars are moving, an interlocking system preventing loading/unloading operations when the earthing cable is not connected and an Emergency Shutdown System. It is a manned-only operation and the tankers are filled by volume or weight. The facility is protected by an automatic non-aspirated AFFF foam spray system covering the floor under the vehicle, the tanker itself plus the adjacent tanker on either side. When all personnel are safe, the foam supply is switched off and the spray system can continue to operate as a water spray system.

The majority of personnel in this area are non-Company personnel who are commissioned to carry out most routine operations without Company supervision.

The fire hazard for such a facility is ignition of spilled product (e.g. as a result of overfilling).

In view of the variety of road tankers and products, the presence of ignition sources in the form of vehicles and the frequency of coupling and uncoupling operations, the probability of occurrence of a spill/fire is quite high. For this type of area the probability of failure of the product transfer equipment is relatively high. The probability of non-Company personnel present in the area is high. The foam system is provided to reduce the probability of injury to personnel.

Depending on the product the fire can be extinguished with water, dry chemical or foam.

The fire risk hazard rating is MEDIUM to HIGH.

5.7.2.2 Deviations / options

For systems not equipped with a vapour return, the extent of the emitted vapour cloud shall be taken into consideration when determining the lay-out of the overall situation and control of potential ignition sources.

For systems not equipped with bottom loading, the likelihood of overfill increases and the overall hazard rating becomes worse.

For systems using loading hoses, the increased probability of spilling product due to hose failure or mishandling shall be taken into consideration. A spill containment area and foam system shall be considered.

The purpose of the automatic AFFF foam spray system is to knock down flames quickly enabling personnel to escape to a safe area. Actual fire-fighting requires more resources. If no fire trucks are available, or if the foam generating capacity of the truck is inadequate or if fire-fighting manpower is not quickly available, a foam station shall be installed providing extended foam supply to the spray system and feeding low expansion foam to strategically located foam monitors.

5.7.3 Jetty terminals

5.7.3.1 General

For the majority of plants, jetties are the main import and export facility for their feedstock and products. Fire incidents at jetties may have a serious impact on the operations of the plant, in particular when the jetty is frequently used and if there are no alternative import and export facilities.

Incidents can originate at the jetty itself, at the ship-shore interface or on board a ship moored to the jetty.

Strict adherence to procedures on all marine and transfer operations is imperative to ensure a continued safe situation of the jetty facilities.

If the jetty is part of a plant, the plant water ring mains system shall be of sufficient capacity to cope with the water demand of the jetty.

If the jetty is located in an area where a fire-water ring mains system is not available, the jetty shall be equipped with its own fire-water system in accordance with (Section 3).

Because access for fire-fighting vehicles to the jetty head is not considered safe and since fast escape of fire fighters in case of escalation may be difficult, jetties are often equipped with fixed fire protection and fire-fighting systems.

Adequate fire protection shall be provided for the jetty and all its equipment against a major fire which may occur on the jetty, or against a fire in the ship's manifold at berth against the jetty.

The protection facilities shall also be designed to protect the directly exposed areas of a ship at berth against a fire on the jetty.

Ships are normally equipped with protection facilities to cope with a major on-board fire. The jetty fire protection facilities therefore need only provide assistance to the ship at berth when requested by the master of the ship or his representative.

Assistance should include:

- the ability to provide the ship's fire-water system with water through an International Shore Fire Connection according to ISGOTT.
- the ability to cool the ship's manifold.
- the ability to provide exposure protection for the ship's crew, e.g. when disconnecting hoses or loading arms under fire emergency conditions.
- the ability to provide exposure protection to the gangway and to the ship's crew when using the gangway to escape from the ship.

5.7.3.2 Standard arrangement for jetty facilities

Jetty structures are generally of a design which provides a high degree of passive protection against fire. During transfer operations the jetty is manned and the jetty operator is in direct contact with the responsible ship's personnel. Transfers take place via loading arms equipped with extension alarms. The shore isolation valves are of the fire safe design and are located as close as possible to the loading arms. All hydrocarbon lines are provided with isolation valves that are safely accessible under jetty head fire conditions and are positioned such that they are unlikely to be in collision with a ship that may have broken away. The drain sump on the jetty contains minor quantities of hydrocarbons.

5.7.3.3 Standard arrangement for fire on the jetty

For a fire on a jetty a number of water monitors are installed, fed via a normally dry supply line. They are directed and adjusted such that the entire manifold area and other process equipment can be wetted by opening the single valve to the dry header. A water spray system is installed to wet the static part of the loading arms.

The fire hazard on a jetty is ignition of leakage of hydrocarbon from a pipe component or a fire in the drain sump.

The probability of occurrence of a jetty fire is very low.

The fire risk rating is LOW.

