



RP 24-1

FIRE PROTECTION - ONSHORE

April 1994

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SCOPE AND PURPOSE This Recommended Practice gives advice for development of an appropriate philosophy for life saving and limitation of Business losses arising from fires in onshore plant. It discusses methods for identification, characterisation and quantification of hazards. It also gives technical requirements for active and passive fire protection systems.											
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FOREWORD

Introduction to BP Group Recommended Practices and Specifications for Engineering

The Introductory Volume contains a series of documents that provide an introduction to the BP Group Recommended Practices and Specifications for Engineering (RPSEs). In particular, the 'General Foreword' sets out the philosophy of the RPSEs. Other documents in the Introductory Volume provide general guidance on using the RPSEs and background information to Engineering Standards in BP. There are also recommendations for specific definitions and requirements.

Value of this Recommended Practice

An approach for accurate determination of active fire protection systems at an early project development stage has been developed. Areas requiring passive fire protection can be readily determined using the recommended methods.

Application

Text in *italics* is Commentary. Commentary provides background information which supports the requirements of the Recommended Practice, and may discuss alternative options. It also gives guidance on the implementation of any 'Specification' or 'Approval' actions; specific actions are indicated by an asterisk (*) preceding a paragraph number.

This document may refer to certain local, national or international regulations but the responsibility to ensure compliance with legislation and any other statutory requirements lies with the user. The user should adapt or supplement this document to ensure compliance for the specific application.

Principal Changes from Previous Edition

Fire protection requirements were previously split between two documents covering active (BP CP 15) and passive (BP CP 16) fire protection, for both onshore and offshore facilities.

Feedback and Further Information

Users are invited to feed back any comments and to detail experiences in the application of BP RPSE's, to assist in the process of their continuous improvement.

For feedback and further information, please contact Standards Group, BP International or the Custodian. See Quarterly Status List for contacts.



1. SCOPE

- 1.1 This Recommended Practice shall be applied to the design of all new onshore installations and used for assessment and modification of existing facilities.

It specifies BP requirements for the design of active and passive fire protection systems for onshore facilities, utilising fire hazard assessments whereby credible risks to life, investment and production can be addressed. It matches fire protection to the potential fire hazard based on BP's operating experience.

- 1.2 Part 1 addresses hazard identification, minimisation and assessment. It addresses the appropriate choice of active and passive fire protection measures to contain and, where practicable, extinguish potential fires.

- 1.3 Part 2 addresses additional considerations specific to areas and gives guidance on the choice of exposure protection, taking into account fire type and equipment or structure to be protected.

- 1.4 Part 3 addresses the technical requirements for selection of active and passive fire protection systems. This part of the document is intended for use with appropriate design guides and codes, e.g. BS, NFPA, API.

- 1.5 This Recommended Practice does not cover explosion hazards. The design of buildings and structures to withstand blast loading shall be in accordance with BP Group [RP 4-6](#).

The Steel Construction Institute interim guidance notes, whilst relating to offshore structures, provide useful information for onshore plant.

- 1.6 Requirements for offshore facilities are given in BP Group [RP 24-2](#).

- 1.7 The design philosophy for fire and gas detection and control systems shall comply with BP Group [RP 30-7](#). Design of these systems should proceed in parallel with the development of fire protection requirements.

- 1.8 Good plant layout can minimise hazards at the outset of design development. Specific requirements are detailed in BP Group [RP 44-7](#).



2. FIRE HAZARD MANAGEMENT PHILOSOPHY

2.1 General

- 2.1.1 Fire hazards shall be managed to minimise personnel exposure, preserve life, minimise injury and limit business losses arising from fires which could reasonably be anticipated.

This Recommended Practice should be used in conjunction with BP Group RPSEs for fire and gas detection, formal safety assessments and other guidelines.

- 2.1.2 Each installation shall have a fire hazard management philosophy which shall be developed at the design concept stage.

The philosophy will require the:-

- (a) Identification of fire hazards at an early stage in design.
- (b) Selection of a strategy to deal with the hazards.
- (c) Optimisation of the design to minimise frequency, scale and consequence.
- (d) Provision of systems to control the hazards.
- (e) Implementation of the strategy and maintenance of the systems.
- (f) Updating of the strategy throughout the life of the installation.

This should be developed as a Fire and Explosion Hazard Management Plan (FEHMP) which is agreed with the operator of the installation, fully documented and included in the operating procedures.

Since hydrocarbon releases are hazardous as potential fuels for both fires and explosions, it is sensible to embrace both aspects in the FEHMP. However, this Recommended Practice does not advise on the specific design requirements for explosion hazards (see 1.5).

The recommended fire hazard management process is shown, in a simplified form in Figure 1 and in detail in Figure 2. It requires that all major fire hazards are identified and quantified, and that a strategy is chosen for each hazard.

- 2.1.3 The choice of a particular strategy should be made at an early stage when it is still possible to optimise the design, to minimise the hazards and take due credit for these features before committing expenditure on



extensive protection. This approach will achieve full integration of prevention, protection and mitigation of all fire hazards.

The possible strategies are:-

- (a) Fire prevention.
- (b) Fire containment and prevention of escalation (i.e. minimisation).
- (c) Acceptance of consequential damage.

Each of these chosen strategies requires the provision of measures to manage the hazard and at each stage cost effectiveness must be considered. These measures will be a combination of prevention and control to minimise the frequency, scale, intensity and duration of the hazard and mitigation to protect personnel and critical equipment. These measures will be identified and designed to suit the type, scale and frequency of the perceived hazard. They will be included in the plan as it develops during the project and ultimately handed over to the Operator as part of the operating procedures.

- 2.1.4 The chosen strategies shall aim to reduce the risks to personnel on the installation to as low as reasonably practicable. They should also address the need to prevent escalation to a major environmental incident. They shall, as a minimum, meet the Client/Operator and national targets for individual risk and major accident frequency.

Considerable asset protection will result from any personnel protection provisions. Further specific asset protection should only be provided following a request from the Client/Operator and may be subjected to a cost benefit analysis.

- 2.1.5 A fire risk analysis shall examine the chosen strategies to independently verify that the measures are adequate. It should also be a formal review of the strategy to ensure that all hazards have been identified and that the quality of the FEHMP is acceptable.

- 2.1.6 The plan should be handed over to, and subject to acceptance by, the Client/Operator who will modify and update it as necessary throughout the installation life.

- 2.2 *Benefits*

- 2.2.1 *General*

This approach provides protection which is matched to the fire hazards and consequences and identifies the 'design case'. This places obligations on the Operator to ensure that the chosen strategy and associated facilities are maintained in an operative condition.



2.2.2 *Implications for Capital Investment*

This approach should ensure that the optimum combination of prevention control and mitigation measures is chosen, eliminating unnecessary systems and selecting the most cost effective way of managing each hazard.

2.2.3 *Implications for Active Fire Protection*

The approach described in this Recommended Practice has the benefit of determining more accurately the information upon which fire water requirements are based. This occurs at an early design stage and requires assessment of potential fires, which are chosen as the design case in individual risk areas, and matching the protection to them. It is more realistic than the traditional Reference Area method and does not require arbitrary correction factors.

2.2.4 *Implications for Passive Fire Protection*

Areas requiring passive protection are more easily identified and unnecessary protection can be avoided.

2.2.5 *Implications for Operators*

A clear strategy is put in place for each hazard and all the thinking behind it, the systems required to implement it and performance standards for each prevention control and mitigation measure, are documented and handed over from a project. This allows effective hazard management to be documented.

The requirements for procedural controls, maintenance, inspection and test as developed during design and construction would therefore be transmitted to the Operator.

2.3 Caution on the Use of This Procedure

Since the hazard management approach is based on different assumptions from the Reference Area method, the two techniques should not be used in combination.

The Reference Area method of determining active protection for hydrocarbon areas uses prescriptive water application rates which are pre-defined regardless of the hazard addressed. One result of this type of approach may be the over or under design of water systems. The Hazard Management approach, which matches fire protection closely to the fire risk, leads to more effective protection and a more effective design.

PART 1 - HAZARD IDENTIFICATION AND ASSESSMENT/SELECTION OF DESIGN CASE

3. HAZARD IDENTIFICATION AND LISTING

3.1 Identification

Identification of hazards shall be approached on a formalised basis. Any attempt to assess hazards unsystematically may cause concentration on certain risks to the exclusion of others.

The installation shall be divided into areas and if necessary sub areas. For each area a Fire Risk Analysis (FRA) report shall be prepared.

The FRA shall establish all hydrocarbon inventories and the valving arrangements in order to identify the major isolatable inventories, source, fire type, combustible material, pressure, etc. This information can be presented in tabular form as shown in Table 1. If an identified hazard can impact upon other equipment or areas then it shall also be listed as shown in the example entry for Table 2.

Special note shall be made of instances where fires may be preceded by an explosion (the initiating event) which may cause larger/multiple releases and fires or structural damage. Fires and explosions in other fire areas which can affect the area in question shall also be considered.

3.2 Information Requirements

3.2.1 When determining the requirements for fire protection facilities, the following factors need to be considered:-

- (a) The statutory requirements of the country in which the installation is operating.
- (b) The type and size of the installation.
- (c) The number of employees on site.
- (d) The products stored, processed or handled.
- (e) The availability and response time of trained fire crews.
- (f) The availability and quality of mutual aid schemes.
- (g) The proximity of adjacent vessels/process plant.
- (h) The proximity of third party and public property.

- (i) The proximity of local population/community.
- (j) The economic importance of the installation.
- (k) Capital cost of replacement plant.
- (l) Potential environmental pollution.
- (m) Business loss.

3.2.2 An assessment of this type requires installation design information which may be available from:-

- (a) Hazardous area drawings.
- (b) Plot plans, including equipment lists.
- (c) P&ID's, e.g. main process area, storage area, etc.
- (d) Process data sheets.
- (e) Plot plans of escape routes.
- (f) Process flow diagrams.
- (g) Key operating procedure details.
- (h) HVAC philosophy.

In the early stages of design, some of the information may only be available in provisional form.

3.3 Fire Types

Different types of fire should be considered:-

- (a) Flash from gaseous hydrocarbons.
- (b) Jet from gaseous hydrocarbons.
- (c) Jet spray from high pressure liquid hydrocarbons.
- (d) Pool from low pressure liquid hydrocarbons.
- (e) Boiling liquid expanding vapour explosion (BLEVE)
- (f) Electrical.

(g) Cellulose.

(h) Fire resulting from an explosion.

Fires may be described in a number of ways. Within this document the following definitions have been assumed:-

3.3.1 *Flash Fire*

A flash fire occurs when the combustion of a flammable liquid and vapour results in a flame which passes through the mixture at less than sonic velocity such that damaging overpressures are negligible.

3.3.2 *Jet Fire*

A jet fire is a stable jet of flame produced when a high velocity discharge catches fire. The flame gives off little smoke as a considerable amount of air entrainment takes place during discharge.

3.3.3 *Jet/Spray Fire*

The understanding of the fire characteristics of pressurised liquid releases is limited. It is known that the proportion of the release which will burn as a jet or spray increases with the pressure and the volatility of the liquid. In the absence of more accurate data, the following may be taken as default pressures above which all the liquid burns as a spray. Below these pressures some or all of the release may burn as a pool.

(a) Condensate: 2 bar g

(b) Light Oil: 4 bar g

(c) Heavy Oil: 7 bar g

Note that under some circumstances a pool fire may be preceded by a jet/spray fire as the plant or process sections depressurise. Under these circumstances jet fire protection should be specified if the pressure quoted above can last longer than 10 minutes. Gas/oil jet fires produce more smoke than either gas or gas/condensate fires and can feed pool fires.

3.3.4 *Pool Fire*

A pool fire involves the combustion of hydrocarbons evaporating from a layer of liquid. It may occur within a clearly defined boundary, e.g. the bunding below a vessel. It may also be unconfined and the spread then depends on numerous factors such as the nature of the surface, the presence of drains and the presence of water surfaces. The flames are often accompanied by large quantities of smoke with both flames and smoke orientated downwind.