5.7.3.4 Standard jetty arrangement for a fire on the ship

For a fire on a ship a number of water monitors fed via a normally dry supply line are located, directed and adjusted such that the entire manifold area can be wetted by opening the single valve to the dry header. A water spray system is installed to wet the static part of the loading arms. In case assistance is required by the ship, one or more of the monitors can be directed to the area to be protected, e.g. the ship's manifold and gangway, leaving sufficient protection for the jetty facilities.

The fire hazard on a ship is ignition of leakage of hydrocarbon from a pipe component in the ship's manifold area.

The probability of occurrence of a ship fire is very low.

The fire risk rating is LOW.

5.7.3.5 Deviations / options

For wooden jetties or jetties supported on non-fireproofed piles, active exposure protection shall be applied against a spill fire on the water, the objective being to maintain the integrity of the jetty structure.

In case of unmanned operation of the jetty, additional instrumented supervision, in the form of CCTV, as well as additional gas and fire detection, shall be considered.

If transfer facilities are equipped with an ESD system, the flow feeding the fire can be isolated easier and quicker, resulting in a smaller fire. The ESD system shall be of a fire safe design and operable from a safe location on the jetty, from the ship and from the control centre.

If the open drain sump is located under hydrocarbon-containing equipment, a water spray system covering the pit shall be considered.

When using loading hoses the probability of loss of containment is increased. A hydrocarbon spill on the water, jetty deck or ship's deck is more likely. Fire proofing or exposure protection of the hose gantry shall be considered to maintain its mechanical integrity under fire conditions underneath.

In cases where loss of the jetty would have a dramatic impact on the import and export capacity of the plant it shall be considered to increase the extent of the fire safety measures.

5.7.3.6 Jetty fire protection facilities

5.7.3.6.1 Standard arrangement

A single fire-water pipeline is installed along the jetty approach up to the jetty head. This pipeline is equipped with two-way hydrants spaced along the approach and with four-way hydrants on the jetty head. One of the four-way hydrants, located near the gangway, is provided with the required International shore fire connection according to ISGOTT.

Two four-way water hydrants shall be provided at the parking space near the approach to the jetty. They shall be connected to the fire-water main system in order to supply the fire-fighting vehicles if these have to back-up the jetty systems.

A subheader of the fire-water line supplies water to the fixed, manually-operated and adjustable water monitors, fitted with jet/fog nozzles, installed on the jetty head. The inlet valve to each water monitor shall be in the normally open position. Water to this header is supplied via a block valve remotely operable from the jetty control room, from the jetty approach on shore and from the nominated control room. Appropriate measures shall be taken to assure operation under all conditions, particularly in climates where freezing can occur.

An automatic water spray systems on the static part of the loading arms is supplied from the fire-water line and is equipped with a strainer and a remotely operated isolating valve. Systems with a small number of spray heads may be combined into a single system to reduce the number of water spray valves.

The required water rate for the overall jetty systems depends on a large number of variables but is mainly determined by the expected size and duration of a fire, including the amount of water required to avert the potential damage caused by that fire. The maximum water requirements shall be based on the maximum number of systems which may be required to operate simultaneously.

If a sustained fire is possible at the jetty, the fire may have to be extinguished by using foam.

Deck-mounted foam monitors, pre-directed to cover the entire jetty manifold area and able to apply foam gently, shall then be considered. Depending on the accessibility under manifold fire conditions the monitors may have to be fed via a dry solution line.

The foam solution shall be provided by fire fighting vehicles and should be able to reach all foam monitors within 2 minutes after the vehicles start pumping foam solution into the header. Measures shall be taken to avoid hydraulic shock when the dry line is being filled.

A parking space for two fire-fighting vehicles and one foam compound carrier shall be provided on the shore at the approach to the jetty, near to the dry foam solution line manifold.

If there are no fire boats available in the port that are able to throw sufficient foam onto the ship's deck it shall be considered to provide a foam monitor with a capacity of 240 m^3/h of foam solution.

The monitor shall be positioned at such an elevation that the ship's manifold area (at all water levels) facing the jetty head and the water between the jetty head and the ship can be covered with a foam blanket. Depending on the accessibility of the monitor under fire conditions at the ship's manifold, it may be required to make the monitor remotely operable, in which case it shall be electrically operated and remotely controlled from a safe location.

If a gantry tower is available, the foam monitor may be installed on this structure, otherwise a separate monitor tower should be provided if considered necessary.

Fire proofing or exposure protection of the gantry/monitor tower shall be considered to maintain its mechanical integrity under fire conditions underneath.

Portable and mobile dry chemical and foam extinguishing equipment shall be provided.

5.7.3.6.2 Deviations / options

If adequate coverage of the gangway or the ship's manifold area cannot be achieved with the fixed monitors normally directed at the jetty manifold, it shall be considered to provide dedicated monitors. These may have to be installed at an elevated position and shall be provided with an adjustable nozzle which, for this situation, should be normally in the spray mode and not in the jet mode. If they are not easily accessible, remote actuation and operation may have to be considered.