In some cases where hydrocarbon containing vessels become very hot in a fire situation and then fail with a resulting loss of containment, the expanding burning vapour results in a BLEVE.

4. SELECTION OF FIRE HAZARD MANAGEMENT STRATEGY/DESIGN FIRE CASES

4.1 General

A strategy is required for every major fire hazard on an installation. The options are detailed in section 2.1.3.

The Client must decide at the beginning of a project if the strategy should only address the preservation of life and the environment or include investment protection.

The selection of the strategy will depend on two considerations: the practicality of implementing it and the scale of the incident. It may also be necessary to review the selected strategy at various points in the design (such as the concept safety evaluation) to verify it is viable. It is preferable and more cost effective to specify prevention measures rather than mitigating measures.

4.2 Fire Prevention

There are some potential events which would overwhelm an installation. These would be classified as extreme accidental events (EAE). Whilst it may be theoretically possible to design to withstand these events the selected approach should utilise CBA. The aim should be to reduce the frequency of these events to within acceptable limits and as low as reasonably practical (ALARP).

It may also be possible, after close examination of all the causes of failure, to prevent incidents which, hitherto, have been considered as design cases. The acceptability of a prevention strategy is not only dependent upon the provision of adequately engineered systems, but equally on the Operator to maintain the systems and follow necessary procedures.

4.3 Fire Containment and Prevention of Escalation

This should be the most common strategy for all process, fuel and non hydrocarbon fires. Critical equipment should be protected by location or systems which match the type and duration of the initial hazard. It also depends on the operation of control equipment such as drains and ESD. The Operator must be aware of his obligations for maintenance and testing to ensure that these systems work when needed.

Where the size, location and character of a fire is predictable, proven extinguishing methods can be employed to put it out or control it before there is critical escalation or loss of life. Extinguishment may be an alternative to passive protection for stored fuel or very low pressure oil processing. Post extinguishment reignition hazards, such as residual pockets of flammable gas or pools of liquid, need to be considered in selecting an appropriate measure.

Extinguishment of gas releases and flashing liquids should not be considered if there may be a subsequent explosion or gas ingress hazard.

4.4 Acceptance of Consequential Damage

This category applies in circumstances where a fire would not cause a significant risk to life and the consequential damage can be limited to an acceptable level. Therefore, fixed protection is not needed.

If containment or control requires the provision of passive protection (e.g. fire walls) or manual fire fighting facilities, the hazard shall be classified under 4.3.

5. HAZARD QUANTIFICATION

5.1 General

Hazard quantification is the means of formally identifying the size, duration, release rate and intensity of all of the major fire hazards which would be chosen as design cases for either active or passive fire protection. A detailed analysis of the low frequency overwhelming events is not needed but a coarse assessment will be required to assist in the selection of the appropriate management strategy. Where the fire hazards are well understood and do not vary significantly on different installations, these may be classed as generic hazards. These do not need to be quantified in the rigorous detail described below.

Where the hazard is variable, but standard methods of protection have proved to be fully effective, it may be classified as standard. Rigorous quantification is not required but a general listing of the variables which would affect the fire, such as the primary flammable inventories or the containment, would be needed. Information is required at the following stages of a project:-

- (a) Concept Selection.
- (b) Fire Hazard Management Strategy Selection.

- (c) Concept Safety Evaluation/Assessment.
- (d) Process Design Optimisation to minimise fire hazards.
- (e) Detail Design of Protection Systems.
- (f) Formal Safety Assessment.
- (g) Operator Handover.
- (h) Plant Modification.

The level of detail will depend on the level of process and layout detail available at the time.

Fire hazard quantification is an ongoing process which should simply be updated as more detailed information becomes available or the design is modified. The project safety plan will identify any requirement to carry out an independent check of the fire hazard quantification at either the concept or formal safety assessment stage.

5.2 Method

5.2.1 The quantification should be carried out using methods approved by the Client/Operator. Different methods may be applied to different fire hazards. The BP computer programs HARP and CIRRUS are considered acceptable for release calculation and fire characterisation respectively. Other techniques will be needed for compartment or obstructed fires. The fires will need to be quantified in a form which can be used as the basis of the fire protection design. It may also provide input data to a quantified risk assessment (QRA). The following cases will be needed for specifying fire protection:-

- (a) The largest design fire case lasting long enough to cause failure.

The duration will need to be specified in order to carry out this analysis. Under intense hydrocarbon fires, items may theoretically fail in a few minutes. In practice, the time to failure may be slightly longer than the theoretical minimum. Items which are particularly weak such as plate heat exchangers should be identified.

- (b) The largest design fire cases at specified times.

These may be the times at which proprietary passive protection fails, e.g. 60 minutes.

- (c) The duration of the smallest significant fires.

Normally this would only be needed if investment protection was required and the duration was likely to significantly exceed any of the other cases already analysed.

5.2.2 The following variables should be taken into account when carrying out the analysis:-

- (a) Each inventory and the proportion which can be released.
- (b) Type of hydrocarbon fluids.
- (c) Burn characteristics for these fluids, including transition pressures from spray to pool for liquid release.
- (d) Management strategy for each inventory.
- (e) Maximum hole size or release rate.

It should be recognised that the largest hole does not necessarily give the worst fire from an isolated inventory for a particular duration. Some methods require selection of a number of hole sizes to represent typical incidents.

- (f) Location of all potential releases.
- (g) ESD operability and time to operate.
- (h) Depressurisation operability and time to operate.
- (i) Release pressure profile taking into account depressurisation and reheat due to the fire.
- (j) Pool size and drainage.
- (k) Ventilation rate.

5.3 **Results**

The following outputs are needed from the analysis, and may be presented in tabular form (See Table 3), with a summary in the FEHMP.

- (a) Fire type: pool, jet, spray or solid combustibles.
- (b) Fire exposed envelope, location and flame geometry. (These should be superimposed on plant layouts and take reasonable account of obstructions and wind effects).

The size of the fire exposed envelope shall be confirmed using hazard assessment methods approved by BP.

- (c) Burn time of releases.
- (d) Heat intensities (fluxes) inside and outside the flame.
- (e) Lists of critical equipment subjected to radiated heat or direct flame impingement.

When the design has been finalised, the fire quantification should form part of the fire hazard management plan and should be included in the handover documentation. It should be in a form which readily communicates the characteristics of the major hazards to the site operating personnel.

It is also a valuable way of conveying the fire hazards associated with the design to process and layout engineers who can contribute to reducing the fire cases.

6. PREVENTION

Prevention is the primary defence against fire and applies to all fire hazards. It is implemented through the selection of appropriate design and construction codes and standards and operational controls. These are considered to be adequate where the potential fire is protectable, i.e. it can be controlled without the need to evacuate the plant.

All the potential causes of failure must be identified and a combination of design features and operational procedures put together to address each one. The causes of failure can, during conceptual design, be identified by a HAZID or hazard identification study. This should be verified by a hazard and operability (HAZOP) study during detail design. The studies should include the following:-

- (a) Fire (the effects of all other major fire hazards on this particular case).
- (b) Impact (dropped objects).
- (c) Corrosion (internal and external).
- (d) Environmental (severe weather).
- (e) Breaches of Containment (maintenance and operation).
- (f) Overpressure (process control failure or overheating).

- (g) Explosion.
- (h) Isolation Failure (failure to isolate the hazard from another part of the plant).

In each case, the contributing elements to the failure should be identified, e.g. the lockout of a fire and gas detection system may prevent closure of the shutdown valves. The HAZOP and HAZID studies may be augmented by a fault tree and a failure modes and effects analysis (FMEA). Once identified, the adequacy of the preventive measures embodied in the normal codes and standards and operational procedures should be examined. This judgement is based on the contribution of the particular hazard to the overall risk to the plant. Where the overall risk is acceptable, ALARP and the hazard is not a primary contributor to that overall risk, then no further action is required other than to ensure that the design codes and procedures are applied. These should, however, be documented as a critical prevention measure in the FEHMP.

If, however, the hazard dominates the overall risk then each cause of failure shall be individually addressed and reasonably practicable design and operational measures shall be put in place. Expenditure on these measures should be as low as reasonably practicable.

Once these additional specific preventive measures have been identified and design features included, then they must be documented together with the general prevention measures such as the design codes, in the fire hazard management plan so that the Operator knows what they are and his obligations for operation and maintenance.

7. HAZARD MINIMISATION AND CONTROL MEASURES

7.1 General

The first stage in hazard minimisation is the use of appropriate codes and standards in the design. However, the use of hazard analysis techniques identifies the largest hazards and allows further examination of them to reduce their scale, duration, intensity and consequence. This is normally only required for the hydrocarbon processing events and the main storage inventories. The aim is to reduce the scale of the hazards to that which would not overwhelm the installation and would be of a size which could be controlled by the fire fighting and protection systems, i.e. to reduce the hazards to a protectable level.

This section concentrates on the techniques to minimise the largest events. The process of design requires the interaction of all engineering disciplines and sufficient time to allow it to take place. The areas which can be optimised are given in the sub-sections that follow.

Control measures are those systems which will limit the size of fires to that which can be counteracted or extinguished by the passive or active protection systems. These are critical elements in the fire hazard management process as, without them, the fire could spread to areas with inadequate protection.

7.2 Inventory Minimisation

The major fire hazards are dominated by a small number of events. These will probably be a few of the individual isolated process inventories such as the separators, slug catchers and storage.

Isolation valves should be located as close to the vessel as possible, with protection or positioning to withstand any anticipated explosions or fires. Valves should close automatically on signals from the Fire & Gas and ESD systems and have local/remote manual initiation.

The fire hazard quantification may also show that the degree of isolation provided between some inventories is disproportionate to others, i.e. that there are a number of small inventories which, if combined, do not constitute as severe a hazard as other individual ones. If this is the case, it may be appropriate to rationalise the isolation philosophy by reducing the valve numbers and concentrate the resources on other, more severe hazards.

In the case of isolated process inventories the design will be restricted by the minimum size of vessel required to carry out the processing. Where the fire quantification shows that the inventory is so large that it can still overwhelm the installation, then it will be necessary to introduce specific design features and procedures to control the rate of release. It may be appropriate to question the design specification that determined the vessel size and discuss with the Operator. It may also be appropriate to consider the dumping of liquid inventories, although the hazards associated with this should not be overlooked. These measures should only be undertaken where the frequency of the overwhelming event is such that it makes an excessive contribution to the overall risk.

7.3 Optimisation of Release Location

Two benefits can be achieved by optimising the location of potential releases.

- (i) The number of fire areas into which the inventory can be released is reduced.
- (ii) The thermal loading of critical plant and structure can be minimised.

The first benefit requires that the major inventories are isolated within the fire area so that they cannot cascade into others via the process pipework and systems. The second requires that the major isolated inventories and well hazards are positioned so that the fires resulting from potential release points have the minimum potential for impact on critical plant, structure, and evacuation routes.

It may be possible to optimise the location of potential sources of release; pig launcher and receiver doors, instrument tappings and flanges so that a pressurised liquid or gas release does not impinge directly onto critical plant or processing equipment with a high escalation potential.

7.4 Control of the Rate of Release

The rate of release can be controlled in two ways:-

(i) Minimisation of the pressure profile with respect to time.

The pressure profile will be a function of the initial pressure and the effects on the inventory of the fire and control actions. The fire itself will cause the liquid inventory to boil off, increasing the pressure. This can be minimised by fire resistant insulation but this should withstand the effects of the fire if credit is to be taken for it.

Depressurisation will reduce the pressure and dispose of a proportion of the gas inventory. It will also help to reduce the pressures generated by boiling liquids. Where the major inventories dominate the fire cases, particularly those of long duration, there may be scope to optimise the allocation of the flare capacity to minimise their post ESD pressure profiles at the expense of other smaller inventories.