If water monitors can be positioned such that they will be able to wet all sides of the static part of the loading arms adequately, it may be considered not to install the water spray system for the loading arms .

If the foam cannot be provided by fire trucks because of distance or slow response, a dedicated foam system shall be provided. A foam station located at a safe location feeding the monitors via the dry solution line shall then be considered. In this case a pipeline shall be installed for refilling the foam station storage tank from the foam carrier.

The foam station shall be so designed and located that the foam solution will reach all foam monitors within 2 minutes after the station has been activated. For further details of the foam station and the dry solution pipeline, see DEP 80.47.10.31-Gen.

5.8 FIRE SAFETY FACILITIES FOR BUILDINGS

5.8.1 General

Buildings shall be designed in accordance with DEP 34.17.00.32-Gen.

The main objective of fire protection facilities in buildings is to protect the life and safety of the occupants. In general, local fire regulations include specific requirements.

The consequence for loss of business, the cost of replacement of equipment in the building and the cost of repair of fire damage shall also be considered when specifying fire protection systems.

Fire water shall be available close to and inside the building. In view of the relatively small quantities and low pressure requirement of fire-water for typical building fires, the potable water supply may be adequate. Both inside and outside the building fire-water hydrant connections shall be provided.

At strategic locations in hallways, corridors and other large spaces in buildings fire extinguishers or hose reels shall be provided. Clear instructions or pictograms shall be provided indicating which type of extinguishing agents is recommended for a particular purpose.

If required, fire call points of the 'break glass type' shall be provided. The call points shall be connected to the central fire alarm system and shall activate an evacuation alarm. The evacuation alarm shall be an audible signal and shall operate throughout the entire building.

The guidelines given in NFPA 101 shall be applied, unless local regulations are more stringent.

5.8.2 Plant buildings

5.8.2.1 Control rooms/control centres

Control rooms are normally manned continuously. Fires which may develop in the manned spaces will thus be discovered at an early stage.

Unnoticed fires in the unmanned parts of a control centre may damage equipment and/or instruments to such an extent that the operation and production of a plant may have to be interrupted for a considerable period of time required for the necessary repairs.

To safeguard plant operation it is therefore crucial that a rapid fire and smoke detection system is provided, allowing prompt intervention by personnel.

It shall be considered to install an ultra-sensitive smoke detection system in all normally unmanned critical areas such as the auxiliary rooms, computer and computer software rooms and all enclosed cabinets where hot spots could develop.

Heat detectors shall be considered for the battery room, laboratory areas and storage rooms.

Gas detectors shall be considered in or near the air inlet ducts to provide an early warning of ingress of flammable gas. On detection of gas the air intake shall be closed and the air handling system shall switch over to internal circulation.

For applications where spurious trips are not acceptable, automatic detection systems classified according to DEP 32.80.10.10-Gen. shall be applied.

The power supply arrangement to process control equipment shall be designed such that in the event of a fire or smoke formation, the individual control cabinets of the relevant systems can be electrically isolated.

If loss of the equipment in the space would have a severe impact on the continued operation of the plant installation a gaseous fire extinguishing system shall be considered.

All heat, smoke, and gas detection systems and automatically operated fire-fighting systems shall be connected to the central fire alarm system.

The fire risk rating is VERY LOW.

5.8.2.2 Field auxiliary rooms (FARs)

FARs are normally unmanned. Unnoticed fires in a FAR may damage equipment and/or instruments to such an extent that the operation and production of a plant may have to be interrupted for a considerable period of time required for the necessary repairs.

To safeguard plant operation it is therefore of utmost importance that a rapid fire and smoke detection system is provided, allowing prompt intervention by personnel. Installation of an ultra-sensitive smoke detection system in all critical spaces and installation of conventional smoke and fire detectors in the other spaces of the buildings shall be considered.

In cases where detection systems have a trip function and where spurious trips are not acceptable, automatic detection systems classified according to DEP 32.80.10.10-Gen. shall be applied.

The power supply arrangement to process control equipment shall be designed such that in the event of a fire or smoke formation, the control cabinets of the relevant systems can be electrically isolated.

If loss of the equipment in the space would have a severe impact on the continued operation of the plant installation of a gaseous fire extinguishing system shall be considered.

All heat, smoke, and gas detection systems and automatically operated gaseous fire-fighting systems shall be connected to the central fire alarm system.

The fire risk rating is VERY LOW.

5.8.2.3 Laboratories

For spaces in laboratory buildings which are not manned continuously, installation of conventional fire and smoke detection facilities shall be considered.

In hazardous areas, near the entrances to the laboratory and to storage and engine rooms and at each workbench, fire extinguishers shall be installed.

In addition, hose reels with 25 mm diameter hoses connected to the potable water system, shall be installed in the corridors, so that storage rooms, offices and laboratory areas will be well within reach of the water nozzles.

All fire and smoke detection systems shall be connected to the central fire alarm system.

The fire risk rating is LOW.

5.8.2.4 Analyser houses & Metering stations

Analyser houses and metering stations are normally unmanned. They may be located in or very close to hazardous plant areas and may contain equipment only suitable for non-hazardous areas. Sample preparation takes place in a well ventilated area adjacent to the enclosed area housing the analysers.

The ventilation air intake is located in a non-hazardous area. It provides a slight overpressure inside the enclosure. Enclosure exhaust intakes are located at floor and ceiling level thus sweeping heavier and lighter-than-air hydrocarbon vapours. The ventilation rate of the enclosure shall be adequate to prevent an explosive mixture inside the enclosure assuming full bore failure of the worst sample line (in terms of size, pressure and fluid).

Gas detectors are installed in the air intake. On confirmed detection of gas all non-Zone 1 electrical equipment inside the enclosure and the ventilation system are switched off.

Gas detection is also installed inside the enclosure. On confirmed detection of gas all non-Zone 1 electrical equipment is switched off. The ventilation system continues to operate.

Conventional smoke detection inside the enclosure has an alarm function only.

Near the entrances of the building carbon dioxide extinguishers shall be provided.

All gas and smoke detection systems shall be connected to the central fire alarm system.

The fire risk rating is LOW.

5.8.2.5 Switch houses / electrical sub-stations

These buildings are located in non-hazardous areas and (normally) contain conventional switch gear and cabling. Provided housekeeping is good, there are no combustible materials located in the buildings to cause a class A fire.

The likely fire scenario in this type of building is due to severe damage of switch gear as a result of a short circuit. In case there is a resultant fire, it is very small.

Malfunctioning of power supply will reveal itself via other indications.

Conventional smoke detection system which can provide information on overheating and fires inside the building shall be installed. The detection shall have an alarm function only.

Near the entrances of the building carbon dioxide extinguishers shall be provided. The smoke detection system shall be connected to the central fire alarm system.

The fire risk rating is VERY LOW.

Electronic equipment, such as Variable Speed Drive Systems, may be installed in the same space in the building. Unnoticed fires in the building may damage the equipment to such an extent that the operation and production of a plant has to be interrupted for a considerable period of time required for the necessary repairs.

To safeguard plant operation it is in that case of utmost importance that a rapid fire and smoke detection system is provided, allowing prompt intervention by personnel. An ultra-sensitive smoke detection system shall then be installed.

5.8.2.6 Transformers

Transformers are located in the open, in fenced-off non-hazardous areas. They contain small quantities of oil which may leak and catch fire. Under the transformer a collection basin is provided.

The likely fire scenario in this type of equipment is damage as result of an explosion. The resultant fire is too small to result in damage to adjacent equipment.

Malfunctioning of a transformer will reveal itself via other indications.

Provide portable carbon dioxide or dry chemical extinguishers in the vicinity of the transformers.

The fire risk rating is VERY LOW.

5.8.2.7 Battery rooms

Battery rooms are unmanned spaces inside control room buildings and FARs. They contain large quantities of either sealed recombination lead acid, vented lead-acid or vented Ni-Cd batteries, which serve as back up power supply in case of failure of the normal power supply. A conventional smoke detector shall be installed to alert personnel of irregularities.

In case conventional vented lead-acid batteries are used, hydrogen vapours will be formed during charging. Ni-Cd batteries produce oxygen vapours. In either case the battery room shall be equipped with an explosion proof exhaust fan.

The air shall be exhausted from the highest location of the space to ensure that the very light and highly explosive hydrogen vapours cannot accumulate. An alarm shall be provided in case the ventilation system fails.

Near the entrances of the building carbon dioxide extinguishers shall be provided.

The smoke detection system shall be connected to the central fire alarm system.

The fire risk rating is LOW.

5.8.2.8 Fire stations

For normally unmanned fire stations it shall be considered to install conventional smoke detectors in all spaces and fire detection in the garage for the fire-fighting vehicles.

All fire and smoke detection systems shall be connected to the central fire alarm system.

The fire risk rating is VERY LOW.

5.8.2.9 Fire water pump houses

In normally unmanned fire-water pump houses it shall be considered to install fire detection above the diesel engines. The diesel fuel tanks should be located in the open air, or at least they shall be located in a space separated from the engines.

Near the entrances of the building carbon dioxide or dry chemical extinguishers shall be provided. The fire detection system shall be connected to the central fire alarm system.

The fire risk rating is LOW.