Relief valves will only keep the pressure to the relief pressure setting if they are realistically sized for the boiloff rates which will be generated by the particular fire types and size.

(ii) Minimisation of the maximum hole size on which the design fire cases are based.

Minimisation of the hole size through which a release can occur can be achieved by a combination of design specifications and procedures. However, these must be thoroughly documented in the FEHMP and implemented if credit is to be taken for it in any safety assessment. The design considerations are the minimisation of fittings above the critical size, the use of particular jointing systems (e.g. ring type joints) above the critical size, design of the process plant to withstand the maximum anticipated explosion conditions, particularly fittings, and the specific identification and minimisation of any cause of large bore failure (e.g. corrosion or erosion). The operational procedures include the control of any breaches of containment above the critical size and the control of any operations likely to cause these larger failures (e.g. heavy lifts). This may not be practical on all process equipment but it can be applied to individual inventories and well operations.

7.5 Control of Liquid Releases

Where there is a possibility of a pool fire, both the location and size of the fire can be optimised by controlling the spread of the flammable liquids. This may be achieved by either bunding or gulleys but, in either case there should be provision to dispose of any firewater and to safely dispose of any unburnt hydrocarbons. Flammable liquid should be prevented from spreading towards any critical structure or plant if possible. The total pool fire area will determine the burn rate and the overall fire size. This is a particularly powerful tool in the control of fire hazards but it is only effective if the liquid release pressure is low enough to prevent the majority of the liquid burning as a spray.

7.6 Control of Fire Spread

The effects of a fire may be controlled by firewalls around the fire area. These may also limit the ventilation causing reduced combustion and possible extinguishment. This should only be considered if there is not a significant gaseous explosion hazard in the area or the firewalls are arranged so that the explosion overpressures are unlikely to cause escalation. Water curtains may be considered for controlling billowing flames from pool or low pressure spray fires.

8. PROTECTION AND MITIGATION METHODS

8.1 General

The protection of an area may be achieved by active means, passive means or a combination of both. The choice will vary from one area to another. Each area should be treated on its own merits.

As part of the review of each area, the fire hazards should be examined to determine whether it is practical to extinguish the fire. Extinguishment shall only be chosen as the sole means of fire protection if all consequent explosion or fire hazards can be eliminated until disposal or dispersion of all inventory has been achieved, or arrangements made to extinguish re-ignited fires. It may be used in addition to exposure protection as a means of damage limitation. This shall be at the discretion of the Client/Operator.

8.2 Protection Measures

8.2.1 Exposure Protection without Extinguishment.

The choices of exposure protection are:-

(a) Active:-

- Deluge systems.
- Monitors.
- Manual Fire fighting.
- Fire and gas detection and alarms.

(b) Passive:-

- Coatings (Intumescent and Cementitious).
- Firewalls.
- Enclosures.
- Insulation or panel systems.

Passive protection may also have dual functions such as blast walls, insulation, segregation and paint systems.

Protection systems should be provided if the anticipated design fire conditions could lead to any of the following failures:-

- Catastrophic failure.
- Significant escalation leading to a combined fire size in excess of the protection possible.
- Penetration, overheat or excessive smoke levels within the control room.
- Loss of sufficient emergency equipment needed to counteract the initial event.
- Loss of sufficient emergency equipment needed to preserve life from the initial event.
- Loss of sufficient emergency equipment needed to control the event before the equipment has operated (e.g. ESD valves).
- Progressive structural collapse.

- Structural failure or the collapse of heavy loads leading to escalation as above.

The duration rating of the passive protection shall be based on the expected fire duration or, if the fire is of extended duration, the time required for shutdown. In all cases the protection should prevent the structure/equipment reaching its failure temperature, within the specified time.

8.2.2 Extinguishment without Exposure Protection

When adopting this approach the protection should guarantee the extinguishment of the fire and any consequential fires (e.g. cable fires, running fires, etc.) before critical failure can take place. In addition the protection should guarantee the prevention of re-ignition or have sufficient residual capacity to extinguish any recurring fire.

8.2.3 Choice of Method of Exposure Protection

Where jet fires are predicted, the point of impingement will receive high levels of heat input. Water spray alone may not be effective in protecting structures and equipment, although some cooling may be achieved. As a result, passive fire protection or limitation of jet fire duration may be the only effective options.

The choice of active and/or passive fire protection and their allocation to equipment, structures and walls will depend on:-

- (a) Suitability of the chosen system to the type of fire.
- (b) Weight and cost constraints.
- (c) Overall site water capacity and infrastructure.
- (d) Corrosion as a result of water deluge.
- (e) The need to insulate vessels for process reasons where passive protection may have a dual role.
- (f) Reliability and availability of active systems.
- (g) Survivability of passive systems in normal operational conditions.
- (h) Survivability of active and passive systems following an explosion.

- (i) The required duration of protection.
- (j) Preventing failure of instrumentation and electrical equipment.
- (k) Access for inspection and reinstatement.
- (l) Disruption to operations during active system testing.
- (m) Predicted life and maintenance refurbishment requirements of active and passive systems.
- (n) The heat intensity of the design event.
- (o) Corrosion under passive fire protection.
- (p) Practicality and complexity of application to exposed plant or structures.
- (q) Environmental conditions in application and use.
- (r) Performance verification.
- (s) Secondary effects, burn rate control.
- (t) Operator exposure.

The reasons behind the choice of protection method shall be documented and handed over to the Operator to support the fire hazard management plan.

8.2.4 Choice of Method of Extinguishment.

The choices of extinguishing method are:-

- (a) Oxygen starvation
- (b) Foam
- (c) Inert Gas
- (d) Water Systems
- (e) Dilution
- (f) Dry Powder

The considerations for the choice of method are:-



- *Suitability for the fire hazard*
- *Post extinguishment security*
- *Personnel safety*
- *Practicality of application*
- *Consequential damage*
- *Speed of response*

Reactive gas systems may be considered if a proven halon replacement becomes available.

9. IMPLEMENTATION AND DOCUMENTATION

9.1 There must be adequate communication and documentation from each stage of a project to the next, and to the Operator, so that the hazard management decisions are understood and recorded. This is, preferably, done in the form of a Fire and Explosion Hazard Management Plan, (FEHMP). It may also be encompassed within an overall plan for the management of all hazards on the installation. The plan should contain the following information:-

- (a) A specific listing of each major fire hazard (e.g. separator fire).
- (b) A listing of groups of generic hazards.

9.2 For each of the major hazards and groups of generic hazards, the following information is required:-

- (a) The strategy to manage the hazard.
- (b) The list of engineered prevention, control and mitigation measures.
- (c) The list of software systems/procedural controls.
- (d) A description and quantification of the design accidental events (the fire hazard quantification).
- (e) A description of the extreme accidental events and consequences.
- (f) Nominated responsible persons for each of the prevention, control and mitigation measures.

9.3

The following support documentation should be provided for the prevention, control and mitigation (PCM) measures (as appropriate):-

- (a) *Performance and design standards, e.g.:-*
 - (i) *corrosion thickness (prevention).*
 - (ii) *ESD closure time (control).*
 - (iii) *drainage flowrate (control).*
 - (iv) *passive protection rating (mitigation).*
 - (v) *deluge application rate (mitigation).*
 - (vi) *availability and reliability (all).*
 - (vii) *Criticality.*
- (b) *Controls and operating restrictions during maintenance or non availability of the PCM measures e.g. deployment of ground monitors during deluge system maintenance.*
- (c) *Documentation for procedural PCM measures e.g. corrosion inspection procedures.*
- (d) *Maintenance procedures and frequencies.*
- (e) *Inspection procedures, test frequencies and performance acceptability limits e.g.*
 - (i) *maximum valve closure time.*
 - (ii) *minimum wall thickness.*
- (f) *Emergency response procedures.*
- (g) *Demonstration, using QRA, that the design meets company and legislative criteria for individual risk.*

The FEHMP should be a living document which conveys information to all those who are responsible for safe operation, in a form which is concise and easily read. It should not be an over detailed, cumbersome, mammoth work. This particularly applies to the description of the fire hazards which should be in pictorial form with a short descriptive text.

9.4

The preparation of the FEHMP should commence at the conceptual design stage when the major hazards are identified. It should be prepared by a responsible person with input from all disciplines and the Operator. As the project progresses, other hazards may be identified, strategies selected and PCM measures specified. The plan should develop as each item of information becomes available. The fire

quantification and engineering sections should be substantially complete before construction. Prior to commissioning, the operational and procedural sections should be completed and handed over to the commissioning/operating team. The FEHMP and supporting documentation should form the basis of the check lists and acceptance procedures for the PCM systems during inspection, test and commissioning.

9.5 The FEHMP will also be a support document to any safety case requirements and must be completed in time for submission if required.

It must be regularly reviewed and updated whenever there is either an engineering modification affecting the hazards or the PCM measures, or a management reorganisation affecting responsible persons.



PART 2 - ADDITIONAL CONSIDERATIONS SPECIFIC TO AREAS

10. PROCESS AREAS

10.1 Hazard Identification

Equipment within process areas shall be identified as having high, medium, or low fire potential according to [API 2218](#).

Hazards shall be identified using appropriate procedures as outlined in Section 3 and shall be listed in tabular form. This list should give the size of all the hydrocarbon inventories, comprising the total volume of hydrocarbons between emergency shutdown valves, which may include vessel inventories, pipeline inventories, etc. Where the vessel inventory is variable, the relevant amount is that defined by the highest level alarm set point. The list should define hydrocarbon vessel identity, type of hydrocarbon, capacity, maximum anticipated working pressure, means of isolation and anticipated fire types. (See Table 1). Other hazards, local to or on adjacent sites, that might precipitate or escalate a potential fire incident should be recorded as in Table 2.

10.2 Hazard Quantification

Fire hazards will be quantified using an approved technique (see Section 5), which shall identify fire types and quantify their frequency, size, duration and associated rate of release. The thermal load to which the fire subjects both the area in which the incident occurs and adjacent areas should also be quantified.

The degree to which fires are ventilated (if in an enclosed area) or fuel controlled must be assessed, since this will affect the thermal fire load on equipment and structures. (Table 3).

10.3 Exposure Protection

10.3.1 Equipment in and around process areas that could be exposed to significant thermal stresses, which could lead to unacceptable consequences, should be protected, i.e.

- (a) Structures directly or indirectly supporting significant hydrocarbon inventories or emergency systems+
- (b) Structures supporting heavy loads that could fall leading to a further significant hydrocarbon release, catastrophic failure, loss or damage to the control room or emergency systems+



- (c) Hydrocarbon or other plant that could fail catastrophically or lead to further significant releases.

+Emergency systems requiring protection are only those which would be required to control the incident.

Even without fire protection, structures, vessels, valves, etc., can (because of their bulk) withstand fire exposure for a period of time before reaching critical failure temperatures. This period of time is influenced by the size, type and direction of the fire together with the duty of the structure, vessel, etc. Software packages are available to calculate heat input, temperature rise and the stress levels of metal surfaces. These should be utilised, as necessary, during the fire risk analysis.

- 10.3.2 Protection systems may be active, passive or a combination of both and must be rated to ensure that they operate until the fire is extinguished. This will occur either when the fire burns out or the protective system achieves extinguishment.

With the correct type of protection, time to failure will be extended; with the incorrect type of protection no benefit is gained. For example, medium velocity water sprays have been shown to be ineffective in jet fire cases. However, they can extend the period of protection when considering an engulfment or radiative heat fire scenario. Credit can, in certain instances, be taken for the beneficial effect of non-specialist protective devices, e.g. thermal insulation for operational purposes.

Many protection systems require a fire to be extinguished. At the design stage, it must be determined how much extinguishant will be provided or stored on site. In making this decision, account can be taken of the supplies available through mutual aid agreements with adjacent industries or other external bodies. However, on-site supplies must be sufficient to meet the immediate fire fighting needs until the external supplies have arrived and been deployed.