5.8.2.10 Packed product warehouses

A detailed assessment is required to determine the fire protection measures required for product warehouses. The type of building, type of product, value stored, likelihood of ignition, presence of ignition sources, type of packing materials, size of compartments in the building, fire resistance of separation walls, presence of (automatic) fire doors etc. shall all be taken into account. See Shell Marketing / Chemicals publication titled "The Shell Guide to the Warehousing of Chemicals" for further guidance.

The fire risk rating is MEDIUM.

5.8.2.11 Packed product storage yard

Packed products like LPG (in bottles) and lubricating oil (in drums) are in general stored in the open air. A detailed assessment, taking into consideration lay-out, type of product, quantities stored and type of transport vehicles used, is required to determine the fire protection measures required for this type of packed product storage.

Dry chemical powder extinguishers and fire water monitors able to keep the product containers cool provides in general adequate protection.

The fire risk rating is LOW to MEDIUM.

5.8.2.12 General warehouses

These warehouses are manned during office hours only and serve to store spare parts and other consumables.

Fire protection shall mainly consist of dry chemical powder fire extinguishers and hose reels with 25 mm hoses connected to the potable water supply.

Depending on the value and criticality of the stored products it shall be considered to provide conventional smoke detectors.

The smoke detection system shall be connected to the central fire alarm system.

The fire risk rating is VERY LOW.

5.8.2.13 Flammables store

Flammables for own use, like paint, fuels and lubricating oils are stored in a normally unmanned well-ventilated enclosure. Electrical equipment in the enclosure complies with the area classification. The walls and roof have a fire resistance of two hours.

Fire detection should be installed inside the enclosure, connected to the central fire alarm system.

Depending on the size of the warehouse and the likelihood that a warehouse fire will escalate into a fire to adjacent buildings if the fire lasts too long, it shall be considered to install an extinguishing system. If required, a high expansion foam system should be used.

Carbon dioxide or dry chemical extinguishers shall be provided near the entrances of the building.

The fire detection system shall be connected to the central fire alarm system.

The fire risk rating is LOW.

5.8.2.14 Workshops

Workshops are located in non-hazardous areas and contain minor quantities of flammable products. Welding and other hot equipment is operated by craftsmen. Bottles with compressed welding gases are stored outside the buildings in fenced-off areas. Housekeeping requires constant attention of all involved.

The fires to be considered are those of rags in dustbins and of very small quantities of liquid hydrocarbons.

Fire protection shall mainly consist of dry chemical powder fire extinguishers and hose reels with 25 mm hoses connected to the potable water supply.

The fire risk rating is LOW.

5.8.3 Office buildings

5.8.3.1 Administration office

Hallways and corridors, as well as rooms with a high potential fire risk, shall be equipped with conventional smoke/fire detectors. These detectors shall also be considered for installation in ventilation systems.

All fire and smoke detection systems shall be connected to the central fire alarm system.

The following fire protection and extinguishing equipment shall be considered:

- A sufficient number of hose reels shall be installed, each containing 25 mm diameter fire hose of maximum length 25 m connected to the potable water system, positioned so that each office is well within reach of the water nozzles.
- For multi-storey buildings dry risers for external fire-fighting assistance shall be installed at two opposite sides of the office building adjacent to the escape stairs. The ground level inlet to the dry riser and the outlets at each floor shall be equipped with valved hose couplings.
- Portable equipment shall be available in accordance with the requirements of DEP 80.47.10.32-Gen.
- See also NFPA 101 for requirements on fire detection systems, fire alarm call points, notification of occupants systems, means of egress, fire extinguishing systems, etc.

The fire risk rating is VERY LOW.

5.8.3.2 Training centre

For the normally unmanned training centre it shall be considered to install conventional smoke and fire detectors in all spaces.

All fire and smoke detection systems shall be connected to the central fire alarm system.

These detectors should also be considered for installation in ventilation systems.

The following fire protection and extinguishing equipment shall be considered:

- A sufficient number of hose reels shall be installed, each containing 25 mm diameter fire hose of maximum length 25 m connected to the potable water system, positioned so that each office is well within reach of the water nozzles.
- For multi-storey buildings dry risers for external fire-fighting assistance shall be installed at two opposite sides of the building adjacent to the escape stairs. The ground level inlet to the dry riser and the outlets at each floor shall be equipped with valved hose couplings.

- Portable equipment, shall be available in accordance with the requirements of DEP 80.47.10.32-Gen.
- See also NFPA 101 for requirements on fire detection systems, fire alarm call points, notification of occupants systems, means of egress, fire extinguishing systems, etc.

The fire risk rating is VERY LOW.

5.8.3.3 Computer rooms

Computer rooms are normally unmanned and have a high degree of fire resistance, which makes escalation of an external fire into the computer room unlikely.

Given proper housekeeping, the likelihood of a fire originating in the computer room is very low. If loss of the computer room would have a serious effect on the continued operation of the plant or would cause loss of critical data it shall be considered to install an ultra-sensitive smoke detection system and a gaseous extinguishing system.

The fire risk rating is VERY LOW.

6. REFERENCES

In this DEP, 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).

SHELL STANDARDS

Index to DEP publications and standard specifications	DEP 00.00.05.05-Gen.
Index to standard drawings	DEP 00.00.06.06-Gen.
Symbols and identification system - Instrumentation	DEP 32.10.03.10-Gen.
Fire, gas and smoke detection systems	DEP 32.30.20.11-Gen.
Classification and implementation of instrumented protective functions	DEP 32.80.10.10-Gen.
Drainage and primary treatment facilities	DEP 34.14.20.31-Gen.
Minimum requirements for design and engineering of buildings	DEP 34.17.00.32-Gen.
Fire hazards and fireproofing/cold splash protection of steel structures	DEP 34.19.20.11-Gen.
Fire-fighting agents	DEP 80.47.10.10-Gen.
Active fire protection systems and equipment for onshore facilities	DEP 80.47.10.31-Gen.
Portable and mobile equipment for fire fighting	DEP 80.47.10.32-Gen.
Fire-fighting vehicles and fire stations	DEP 80.47.10.33-Gen.
The Shell Guide to the Warehousing of Chemicals	
FRED user guide version 2.1	MF Report 94-0215

STANDARD DRAWINGS

NOTE: The latest edition of Standard Drawings can be found in DEP 00.00.06.06-Gen.

Fire training ground for first aid training	S 88.030
Fire training ground for hose team training	S 88.031

AMERICAN STANDARDS

Guide for pressure-relieving and depressuring systems	API RP 521

Issued by:
American Petroleum Institute
Publication and Distribution Section
2101 L Street N.W.
Washington, D.C. 2003J
USA.

Standard for portable fire extinguishers	NFPA 10
Standard for low expansion foam	NFPA 11

Installation of sprinkler systems	NFPA 13
Flammable and combustible liquids code	NFPA 30
Code for safety to life from fire in buildings and structures	NFPA 101
Guide to fire hazard properties of flammable liquids, gases, and volatile solids	NFPA 325
Standard system for the identification of the fire hazards of materials	NFPA 704

Issued by:
National Fire Protection Association (NFPA)
Batterymarch Park,
Quincy, MA 02269
USA.

BRITISH STANDARDS

Recommendations for graphic symbols and abbreviations for fire protection drawings	BS 1635
Testing of valves Specification for fire type-testing requirements	BS 6755, Part 2

Issued by:
British Standards Institution
389 Chiswick High Road
London W4 4AL
England, United Kingdom.

Model code of safe practice in the petroleum industry; Part 3: Refining	IP Code Part 3

Issued by:
The Institute of Petroleum
61, New Cavendish Street
London W1M 8AR
England, United Kingdom.

International safety guide for oil tankers and terminals	ISGOTT

Issued by:
International Chamber of shipping
Carthusian Court
12 Carthusian Street
London ECIM 6EB
England, United Kingdom.

APPENDIX 1 GRAPHICAL SYMBOLS AND ABBREVIATIONS

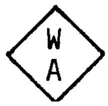
The following typical graphical symbols and abbreviations should be applied for fire protection schemes and drawings.

If the NFPA codes are specified for the design of the fire-fighting systems, the symbols and abbreviations of the NFPA codes may be applied if approved by the Principal. In which case, where the NFPA codes do not provide the appropriate symbols for the fire protection drawings of onshore installations, the symbols in this Appendix should be applied.

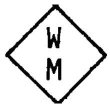
BS 1635 may be used if additional symbols and abbreviations are required.

1.1 FIXED FIRE PROTECTION EQUIPMENT/SYSTEMS

Fixed automatic water spray system

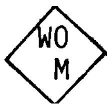


Fixed manually operated water spray system

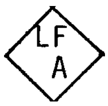


Fixed automatic water fog system

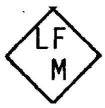
Fixed manually operated water fog system



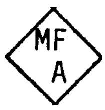
Fixed automatic low expansion foam system



Fixed manually operated low expansion foam system



Fixed automatic medium expansion foam system

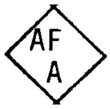


Fixed manually operated medium expansion foam system

Fixed automatic high expansion foam system

Fixed manually operated high expansion foam system

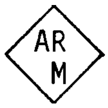
Fixed automatic AFFF (aqueous film forming foam) system



Fixed manually operated AFFF system

Fixed automatic alcohol-resistant foam system

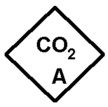
Fixed manually operated alcohol-resistant foam system



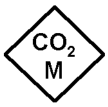
Fixed automatic Inergen system

Fixed manually operated Inergen system

Fixed automatic carbon dioxide system



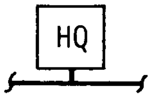
Fixed manually operated carbon dioxide system