- 10.3.3 Protection may be applied to additional equipment if considered necessary to protect investment and production. In this case either the equipment, or the means by which the criticality of such equipment is assessed, must be specified. This may include for example:-

- (a) Cabling and instrumentation.
- (b) Motors.
- (c) Non hydrocarbon plant.

- 10.3.4 Exposure protection may be achieved by the application of water, which should be considered for cooling, intensity control and personnel escape. In process areas water would be applied mainly by portable monitors and/or hand held hoses. However, fixed water deluge systems and monitors shall be identified where necessary for high fire

potential areas and/or congested areas. Activation of fixed application systems may require automatic initiation, from fire and gas detection equipment, or manual initiation, either local or remote from a permanently manned control centre. The choice of automatic and/or manual activation will depend on factors including fire severity, proximity of adjacent equipment, reliability of detection, access and deployment time of trained fire fighters. In siting the local initiation devices, consideration shall be given to both the type of fire and the need to permit safe access.

- 10.3.5 Where there is a potential for jet/torching fires, water alone may not be effective in protecting adjacent structures and equipment. Passive protection can prevent failure of structural members for a given period under these conditions. However, the use of passive protection for valves, etc., where there is a need for regular testing and service, may require frequent removal and repair of the coating. In these situations, proprietary types of passive protection system, or high velocity active protection with water may be better. For load bearing structures and key equipment, passive protection should be considered and rated on the predicted exposure period and the predicted radiation.
- 10.3.6 Where fire could engulf or impinge upon structural steel or valves critical to continued operation, passive fire proofing should be considered as the primary method for protection.
- 10.3.7 Guidance on the choice of protection method is given in Table 4. This addresses the fire type and the equipment or structure to be protected. Alternative protection methods are indicated where appropriate.

10.4 Extinguishment

- 10.4.1 The choice of extinguishing agent and application method should recognise both the type of fire and location. When the fuel is gaseous, it is not advisable to use active protection methods and successful extinguishment normally relies on isolation of the fuel source. The duration of a fire can, therefore, be minimised by reducing inventories (either by limiting vessel capacity or by the strategic location of isolation) and providing depressurisation facilities. The actuation of shutdown, isolation and depressurisation should be automatic from the fire and gas detection systems or, if a permanently manned control centre is on site, then manual (local or remote) actuation is preferred. Siting of local initiation devices, while needing to be close to the item being protected, should be in a safe location.
- 10.4.2 Extinguishment of pool, pump seal leak and electrical fires can be achieved successfully. The choice of extinguishant and method of application will depend on the type of burning material and

circumstances of the fire. Oil related material fires in process areas can be extinguished using low expansion foam or dry powder applied by portable extinguishers, hand held hoses or portable monitors. Extinguishing agents and propulsion devices for fires associated with petrochemicals within process areas should be confirmed during the fire risk analysis.

10.4.3 Single seal pumps handling materials above their auto-ignition temperatures are regarded as having a high fire potential. As a consequence these pumps normally require fixed protection systems. The systems should be activated manually (local or remote), if a permanently manned control room is on site. The manually operated valves should be located in a safe area, from which the pump is clearly visible. Automatic initiation of the systems may be necessary with low manning levels or unattended installations. The use of double mechanical seals and isolation can reduce the fire risk potential to a point where additional fire protection is not necessary.

10.4.4 Specialised fire extinguishing systems available for use in process areas include:-

- fine water spray
- carbon dioxide (CO₂)
- chemical dry powder
- steam

For details refer to Sections 17.5 to 17.8 inclusive.

11. STORAGE AREAS (EXCLUDING CLASS 0 PETROLEUM AND PETROCHEMICAL PRODUCTS)

11.1 Hazard Identification

The most likely hazards involving hydrocarbon storage tanks include:-

- Fixed roof tank - internal explosion, full surface fire, pool/bund fire, boil-over.
- Fixed roof tank with internal floating roof - as fixed roof.
- Open top floating roof tank - rim seal fire, full surface fire, pool/bund fire, boil-over.



*** 11.2 Hazard Quantification**

The level of radiation to which adjacent structures are exposed will depend on a number of factors, e.g. burning characteristics of the material, wind velocity and direction, geometry and stress levels of structures and elevation of plant relative to the fire source. Radiation, jet/torcing and engulfment fires shall be considered.

The thermal flux to which surfaces are exposed in a fire shall be used as a basis from which protection requirements are determined. The empirical basis for the thermal flux calculations and any computer software shall be approved by the Client prior to use.

11.3 Exposure Protection

11.3.1 For a full surface fire within a tank farm a separation distance of 1.5 to 2 diameters is a good general rule to indicate that unprotected equipment and structures are unlikely to be exposed to excessive heat fluxes. Smaller separation distances indicate that exposure protection will be required, however this rule is not binding. Protection requirements for adjacent vessels and equipment are influenced by:-

- geometry of the structure and or vessel
- metal thickness
- flash point of the stored product
- burning characteristics of the fuel on fire
- nature of the heat source

Software packages are available for calculating these parameters and, if necessary, should be used during the fire risk analysis.

11.3.2 When specified, exposure protection for storage areas containing petroleum and petrochemical liquids of Class I, II(1), II(2) and III(2), (see Appendix A) shall be primarily provided by water cooling applied using :-

- (a) portable monitors, and/or
- (b) fixed monitors, and/or
- (c) fixed pipe systems.

11.3.3 Where there is a possibility of an engulfment fire and where no passive protection is added to the vessel, fixed pipe cooling systems shall be considered. Supplies to these systems shall be fed directly from the fire water main through a valve located in a safe area. This valve shall normally be closed in order to keep the downstream system dry. Actuation of this valve may be automatic or manual (remote or local) dependent upon location and operational requirements. The system

shall be sized to ensure that a continuous layer of water is maintained on the target area. In order to conserve water, the system may be sectionalised so as to limit water application only to those areas exposed to fire.

Rundown considerations:-

- *Spheres or horizontal cylindrical surfaces below the vessel centreline cannot be considered wetted from rundown*
- *vertical or inclined surfaces can permit up to 2 metres of rundown*

The quantity and distribution of the applied water shall reflect the predicted duration and heat input from a fire. A maximum design rate of 9.8 l/min/m² shall be applied to unprotected metal surfaces in the event of an engulfment fire. However, the design rate shall decrease in accordance with the thermal fluxes as calculated in 11.2.

A core question is: how much radiation, or heat, will water absorb? Research using water spray systems (designed to give an even film thickness) indicated that increasing the water application rate would increase the film thickness. However, the benefit of an increased film thickness diminishes because the rate of evaporation is limited by internal heat transfer within the film.

An indication of the relative performance of any system is given by an efficiency factor. This factor indicates the percentage evaporation of the applied water as steam and for water spray systems it was found to be 50% or less. For water applied by monitors, or hoses which are not designed for even film thickness, the efficiency is greatly reduced. A conservative estimate for cooling purposes would be 25%.

Water application to the shell of a tank which is on fire is generally ineffective and a waste of resources. An exception is shell cooling at the liquid level, which may assist in the later stages of extinguishment of a full surface or rim seal fire.

11.3.4

For non-engulfment fires the water quantity shall be calculated in accordance with the radiation flux predicted at the roof and shell surface. The water quantity will be calculated using the principle in the [IP Code, Part 9, Appendix 5](#).

Example to determine the necessary water application rate:-

- *Assume the maximum heat flux received on target = 32 kW/m²*
- *The spray water system does not involve water recirculation*
- *Ambient water temperature max: 20°C*
- *Required maximum target surface temperature 100°C*

- *As a safety factor it is normally assumed that only 25% of the heat of evaporation is taken into account.*

Water absorbs 336 kJ/kg when its temperature is raised from 20°C to 100°C and 2257 kJ/kg when evaporating.

So if allowance is made for only 25% of the heat of evaporation;

$$\frac{2257}{4} + 336 = 900 \text{ kJ/kg may be taken into account.}$$

Radiant heat flux to be absorbed = 32 kW/m² = 32 kJ/m²s

$$\text{Therefore required water application rate} = \frac{32}{900} = 0.036 \text{ kg/m}^2\text{s}$$

11.4 Extinguishment

11.4.1 The appropriate extinguishing agent for storage areas is low expansion foam.

When identified as being necessary by the FRA, the following delivery systems may be considered.

Extinguishment as the sole means of protection shall only be considered if there is a high probability that:-

- (a) the fire can be successfully put out and any consequential fires (e.g. rim seal fires) prevented before failure takes place and,
- (b) re-ignition can be prevented and sufficient residual capacity will exist to extinguish any recurring fire.

11.4.2 The design philosophy for tankage is based on the following concepts:-

- (a) Full surface tank fires cannot be extinguished using traditional portable equipment on tanks greater than 45 m diameter. It is considered feasible using appropriately designed fixed or semi fixed equipment to extinguish full roof tank fires on tanks up to 60 m diameter. For extinguishing full roof fires on tanks of 60 - 100m diameter special high output monitors (18,000 litres /min) and pumps are required. Above 100m diameter it is assumed that full roof tank fires cannot be extinguished.

Trajectory profiles of traditional portable monitors can prohibit their use from the relative safety of areas outside of the bund walls.

- (b) Monitors shall not be considered as the primary means of extinguishment of surface or rim seal fires for tanks over 18 m diameter.
- (c) Foam handlines shall not be considered as the primary means of extinguishment for fixed roof tankage over 9 m diameter or over 6 m high.

Refer to 17.4.2 for details of fixed foam systems applied to tanks.

For information on fighting fires in petroleum storage tanks and foam types see [BP GN 91/17](#).

11.4.3 Foam Stocks

Arrangements should be made at each site for rapid call-up of sufficient quantity and quality of foam for the largest exposure recognised in the pre-fire plan. An additional 50% of the foam requirement for this largest exposure should be available to site within 6 hours.

NFPA 11 Section 3 gives recommended application rates and the duration for which foam supplies must be maintained for specific fuels. These application rates are based on the premise that all the foam solution will reach the burning surface.

However, when using mobile equipment considerable losses of foam may be experienced (up to 60%) before any foam reaches the burning target. The calculated losses will depend on the distance to the tank, the height of the tank, thermal updraft and include an allowance for potential submergence of foam into the burning fuel.

When considering the volume of foam to be kept on site, regard should be paid to the potential for stored products (e.g. polar solvents) to adversely effect the applied foam and the compatibility of different foam stocks. Another consideration is provision of back up supplies of suitable foam stocks from:-

- (a) *Adjacent sites by mutual agreement.*
- (b) *Foam suppliers.*
- (c) *Public or military fire brigades.*

11.4.4 Fixed Roof Tankage

11.4.4.1 High Flash Point Liquids

High flash point liquids (i.e. closed cup flash point of 65.5_C or higher) are normally considered safe in terms of ignition frequencies. Fixed systems providing water or foam extinguishant shall not be required provided the following conditions are met:-



- (a) The temperature of stored liquid does not exceed either the flash point or 93.3°C.
- (b) Liquid streams do not enter the tank at temperatures above 93.3 °C, or within 4.8°C of their flash point.
- (c) Blending with liquids having a flash point below the storage temperature in the tank is not allowed.
- (d) Sufficient fire water supplies are available to cool exposed adjacent tankage in the event of a fire.
- (e) Tank spacing is, as a minimum, in accordance with [NFPA 30](#).

Foam applied to liquid, stored above its flash point, is likely to be destroyed and cause boil-over or frothing.

11.4.4.2 Low Flash Point Liquids

For fixed roof tanks where a weak shell to roof weld is used for emergency venting, foam and/or water piping should be attached below the weak weld in order to prevent its failure.

Where the liquid flashpoint is less than 65.5°C protection shall be either:-

- (a) Sub-surface Foam Injection

This system is designed to discharge foam into the base of a tank, where it will float to the surface of the liquid, unaffected by flames or thermal updraft.