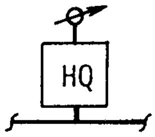
Fixed manually operated dry powder system

Hydrant post (pillar) double

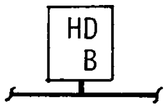
Hydrant post (pillar) quadruple



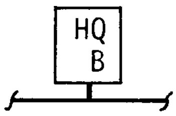
Hydrant post (pillar) quadruple with monitor



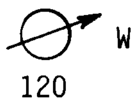
Hydrant post (pillar) double equipped with bottom drain valve



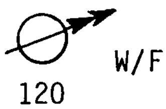
Hydrant post (pillar) quadruple equipped with bottom drain valve



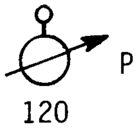
Fixed-installed monitor, manually adjustable and operated, for water (capacity in m^3/h)



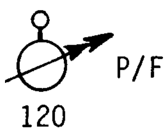
Fixed-installed monitor, manually adjustable and operated, for water and for foam (capacity in m^3/h water foam solution)



Fixed-installed monitor, remotely adjustable and operated, for powder (capacity in m^3/h)

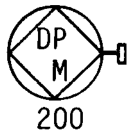


Fixed-installed monitor, remotely adjustable and operated, for powder and for foam (capacity in m^3/h water foam solution)

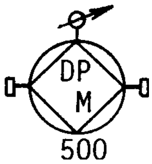


Fixed manually operated dry powder unit with one hose reel

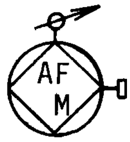
(capacity in kg)



Fixed manually operated dry powder unit with two hose reels and powder gun (capacity in kg)



Fixed manually operated AFFF unit with one hose reel and monitor (capacity in m^3)

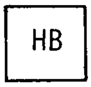


Fixed installed high back pressure foam generator

Dry riser

Steam ring

Hose box



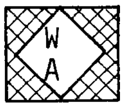
Fire point

On/off control valve for automatic spray systems spring opening

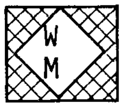
Fixed manually operated sub-surface foam system

Fixed manually operated semi-sub-surface foam system

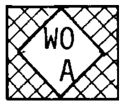
Area protected by fixed automatic water spray system



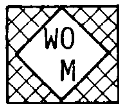
Area protected by fixed manually operated water spray system



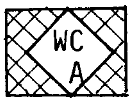
Area protected by fixed automatic water fog system



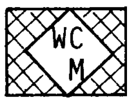
Area protected by fixed manually operated fog system



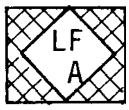
Area protected by fixed automatic water curtain



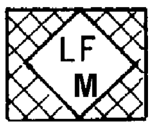
Area protected by fixed manually operated water curtain



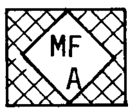
Area protected by fixed automatic low expansion foam system



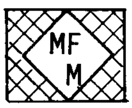
Area protected by fixed manually operated low expansion foam system



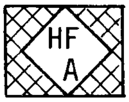
Area protected by fixed automatic medium expansion foam system



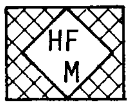
Area protected by fixed manually operated medium expansion foam system



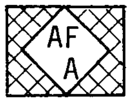
Area protected by fixed automatic high expansion foam system



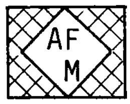
Area protected by fixed manually operated high expansion foam system



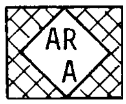
Area protected by fixed automatic AFFF system



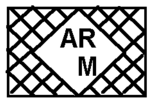
Area protected by fixed manually operated AFFF system



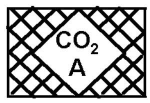
Area protected by fixed automatic alcohol-resistant foam system



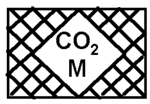
Area protected by fixed manually operated alcohol-resistant foam system



Area protected by fixed automatic carbon dioxide system



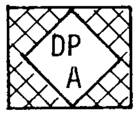
Area protected by fixed manually operated carbon dioxide system

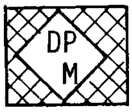


Area protected by fixed automatic Inergen system

Area protected by fixed manually operated Inergen system

Area protected by fixed automatic dry powder system

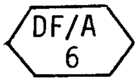


Area protected by manually operated dry powder system 

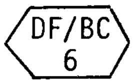
1.2 PORTABLE FIRE EXTINGUISHING EQUIPMENT

1.2.1 Portable extinguishers

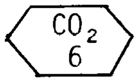
Powder,
where A indicates the type of dry powder, and the number is the filling weight in kg, which may be 2, 6, 9, or 12 kg.



Powder,
where BC indicates the type of dry powder, and the number is the filling weight in kg, which may be 2, 6, 9, or 12 kg.