This technique should be used except where tanks contain hydrocarbon liquids with a flashpoint below 22.8°C, alcohols or polar solvents.

Although top pourers are preferable, sub-surface injection is also acceptable as a method of protecting fixed roof tanks which have a lightweight internal floating roof.

or

- (b) Top Foam Pourers

This system is designed to place foam directly on the surface of the liquid through the ullage space at the top of the tank.



This technique should be used for alcohols, polar solvents and hydrocarbon liquids with a flashpoint greater or equal to 22.8° C

This method is sometimes required by national regulations for fixed roof tanks. It is also suitable for tanks constructed with a substantial metal (pan type) internal floating roof.

11.4.5 Open Top Floating Roof Tankage

11.4.5.1 The most frequent fire incidents associated with floating roof tanks have been in the rim seal area. Rim seal fires can burn unnoticed due to:-

- (a) the tank being in a remote location, and/or
- (b) the roof being at a low level because of reduced inventory.

Rim seal fires can burn for extended periods without escalation. However, rapid escalation into a full surface fire can occur if, for example, pools of liquid form on the roof or a flammable atmosphere is created within the pontoon(s).

Further escalation of the fire onto adjacent tanks is influenced by separation distance, the type of liquid on fire, the type of liquid in the adjacent tank, size, roof type, cooling provisions, etc. Without protection, escalation may occur at almost any time, ranging from less than 30 minutes to greater than 24 hours.

The criteria for fire protection and detection need to be established during the FRA and any necessary measures should be primarily directed towards the rim seal area.

This shall comprise:-

- (a) Tanks less than 18 m diameter.

As a minimum a foam dam shall be provided and consideration should be given to provision of external foam/water dry risers, terminating at the top of the access stairway with a hose connection point.

- (b) Tanks greater than 18 m diameter.

As a minimum a foam dam and top-of-seal application semi fixed foam pourers (or proprietary system) shall be provided about the tank circumference. (See also 17.4.1 and Figure 12).

(c) Tanks greater than 45 m diameter.

A cost benefit analysis shall be carried out to determine whether the semi fixed system should be designed to cater for a rim seal fire only or for a full roof fire.

Tests conducted at various sites have shown that foam loss is considerably reduced if the foam dam is located 600 mm (24 in) from the edge of the floating roof.

Full surface fires developed in a tank of about 40m diameter or more will prove difficult to extinguish. A 40 m tank, reliant on monitor application, would require an uninterrupted supply of foam concentrate and water of up to 400 l/min (3%) and 12 700 l/min respectively for 1 hour. For polar products the foam types and application rates are indicated in [BP Group GN 91/17](#).

When a burning hydrocarbon has components with a wide range of boiling points, (crude oil for example) there is potential for a boil-over to occur during fire fighting. The water draining from the applied foam will sink to the bottom of the tank. It is this water that evaporates energetically during boil-over. The resultant damage and danger to fire fighters should be avoided if possible. Therefore, when there is no possibility of extinguishing a large tank fire, adjacent tankage, lines and equipment should be cooled but no foam should be applied to the fire.

- 11.4.5.2 In storage areas containing highly flammable products and/or having minimum tank spacings, and where the response time of a full time fire department is more than 15 minutes, consideration should be given to installation of continuously monitoring fire detection and first strike seal foam application systems about the rim seal area. Consideration should also be given to upgrading to fixed protection systems, which should be capable of remote operation, preferably from a permanently manned control room. Floating roof tanks less than 45 m diameter should be upgraded to the requirements of a tank greater than 45 m diameter.
- 11.4.5.3 The incidence of rim fires shall be minimised by the provision of:-
- effective maintenance,
 - roof earthing arrangements,
 - non-flammable sealing material
- 11.4.5.4 For the safety of firemen, handrailing around the wind girder is necessary for tanks 18 m (58 ft) diameter and above. For tanks greater than 48 m diameter a vertical steel ladder shall be positioned at 180° from the main access stairway (see [BP Group GS 158-2](#)).
- 11.4.5.5 If possible, product pump-out arrangements should be provided to allow operational measures to reduce the duration of the fire.



11.4.6 Bund Fires

Semi fixed equipment can be used for bund area fires. However, where a full time fire brigade with a response time of less than 15 minutes is available, then such incidents should be attacked using portable monitors, or foam hose streams, or both.

12 HANDLING AREAS

12.1 Hazard Identification

The most likely hazards involving petroleum and petrochemical product handling areas include:-

- (a) Class I, II(1), II(2) and III(2) Petroleum and Petrochemical Products:-

Running fire originating from leaks at a manifold, flange, or pump seal.

Pool/engulfment fires on water, on the ground, in drains or bunds.

- (b) Class 0 Petroleum and Petrochemical Products:-

Jet/torch fire from leaks at a manifold, flange, pump seal, or relief valve.

Pool/engulfment fires at ground level, in drains, impounding area or on water.

BLEVE

12.2 Hazard Quantification

Quantification of the fire risk shall use the methods described in section 5.

12.3 Exposure Protection

- 12.3.1 Fire protection requirements should be minimised by good engineering practices in selecting separation distances between loading pumps, berths/loading bays and tankage, the use of ground grading, emergency shut down valves, quick release couplings, etc. (See BP Group [RP 44-7](#) for recommendations on plant layout).



- 12.3.2 A number of factors must be considered. These include:-
- (a) The number and size of ships road or rail cars.
 - (b) The type and size of the berth or loading bay.
 - (c) The products being transferred.
 - (d) The availability, response time and ease of access for effective fire fighting vessels or mobile land based trained fire crews and fire fighting equipment.
 - (e) The source and quantity of water available for fire fighting purposes.
 - (f) The economic importance of the installation.
- 12.3.3 Buoy berths (monobuoys) are not expected to require any fixed fire protection.
- 12.3.4 At installations handling class 0 petroleum and petrochemical products or toxic products there may be a need to supply water for gas dispersion.
- Where deemed necessary by the fire risk analysis remote shut down devices, water mains, hydrants and/or fixed water application systems shall be provided.
- 12.3.5 Where defined personnel escape routes exist, protection may be provided by a water spray system.
- 12.3.6 Island berths should be provided with an approved totally enclosed motor propelled survival craft, located in a safe or protected area. Seating capacity of the survival craft should reflect 150% of the normal complement of operators.
- Life rafts and inflatable lifecraft are not regarded as substitutes for totally enclosed (encapsulated) lifeboats. They are provided purely for man overboard situations when other craft are not available.*
- 12.3.7 Effective ESD valve isolation and fire alarm systems are vital for all flammable liquid handling areas.
- An ESD system should include a single push button, sited in an accessible but safe location, which will shut down the loading pump(s) and isolation valve(s).*
- A fire alarm system would not be required where surrounding installations already have this.*

12.3.8 All marine berths shall have a multi-channel communications system which has the flexibility to cover operations:-

- (a) On a tanker.
- (b) On the berth.
- (c) On adjacent water.
- (d) Elsewhere in the terminal.

One channel shall be capable of dedication to emergency services.

12.4 Extinguishment

12.4.1 Actuation of the system could be automatic or manual (remote or local) dependent upon operational and commercial requirements.

12.4.2 Road/Rail Transfer Facilities

12.4.2.1 Fire fighting at loading and unloading units handling Class I, II(1), II(2) or III(2) petroleum and petrochemical products should be by portable and/or mobile, foam or dry powder, fire extinguishers. In circumstances where fire could result in unacceptable consequential damage to pumps, structures, etc., fixed, low expansion foam spray systems shall be used.

12.4.2.2 Fire protection for Class 0 petroleum and petrochemical products should be by a fixed, dry pipe, water spray system encompassing wide angle, flat-fan spray pattern nozzles. The system shall be designed and sized for an engulfment fire to the side of a road/rail car. Water shall be projected over the whole surface area of the protected road/rail car, i.e. protection should cover both the top and bottom halves of affected road/rail cars.

12.4.2.3 Protection at road/rail car installations shall cover the entire length of the loading bay together with an additional half car length at both ends of the bay. The system shall normally be dry with supply pipework laid below ground to minimise the effect of fire and explosion. Water should be fed directly from the fire water main through a normally closed valve located in a safe area.

Foam introduction shall be undertaken either from fixed or semi fixed units located in a safe area.

Where elevated dry pipe deluge systems are used, the supports shall be provided with passive fire protection rated for 2 hour hydrocarbon fire protection. (see 18.2)



12.4.3 Marine Transfer Facilities

12.4.3.1 Where deemed necessary, loading platforms could be equipped with an array of remote controlled, elevated water or foam monitors (2 for Class I, and II petroleum/petrochemical products, 3 for Class 0 petroleum/petrochemical products). The monitors should be sited to cover manifold areas, both on a ship and on the jetty, and the full length of the loading arms. The additional monitor for Class 0 petroleum/petrochemical products is intended for fire and vapour cloud control.

Foreseeable weather conditions must be considered when assessing the size and location of the monitors. The height of the monitor towers shall be determined by their location, wind effects, monitor capacity, the size of vessels handled, the maximum freeboard laden and unladen, and local tide conditions. Where deemed necessary, primary member supports for the monitors and loading arm risers shall be provided with passive fire protection rated for up to 2 hour hydrocarbon fire, or alternatively water spray coverage in accordance with [NFPA 15](#). (see 18.2).

12.4.3.2 Bunded areas on loading platforms which have solid flooring and contain pumps and/or manifolds should be protected by a fixed foam application system for Class I and II petroleum/petrochemical products, or dry chemical systems for Class 0 petroleum/petrochemical products.

12.4.3.3 Water spray systems provided at heads of jetties should be set at grade level to reduce snagging problems from ship mooring ropes. Spray systems for personnel protection shall be capable of initiation manually or by heat activated devices situated in strategic positions. Operation of the heat activated devices should initiate the start up of the fire pumps (when automatic start up facilities are provided) or initiate an alarm in the central control room (when manual only start up facilities are provided).

12.4.3.4 Fixed water spray systems with remotely operated valves should be installed for the underside protection of wooden jetties.

12.4.3.5 Fire water and foam mains running underneath a berth shall have protection against spill fires on the water. Means of reducing the initiation and priming time for the system shall be considered in order to minimise overheating and possible pipe failure. However, this must be a compromise to limit unacceptable surge pressures.

13. CLASS 0 PETROLEUM AND PETROCHEMICAL PRODUCTS PRODUCTION AND STORAGE AREAS

13.1 Hazard Identification

The most likely hazards to be encountered with Class 0 petroleum and petrochemical facilities are:-

- Jet/torch fire from leaks at a manifold, flange, pump seal or relief valve.
- Pool/engulfment fires at ground level, in drains, impounding area or on water.
- BLEVE.
- unignited leakage.

13.2 Hazard Quantification

Quantification of the fire risk shall use the methods described in Section 5.

13.3 Exposure Protection

Water spray alone will not be effective in protecting adjacent structures and equipment against jet/torching fires. Though some cooling may be achieved, the point of impingement of a jet flame will disrupt the water coverage through turbulence and will be subject to high rates of heat transfer. Passive protection will be needed if the FRA identifies the potential for structural weakening or a BLEVE.

The degree of protection should reflect the period of an engulfment or jet/torch fire impingement on the vapour space of a vessel. The passive protection rating against jet/torch fire can be lowered where localised cooling is provided by a water monitor. A higher protection rating should be provided if the fire risk analysis justifies it. (see 18.1.3)

Many countries are requiring a minimum 90 minute protection for above grade storage vessels against a hydrocarbon engulfment fire. The level of protection afforded should be measured against rapid rise fire criteria. (UL 1709) Recent BP QRA studies, for above grade, pressurised storage vessels, support the need for 120 minute protection against jet/torching and engulfment fires.

13.4 Extinguishment

Extinguishing agents shall be those specifically suited to gas fires, e.g. dry chemical type or medium expansion foams. Application facilities may be fixed or mobile according to the risk.



13.5 Spill Control

13.5.1 Catchment Pits

Catchment pits are generally associated with liquefied storage facilities. Where catchment pits are required to contain a spill, they should be remote from dwellings and normally manned areas both inside and outside of the site perimeter.

They shall be sized to accommodate the largest credible spill and located so that, if the spill is ignited, the radiated heat levels do not endanger important structures, equipment, property or human population.

There are no accepted practices for estimating the largest credible leak for sizing catchment pits. Those catchment pits designed to date range in size between 15 minute leakage at the largest rate of liquid spillage to a full vessel spillage.

The design of a catchment pit could range in size from a simple sump to a complex impounding basin. For small, single tank installations, the requirement could range from a graded concrete base, to a series of open channels. An impounding basin would usually only be specified for large, multi-tank installations.

In general, a series of open channels would carry the liquids away from the tanks and pipework to a remote impounding basin. Vaporisation rate reduction and fire fighting facilities should be tailored to suit the physical characteristics of the liquefied gas being stored.

Vapour releases and/or fire associated with a spill contained in a designated retention pit should be controlled with dry chemical powder or medium expansion foam. Such pits should be fitted with fixed fire and gas detection and a fixed dry chemical powder or medium expansion foam system.

13.5.2 Vapour Control

Water may be used to disperse a cloud of vaporised Class 0 petroleum gases. Monitors and water spray systems which have been installed for exposure protection can be used for this purpose. However, in no circumstances must water be applied directly on to liquid spills, since this will speed up the process of evaporation.

Mobile water curtains consisting of a series of flat-fan spray nozzles on a pipe section or flat-fan spray branch pipes attached to hoses can be used successfully to disperse small gas clouds. They must be deployed manually upwind of the gas cloud.

Permanent water curtains may be installed where there is a very high risk to personnel or third parties beyond the site fence. The cost of water curtains also may be justified if this added protection significantly reduces the potential for loss during an incident.

Foam can reduce the rate of evaporation from liquid spills. Medium expansion foams are the most effective.

14. UTILITIES AREAS

14.1 Hazard Identification

Utilities areas which require fire protection can be categorised as either:-

- (a) areas that contain flammable materials or represent a fire risk, such as closed drains, seal and lube oils, methanol, fuel storage or,
- (b) areas that are essential for inventory and/or incident control such as electrical power generation, switchgear rooms, fire water plant.

Each utility system fire hazard should be quantified in a similar manner to process area hazards - see section 10.1.

14.2 Hazard Quantification

Utilities areas and utilities systems designed to good engineering practices and regulating codes are considered as low fire risks. Special or unique design features should undergo analysis to quantify the potential fire risk.

14.3 Exposure Protection

14.3.1 Where fire protection is required, the primary means shall be to shut down or render the plant safe by use of fail-safe remotely operated controls.

14.3.2 Fire water pumps, compressors, power generation sets and electrical sub-stations are often housed within enclosures to afford weather/noise protection. Where enclosures are fitted with forced ventilation, the ventilation system shall be provided with controls actuated by the fire detection system to:-

- stop the ventilation fans
- close any damper

Ventilation controls shall be both fail-safe and capable of remote operation from a safe location. The controls shall also enable the



ventilation fans and/or dampers to be operated as an aid to fire fighting by effecting smoke and gas dispersion.

The override control of the facilities must lie with the fire fighting team and a safe location would typically be a fireman's panel. This panel would normally be situated in an accessible position adjacent to the main exit from the enclosed area.

14.3.3 Machinery which is supplied with liquid or gaseous fuel, e.g. generation sets, shall be equipped with fail-safe and remotely operated controls capable of:-

- shutting down the engine, the fuel pump, and associated equipment and/or
- isolating the supply from gas pipelines, related fuel vessels or storage tanks.

14.3.4 Hydrocarbon containing equipment housed in enclosures may require fixed fire protection systems because of the potential for gas accumulation and fire spread. Where the operational importance of equipment is identified, the following active fire protection systems shall be considered according to the resultant danger to personnel and damage to equipment as a result of using the extinguishing agents.

- (a) Water spray (dry deluge),
- (b) Sprinklers,
- (c) Foam used with (a) and (b) in a non-aspirated mode, fixed or mobile,
- (d) CO₂ total flooding, fixed or mobile attack.
- (e) Fine water spray,

Table 6 indicates the most suitable of these methods of protection for different utility systems.

14.3.5 Where electrical or hot running equipment is likely to be exposed to water or foam extinguishing agents, equipment specifications shall allow for:-

- (a) a degree of ingress protection,
- (b) thermal shock,

without causing serious damage.



- 14.3.6 With minimum manning levels and/or the need to minimise fire damage, isolation controls and/or fixed extinguishing systems shall be capable of automatic initiation from the fire and gas detection systems. Where safety devices are arranged for automatic operation, these shall be in addition to the manually operated controls.

15. PUMPING STATIONS

15.1 Hazard Identification

Pumping stations have a high fire risk potential. They can handle petroleum and petrochemical products at high temperatures, pressures and flowrates, and are often in remote unmanned locations. In certain instances, hydrocarbons may be at or above their flash point or auto-ignition temperature. The pumps may also require high pressure seal and lubricating oil systems. Pumping stations represent large inventories in the context of the locked-in volume within the pipelines.

15.2 Hazard Quantification

The fire hazards associated with pumping stations should be quantified in accordance with section 5. In doing so, the following points should be borne in mind.

Many fires will be self extinguishing through early detection and the use of automatic shut down and isolation. Pump units may be equipped with fail-safe remotely operated control valves on the pump suction and discharge lines together with remote shut down of the pump. These facilities will reduce the size and/or duration of the predicted fire.

15.3 Fire Protection

Fire extinguishment may be achieved by various agents, e.g. water, foam, gaseous or dry chemical. The type and means of application (fixed or mobile/portable units) shall be determined after considering the speed of response of personnel, predicted duration and size of the fire together with the degree of business loss.

All ESD valves shall be fail-safe. If auxiliary power (hydraulic or pneumatic) is required to drive the valve to a safe position then the actuator, power cables, feeder lines and power packs shall be passively protected. Consideration needs to be given to the requirements for passively protecting the valve body, the line either side of the valve and manifolds.

When shown to be necessary by the FRA, shut down of pumps, ESD valves and operation of extinguishers (where fitted) shall be automatically initiated by means of a fire and gas detection system.

16. BUILDINGS

16.1 Hazard Identification

Building usage, occupancy and business loss impact shall be determining factors when considering appropriate protective measures. Hazards should be defined typically as:-

- (a) Non-industrial buildings where the amount and combustibility of the contents is low are considered as light hazard.
- (b) Buildings where processing and handling of non-hydrocarbon materials is undertaken are considered ordinary hazard.
- (c) Buildings where processing and handling of hydrocarbons and/or other highly combustible materials is undertaken are considered as high hazard.

See [BS 5306 Part 2](#), NFPA or equivalent for detailed definitions.

16.2 Hazard Quantification

The potential size of the fire and duration shall be estimated, both in the incident area and in adjacent areas, together with the potential danger to fire fighters. The degree to which any fire is ventilated (if in an enclosed area) and the likely effect of this on fire behaviour shall be determined.

16.3 Fire Protection

- 16.3.1 Protection of light hazard areas shall be effected by manual action using hand held extinguishers or hose reels. Buildings classified as ordinary or high hazard should have fixed extinguishant systems. As a minimum, the design, construction and fitment of internal fire protection shall conform to the appropriate national/local building regulations.

Requirements for fixed sprinkler or proprietary halon replacement systems shall be assessed on an individual basis. Where fixed sprinkler protection is being considered this shall satisfy the requirements of [BS 5306 Part 2](#) or equivalent.

For proprietary halon replacement systems refer to BP (Custodian) for updated information.

16.3.2 Specialised Protection

Additional specialised protection shall be considered in the case of the following:-

16.3.2.1 Large Computer (CDP) Centres

Rapid response smoke detection may be provided to cover all above-floor areas. Alarms should be the primary level of protection. Where necessary, the detection system can be extended to initiate an orderly shut down of the computers. For unmanned areas conventional smoke detection may be used connected to CO₂ total flood, pre-actioned sprinkler or halon replacement systems. Where fixed CO₂ systems are used a disarming mechanism must be provided at the point of entry into the enclosure. Sprinkler systems will cause a significant amount of damage due to water ingress and this should be considered in selecting an appropriate design.

Automatic CO₂ may be used to protect areas below any raised flooring. The system should be equipped with a pre-discharge alarm and abort switch. There shall also be a means of locking out the system to allow safe maintenance below the floor.

Auxiliary equipment rooms, such as for power supply equipment, may be protected with pre-action sprinklers or provided with smoke detection for alarm only.

All offices, storage areas, floors above and below the computer room and all adjacent areas within the same building should be protected by sprinklers.

16.3.2.2 Process Control Rooms

Control rooms that are staffed on a continuous basis should be provided with smoke detection and an alarm system. In selected locations where there is a risk of fire coupled with periods of unmanning the smoke detection and alarm system may be extended to include an automatic fire extinguishing system.

16.3.2.3 Electrical Equipment Rooms/Buildings

Smoke detection (standard or rapid response) with an alarm to a continuously attended location should be provided. Electrical rooms

within buildings shall be separated from all other building areas by walls rated to give one hour protection from fire (BS 476 or equivalent).

16.3.2.4 Telecommunications Rooms, Archives and Libraries

These areas should be provided with a very early smoke detector systems. If the consequence of fire is a significant commercial loss then consideration should be give to including pre-actioned sprinklers.

16.3.2.5 Laboratory Rooms

Laboratory rooms should be protected by a smoke detection system. Sprinkler protection may also be provided. The interior of ventilation hoods or protective enclosures may be provided with proprietary CO₂ or dry chemical extinguishant systems if there is a risk of escalation of the fire.

PART 3 - TECHNICAL REQUIREMENTS: ACTIVE AND PASSIVE FIRE PROTECTION SYSTEMS

17. ACTIVE FIRE PROTECTION

*** 17.1 General**

The fire protection system, the need for detection, and the interaction of detection and active protection systems shall be subject to approval by the Client.

Halogen compounds (i.e. Halon 1211, 1301 or other products identified within the Montreal Protocol) shall not be used. However, in some jurisdictions their use may be considered if it is defined as an essential requirement: BP must be consulted and give approval of any such case.

17.2 Fire Fighting Water Systems

- * 17.2.1** Water may be used for fire extinguishment, for the cooling of equipment, for the protection of escape routes, and for the production of foam. The basic elements of a fire fighting water system shall be an independent fire grid main (or ring main) fed by permanently installed fire pumps. The ring main and fire pumps shall be sized to provide water sufficient for the worst single potential fire incident identified for the installation. This may include the supply of large fixed water spray systems and fixed monitors as well as mobile attack. Water supply shall be from a source of water capable of supplying the worst fire incident for a duration to be specified by the Client.

The water source could be a storage tank, cooling water reservoir, river, sea, etc., dependent on local conditions.

17.2.2 Fire Water Demands

The fire water demand for any installation shall be calculated using approved fire assessment methods as described in Part 1.

As a guide the total fire water demand for installations having a high potential fire hazard is typically between 800 m³/h and 2000 m³/h.

Water demands for foam manufacture, personnel escape and extinguishment using fixed and portable equipment, shall be calculated according to the risk. Water rates identified in the appropriate NFPA codes shall be used.

Cooling water requirements for the protection of steel structures, hydrocarbon storage and process vessels exposed to thermal radiation shall be calculated in accordance with [IP Part 9, Appendix 5](#).

When calculating the foam demand, due allowance shall be made for losses of foam when using portable equipment. These losses may be due to wind deflection, thermal updraft and submergence during fire fighting. The total losses may add up to 60% of the foam applied during an incident.