Carbon dioxide



Steam lance

1.2.2 Portable foam generators

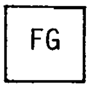
High expansion foam generator

Medium expansion foam generator

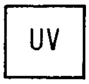
High back pressure foam generator

1.3 FIXED FIRE-DETECTION EQUIPMENT, AUTOMATIC

Area covered by flammable gas detector



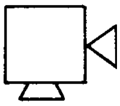
Area covered by ultraviolet flame detector



Area covered by infra-red flame detector

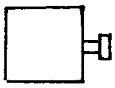
1.4 FIRE-WARNING SYSTEM, MANUAL

Siren

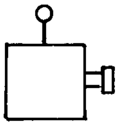


1.5 FIRE SUPERVISORY SYSTEM, AUTOMATIC

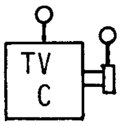
Fixed installation television camera



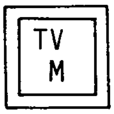
Fixed remotely operated television camera



Fixed remotely operated television camera with remotely operated zoom lens



Television monitor



1.6 SYMBOLS AND IDENTIFICATION SYSTEM - INSTRUMENTATION

See DEP 32.10.03.10-Gen.

APPENDIX 2 TYPICAL APPLICATIONS FOR HEAT, FIRE, SMOKE AND FLAMMABLE GAS DETECTION

Areas of application	Detection type						
	Heat		Fire	Smoke		Flammable gas	
	Linear	Spot (1)	UV IR	Conventional	Ultra-sensitive	Line-of-sight	Point
Selected hydrocarbon pumps	X						X
Gas turbine/gas compressor in enclosures		X (2)	X UV/IR				X
Selected areas or equipment holding hydrocarbons	X						
LPG bottle filling			X IR			X	X
LNG containment area	X (3)					X	
Floating roof tank rim seal area	X (4)	X (4)					
LPG storage vessel	X						X
Refrigerated LPG/LNG tank	X					X	
Control room building		(X)		X			X
Analyser house		(X)		X			X
Plant laboratory		(X)		X			
Main laboratory		(X)		X			
Instrument auxiliary room, cabinets, floor cavity, cable routes					X		
Battery room		(X)		X			
Computer auxiliary room					X		
Switchhouse / Substation		(X)		X			
Workshop - general		(X)		X			
Workshop - process analysers		(X)		X			X

APPENDIX 2 (continued)

Areas of application	Detection type						
	Heat		Fire	Smoke		Flammable gas	
	Linear	Spot (1)	UV IR	Conventional	Ultra-sensitive	Line-of-sight	Point
Warehouse - general		(X)		X			
Warehouse - packed products		(X)		X			
Packed product (incl. LPG) storage yard			X IR			X	
Administration buildings		(X)		X			
Canteen		(X)		X			
Kitchen		(X)	X IR	X			
Training centre		(X)		X			
Fire station			X IR	X			
Garage			X IR	X			

NOTES:
1. (X) indicates that spot smoke detectors should be of the integral heat detection type.
2. Rate of rise heat detector
3. Low temperature heat detector
4. Use either polyethylene tube or frangible quartzoid bulb detector

APPENDIX 3 TYPICAL CAUSE AND ALARM/ACTION MATRIX

CAUSE	Detected or signalled by	RESULTING ALARM OR ACTION											
		Audible alarm in CR	Visual and audible alarm on DCS	Visual alarm on mimic panel	Audible alarm in building	Visual alarm in building	Audible alarm in plant 1)	Visual alarm in plant 1)	Close fresh air intake 1)	Close fire tight dampers 1)	Start fire-water pump 1)	Open water spray valves 1)	Activate gaseous extinguishing system 1)
GENERAL	Manual call point (in building)	X	X	X	X	X			X				
ALERT	Manual call point (in open plant)	X	X	X			X	X			X		
HEAT	Space	X	X	X	X	X							
	Rate of rise	X	X	X	X	X			X				X
	Polyethylene tube	X	X	X							X	X	
	Frangible quartzoid bulb	X	X	X							X	X	
FIRE or	Infrared	X	X	X	X	X			X	X			X
FLAME	Ultraviolet	X	X	X	X	X				X			
	Building air intake high temperature	X	X	X	X				X				
SMOKE	Ionisation	X	X	X	X	X			X	X			
	Scattered light	X	X	X	X	X			X	X			
	Ultra sensitive	X	X	X	X	X			X	X			X
GAS	Toxic gas	X	X	X	X	X	X	X	X				
	Flammable gas high	X	X	X					X				
	Flammable gas high high	X	X	X	X	X	X	X	X				X

NOTES:

1) Where revealed failure robust initiators are implemented, action shall only be performed when 2 out of 'n' initiators are in alarm.
2) This matrix is also used in DEP 32.30.20.11-Gen.