Where fire water management systems are employed to conserve water (e.g. split water spray systems), these shall be taken into account when calculating the total fire water demand in that area. For any area or plant the total calculated fire water demand shall be increased by a minimum of two hand branches, each rated at 27 m³/h.

In assessing the total demand for any site, the area or plant with the largest fire water demand shall be the governing factor. However, should this demand exceed 2000 m³/h, consideration shall be given to separation of part of the area or plant in question by passive means (e.g. physical separation by fire walls) to reduce the total demand to a more reasonable level.

Table 7 gives typical fire water demands for various plant types. These figures are provided for guidance only, actual demands shall be assessed as previously indicated.

17.2.3 Fire Water Supply

When the pumps take suction from static storage such as tanks, cooling water reservoirs, tower basins, etc., the available quantity of water is limited. The minimum storage required will depend on the potential fire risks involved, and in particular on the inventory of flammables. For refineries, chemical plants or crude oil/product terminals a minimum of 6 hours supply at full design delivery rate should be provided.

For gas treating plant, provided with satisfactory sectional isolation and a low hydrocarbon inventory, a 2 hour minimum supply is acceptable.

Credit can be taken for make-up. Recovery and recycling of fire water is strongly advised. Such an approach ensures adequacy of supplies together with minimising environmental dangers, drainage and treatment costs.

Many countries around the world prohibit the direct discharge of untreated firewater into water courses.

The quantity of water for fire fighting purposes should be additional to and segregated from, that required for any other user taking water from the same static storage. The piping arrangements should, where possible, be arranged so that other users cannot draw on the fire fighting water capacity.

Where water is taken from static storage, precautions should be taken to:-

- *prevent freezing,*
- *make-up evaporation and user losses,*
- *limit bacterial growth.*

Where the plant to be protected is constructed of stainless steel, (e.g. cryogenic plant handling Class 0 petroleum/petrochemical products) and where the principal source of fire fighting water is saline, an additional supply of fresh water shall be specified. The fresh water should be used as the initial fill of the reticulation, which would allow for the routine testing of fixed systems, washing down of equipment and for fire fighting during the initial stages of an incident. Typically a quantity of fresh water equivalent to 1 to 2 hours pumping at 100% throughput should be provided. After the fresh water supply is exhausted, salt water may be introduced into the system.

Where available, additional emergency water supplies should be obtained through a mutual aid scheme or recycling.

17.2.4 Fire Water Contamination

Foam produced from clean water performs better than foam produced from contaminated water in terms of fire resistance and stability of the foam blanket. However, satisfactory foam performance can be achieved with a limited amount of contamination. (The amount and type of products that can be tolerated should be confirmed with the foam manufacturer). On recycled water systems, settling times should permit disentrainment of oils and/or light ends prior to pumping back into the fire water main.

An alternative source of recycled water could be treated effluent. This would help to minimise the potential for contaminating the water supply with oil. Polar solvent entry into firewater systems will prevent foam generation and, in certain instances, distribute a flammable mixture to the seat of the fire.

17.2.5 Fire Water Pumps

The minimum number of fire water pumps required on any onshore installation with a high potential fire hazard shall be N+1. (N is the number of pumps required to satisfy the maximum fire water demand.)

High potential fire hazard installations shall include refineries, petrochemical plant, crude oil and gas production areas, major storage areas, terminals, jetties and berths. The economic penalty for spare pump capacity at marketing sites is rarely justified, and N pumps are usually deemed adequate. Consideration should be given to providing alternative facilities to cover the situation where one pump is out of service and the standby pump (if provided) fails to start. This may involve the installation of a second standby pump, mutual aid schemes, provision of temporary or transportable pumps during periods of maintenance on a permanent unit, use of cooling water supplies, and use of tugs' or ships' fire water pumps on jetties or wharves.

The fire water pumps should be sited to avoid:-

- tidal flooding, or
- site fire, or
- flammable gas, or
- collision damage.

Permanently installed pumps shall have flooded suctions. They shall be capable of operating in parallel and should be of identical rating.

The pumps shall comply with BP Group [GS 124-1](#). When operating at the duty point, the pump(s) shall supply the total water requirement whilst sustaining a pressure of between 8 and 10 bar (ga) at the furthest point of the system, dependent on the throw requirements of the monitors. The pump characteristics should conform with [NFPA 20](#).

When calculating the required pump discharge head, water shall be assumed to be flowing through all sections of the grid, with no portion out of service. Pressure drop calculations shall be based on the maximum fire water demand, including direct fire fighting and associated cooling requirements. Flow and pressure drop calculations shall include allowance for static and frictional losses.

The pump suction manifold, power and fuel supplies, and any other utilities shall be designed such that all installed pumps can be run simultaneously.

Pump suction lines shall be positioned in a protected location and incorporate permanent, but easily cleanable, strainers or screening equipment.

Where fire and cooling water pumps take suction from a common source, the capacity of any common inlet screens should allow both fire and cooling water pumps to operate together at their respective design outputs.

The NPSHA should be determined for the minimum water level condition excluding wave effects, where relevant. This will correspond to the maximum water temperature in combination with the following, as appropriate:-

- Minimum level in sumps
- Lowest astronomical tide
- Maximum drawdown in caissons
- Maximum drawdown in wells

When a pump operates in a well or caisson, the level of water may drop relative to the external water level. This difference is referred to as drawdown.

Additionally, allowance shall be made for any wave effect, if applicable, when the minimum trough exceeds 10% of the NPSHA under continuous conditions as determined above.

If the risk of fouling is high, strainers must be arranged in parallel and it shall be assumed that 50% of the strainers are blocked when determining the NPSHA.

Additionally, a ten percent margin should be provided on the calculated NPSHA to cover inaccuracies in estimates of the suction conditions. It will also cover temporary losses due to modest fouling of the strainers.

The pump's discharge line should be fitted with a pressure controlled dump valve for testing purposes and to ensure a minimum flow for cooling. The dump line shall be fitted with a flow element capable of measuring 150% of the rated pump capacity so that pump performance required by [NFPA 20](#) can be monitored.

17.2.6 Fire Pump Drivers

Steam turbine, electric motor and diesel engine driven pumps may be provided but gasoline engine driven pumps shall not be permitted. Any combination of steam turbine, electric motor or diesel engine may be used at an installation or site subject to the following:-

- (a) Whenever possible, at least one fire pump should be electric motor driven, in order to achieve fast starting and generally high reliability.
- (b) The selected driver types should not permit a common mode failure between pumps, thereby ensuring that an incident or fault affecting one pump does not affect another.



In areas subject to low ambient temperatures diesel engine fuel tanks and lines should be insulated and heated to ensure fuel availability or be supplied with an appropriate grade of diesel fuel. The choice of steam turbine and electric drivers shall take into account the reliability of steam and power supplies.

* 17.2.7 Fire Pump Control

Pump control panels shall be located adjacent to the pump driver. Fire water pressure adjacent to the pump discharge manifold and at extremes of the ring main should be indicated at the nominated remote location. For electric motor driven pumps, the control arrangements shall comply with BP Group [RP 12-4](#).

A permanently manned central control room, or fire station control room, shall be provided with manual fire pump start facilities. An audible alarm shall be provided in the nominated control room indicating a sudden change in the fire main pressure. The alarm pressure setting shall be subject to approval by the Client.

In installations with a high potential fire hazard, additional manual start locations should be considered.

At unmanned or only manned part time locations, or when required by local or national regulations, the fire pumps shall be provided with automatic start. The initiation can be from the manual alarm call point system, fire and gas detection system or pressure loss in the fire main.

Consideration must be given to the risks involved with the sudden increase in line pressure that could result in possible injury to personnel using fire hydrants or associated equipment.

17.2.8 Fire Mains

* 17.2.8.1 General Requirements

All new systems and major extensions to existing systems should be subject to:-

- a full hydraulic analysis to ensure that the required water quantities can be delivered for all major fire scenarios, and
- a surge study to identify unacceptable high pressure transients during fire main operations.

Hydraulic analysis and surge study computer programs shall be approved by the Client.



Fire mains should be of steel construction. When the water is classified as aggressive, the pipe should be lined with cement mortar in accordance with the requirements of BP Group [RP 42-1](#) and BP Group [GS 106-1](#). Linings may not be necessary when dry fire mains are used. Fire mains in alternative materials shall be approved by the Client.

The design pressure of the system and its components should be equal to or greater than the shut-in pressure of the fire pumps plus any allowances to be made for differences in elevation between the fire pump discharges and the lowest point. This philosophy eliminates the need for over pressure protection (e.g. relief valves) within the fire water system.

When the above philosophy results in high design pressures, advantage can be taken of the intermittent use of a fire main and pressure level excursions allowed by the design code [ANSI B31.3](#).

Fire main piping should be at least NPS 8 with laterals being NPS 6 minimum. At sites where future expansions are foreseen the pipe sizes should anticipate the likely future water demands.

At extremities of the fire main system suitable valved and blanked flushing points shall be provided.

17.2.8.2 Land Based Applications

The fire main system shall be designed as a grid. Process area blocks shall be enclosed by elements of the grid with loops along each of the four sides.

Fire mains should be routed adjacent to roads and other routes to provide easy and safe access to hydrant outlets and operating valves for fixed systems.

Fire mains shall be below grade in process areas, up to the battery limits. In storage areas fire water piping shall be located outside tank bund walls. Where fire water lines cross tankage areas inside bund walls, piping shall be buried to provide protection from spill fires. In cold climates where no provision is made for maintaining a small continuous flow of water through the main to prevent freezing, fire water lines should be buried below the frost line. A dry pipe system installed above grade may be provided in a cold climate if burying is not a viable option. It shall be sloped to drain valves and designed so that the portion above grade can be shut off and drained when not in use. In locations where freezing is not a problem, fire mains may be located above grade.



Above or below grade mains run alongside roads in remote areas should be designed to avoid traffic impact.

Steel fire water lines buried in areas containing cathodically protected structures shall normally be bonded into the cathodic protection system or otherwise protected against anodic/cathodic interference damage.

Isolating valves shall be provided at grid intersections, at the centre of long loops, and at each fire pump discharge. The valves shall be located so that any section of the grid can be taken out of service and water will still be available through adjacent sections to protect all plant areas. Fire main isolating valves shall be located such that no more than six hydrants or systems and monitors having a single feeder will be capable of isolation within any one section of the fire main. Buried isolating valves shall be the indicating type, identified by permanent signs displaying the valve purpose, and protected against damage from vehicles. Plant and equipment location in relation to fire hydrant positions shall be reviewed to determine the minimum use of isolation valves to provide reliability. Isolating valves shall be provided, adjacent to the main, on branch lines feeding fire fighting equipment other than single fire hydrants. Isolating valves shall be in accordance with BP Group [GS 162-1](#).

Mains that are to be kept full of water, shall, by a cross connection from a suitable water supply such as cooling water, static water tank, or pressurising (jockey) pump, be maintained above 1 bar (ga) at the highest point to prevent the ingress of air. The cross connection shall be provided with a non-return valve to prevent backflow of water when the fire pumps are started. No cross connection shall be taken from a system supplying domestic or drinking water.

* 17.2.8.3 Jetty Applications

Jetty fire mains designed to be dry during winter periods, shall have a priming time acceptable to the Client. This time shall be determined by hydraulic analysis.

Priming of the dry main shall be through an isolating valve, remotely operated from a control room. A manual override facility shall be located at the jetty access point and adjacent to all fixed system operating points.

Jetty fire mains shall be sloped to a drain valve, operable from the jetty deck.



The priming time of the fire main system can be influenced by such factors as the operational manning levels and back up fire fighting facilities available on site and from outside sources.

* 17.2.9 Fire Hydrants

All hydrant outlets shall be compatible with the national design code applicable to the country of operation. Fire hydrants shall be located in process areas at between 33 and 45 m centres alongside accessways and roadways. Any portion of a plant shall be accessible from adjacent hydrants by a 70 mm hose with a maximum length of 78 m. Hydrant location shall be such as to permit equipment to be reached from at least two opposite directions. Hydrants shall be located so that they may also be used to protect equipment in adjacent units or areas. When there is a danger of hydrants being damaged by vehicular impact, the hydrants shall be protected by guard rails.

Where there is a likelihood of hydrants being damaged in any incident involving explosive overpressure, the design of the hydrant shall be agreed with the Client.

Consideration shall be given to making hydrant outlets of the dual pressure type:-

- high pressure supplies shall be able to deliver water at full system pressure for monitors.
- reduced pressure shall be for hand held hoses.

Dual pressure outlets should be normally set to the low pressure mode; changeover to high pressure shall be by a simple local operation, e.g. by the movement of a lever on the hydrant outlet assembly.

All hydrant risers protecting a process area and located along a road or accessway shall be NPS 6, fitted with four 70 mm valved hose connections or alternatively a single 100 mm outlet and two 70mm outlets. Where a hydrant riser is placed within a process area and is not adjacent to a roadway, the riser shall be no less than NPS 4, with two 70mm valved hose connections.

In storage areas fire hydrants shall be NPS4, with two 70 mm valved hose connections, and located along the roadway at predetermined risk sources. In tank farms there should normally be a minimum of two hydrants in each bund area. Where there are tanks of 46 m diameter or larger, NPS 8 hydrants with at least six 70 mm hose connections or a single 150 mm outlet and four 70 mm outlets, shall be used.

Hydrants adjacent to cooling towers or in the vicinity of small hydrocarbon storage tanks shall be NPS 6 with two 70 mm valved hose connections or alternatively a single 100 mm outlet with two 70 mm connections.

Hydrants in administrative areas, work shops and other non-process areas shall be located in accordance with [NFPA 24](#) or equivalent. NPS 4 hydrants with two 70 mm valved hose connections placed on a maximum of 77 m centres shall be used.

On berths using hose streams as the primary protection, hydrants shall be located on a maximum of 31 m centres. Wet barrel type hydrants may be installed comprising NPS 4 hydrant riser with two 70 mm valved hose connections. Suitably designed and located pump-in points shall also be provided for tug or mobile appliance connection.

Consideration should be given to the method for maintaining the fire tug safely on station, accessing the pump-in points, and preventing overpressure and reverse flow.

In other areas, NPS 6 hydrants with 70 mm valved outlets shall be strategically located to cover areas where foam may be required for fire fighting.

The connections from all outlets shall be compatible with local emergency services connections.

Cast iron or fabricated carbon steel, self draining, compression type or flanged hydrants shall be used in cold climates. Cast iron hydrants shall be approved by a recognised certification agency. Hydrant assemblies shall be provided for a normal working pressure of 10 bar (ga), and should have a design pressure equal to or in excess of the design pressure of the fire main. Cast iron hydrants shall be provided with a replaceable 'breakable' barrel section designed for minimal leakage when closed. Compression-type hydrants are not suited for installation above grade but are designed for use with buried mains.

Wet barrel hydrants shall be used in warmer climates where freezing is not a problem or where a dry pipe fire main is provided. Such hydrants are suited for above grade fire mains. Each hose connection shall be valved. The barrels shall be hot-dip galvanised after welding.

Clay soils may prevent water draining from the 3 mm bleed hole, therefore it may be necessary to provide water drainage by excavation and infilling with medium sized (25 mm to 75 mm) stones.

To prevent corrosion by seawater, corrosion resistant tappings should be considered.

17.2.10 Monitors

17.2.10.1 Monitors to be considered include:-

- permanently located, fixed or oscillating, installed at grade or elevated
- portable, traditional or high throughput

Permanently located monitors, at grade or elevated, may be used when they can be located so as to protect more than one item of process equipment or where their use is more effective than a fixed water spray system for fire fighting.

Monitors are effective for vapour cloud dispersion and cooling fire exposed equipment, as well as for fire intensity control. They can be used to flush burning flammable liquids away from equipment, provided care is taken not to spread the fire. Portable monitors provide additional flexibility in fire control operations and can be provided for supplemental water cooling.

For marine facilities permanently located monitors shall be provided with dual control, i.e. remote and local. The local control is intended for maintenance purposes only, and shall not be used in a fire incident in view of the hazards for personnel. The remote control point should be at least 50 m from the loading arms and with a clear view of the loading platform. Foam monitors shall be provided with valving to enable supply with either water or foam solution. This valving shall be controlled from the monitor remote control point.

The following factors shall be considered when siting permanently located monitors:-

- (a) physical obstructions between the monitor and protected equipment.
- (b) local wind conditions where shifting wind patterns may block use of monitors or reduce effectiveness of protection.
- (c) Accessibility: to ensure minimum risk to operating personnel during a fire.
- (d) Vertical and horizontal trajectory pattern. The minimum and maximum distance from protected equipment should be 15 m and 30 m respectively.

Water supplies to permanently located monitors should be through a normally closed clack or flexible sleeve valve. Operation of the valve may be manual, remote or local dependent upon the risk. The valve

shall be located so as to permit safe access during a fire situation and shall permit local override by emergency services personnel.

Monitors provided with automatic operation shall be supplied with water from two different sources. These two sources may be from the same reticulation system but there shall be at least one fire main isolation valve between the two offtakes.

Monitors may be fixed or automatic traverse (water powered type) dependent upon the risk.

17.2.10.2 Fixed Water Monitor

Fixed water monitors shall be of the hand lever operation type, with locking devices, and should allow full rotational movement of 360° and elevation movement from 15° below horizontal to 35° above horizontal. The monitor nozzle shall be of the variable type with a water discharge pattern ranging from straight stream to fog. Each monitor shall be provided with a NPS 4 quarter turn ball valve at the inlet. For elevated monitors consideration should be given to remote operation from a designated control point together with local manual operation from grade.

Fixed water monitors at ground level shall have a straight stream range of at least 36 m in still air conditions at the normal water operating pressure.

Whilst monitors should normally be located at least 15 m away from the ground level equipment to be protected, it is permissible to reduce this distance to a minimum of 12 m if the monitor is located inside a process unit.

If permanently charged, care should be taken to ensure that any leakage from the monitor does not accelerate corrosion of pipework and equipment located beneath the monitor. Charging times of dry legs associated with elevated monitors need to be adjusted to minimise surge pressures.

The base support requirements need to be addressed during the design phase to minimise the potential for overturning moments.

When a monitor to cover elevated equipment is located within 15 m of ground level equipment, the ground level equipment shall be covered by a neighbouring monitor.

As an alternative to elevated fixed water monitors consideration may be given to the use of portable monitors attached to telescopic fire towers or cranes.

Oscillating monitors shall be oscillated automatically in the horizontal plane by the fire water when flowing. They shall be able to operate in either automatic oscillation or manual mode by operation of a lever. The nozzle shall be variable to discharge a pattern ranging from straight stream to fog. Vertical nozzle orientation shall be manually adjustable and lockable at a suitable position. To avoid clogging, the automatic oscillation mechanism shall be of the rotary type and not of the piston type.

17.2.10.3 *Portable Monitors - For details refer to [BPGN 91/17](#).*

17.2.11 Fixed Water Spray Systems

These may be used for:-

- Exposure protection of personnel, structural steel members, critical valves and vessels
- Control of burning
- Dispersing flammable and toxic vapour clouds
- Extinguishing fires, normally in conjunction with foam

For applications see Table 8.

Systems for plant exposure protection and control of burning shall be designed and installed in accordance with [NFPA 15](#) or equivalent.

Systems for personnel exposure protection within complex and congested structures, together with those for the dispersion of flammable and toxic vapour clouds, require more onerous nozzle designs and piping arrangements. Such systems should be developed by a specialist water spray company.

Where cooling water may be sprayed onto the top of a fixed roof tank, a deflector plate should be located at the edge of the roof to ensure that water is deflected onto the shell.

Where the source water is corrosive or brackish it is recommended that:-

- all pipework be NPS 2 or greater
- nozzle openings be not less than 8 mm diameter
- pipework materials be stainless steel, cupro-nickel or fire protected GRP
- strainers be installed at strategic points

- lockable drain valves or drain holes be provided

Water supplies to multiple dry pipe systems fed from a single deluge valve should be through a normally closed flexible sleeve valve. For single systems check valves are acceptable. Operation of the deluge valve may be either automatic or manual, remote or local, dependent upon the risk. The valve shall be located to permit safe access during a fire incident. Dry pipe systems incorporating automatic valve opening shall be supplied with water from two different sources. These two sources may be from the same reticulation system but there shall be at least one fire main isolation valve between the two offtakes. One offtake shall be routed to the deluge valve and then to the distribution pipework. The second offtake shall by-pass the deluge valve and be connected directly to the distribution pipework. This second source shall be isolated by a normally closed, manually operated, valve. Sufficient valving shall be provided to permit maintenance to be carried out whilst sustaining water supplies to the dry pipe system.

17.3 Area Drainage

Adequate provisions shall be made to promptly and effectively contain and/or dispose of all liquids from the fire area during operation of all fire water systems. Such provisions shall be designed to accommodate:-

- Hydrocarbon spillages.
- Fire water and foam discharged from fixed systems at maximum flow conditions.
- Fire water and foam discharged by hose streams and monitors.
- Rain water.
- Other water sources.

The following methods of disposal or containment shall be considered:-

- Grading
- Bunding (Diking)
- Trenching
- Underground or enclosed drainage

The method adopted will be dependent on:-

- extent of the hazard

- clear space available
- protection required

Where the hazard is low, the spacing is adequate, and the degree of protection required is not great, grading alone is acceptable. Where these conditions are not present, consideration should be given to bunding, trenching, or underground/enclosed drainage.

Many countries recognise there are environmental hazards associated with all drainage, including that used for fire protection, and are formulating appropriate policies. A policy document on the containment of fire water and chemical spills in the UK is currently being prepared by the National Rivers Authority for the Health and Safety Executive. Issue of the draft document is expected in late 1994.

Bunding and drainage requirements should be in accordance with BP Group [RP 4-1](#).

17.4 Fixed Foam Systems

17.4.1 General

Permanently installed foam systems shall either be semi fixed or fixed.

Semi fixed systems are those comprising permanently installed foam distribution equipment but requiring manual intervention to connect up foam making equipment.

Fixed systems are those comprising permanently installed foam distribution equipment and foam making equipment. These may be initiated automatically or manually with remote or local control.

The selection of semi fixed and fixed systems shall be based on the level of risk, with special attention paid to the risk to personnel required to operate a semi fixed system in an incident.

The main areas where permanently installed foam protection systems may be used are:-

- tanks storing Class I(1), II(2), III(2) petroleum and petrochemical liquids.
- tanks storing Class III(1) petroleum liquids that are heated near or above their flash point.
- Class I petroleum and petrochemical product loading/unloading racks.
- enclosed process areas.
- Class 0 petroleum and petrochemical liquids spill protection.
- pier and wharf protection.



Fixed foam systems shall not be provided for Class 0 tankage.

Table 9 summarises the suitability of different types of foam.

Table 10 lists foam application rate and minimum supply requirements. This table relates to hydrocarbon liquid tanks with a maximum polar solvent content of 10%.

Considerable problems have been experienced in bag tank foam systems and their use is not recommended. Positive induction pelton wheel systems are preferred. Minimum fixed system foam stocks should relate to the time required to bring forward and charge additional supplies from another source.

When the polar content exceeds 10% refer to the Custodian for guidance.

A major factor that may influence the selection of foam is the need to be compatible with the stocks and equipment of external/mutual aid fire teams.

For further details of the properties of foam refer to BP GN 91/17.

17.4.2 Tank Protection (Excluding Class 0 liquids)

Table 5 summarises the foam requirements for fire extinguishing of storage tanks containing Class I, II or III(1) liquids based on the diameter and type of tank. The fire protection requirements for heated tanks containing Class III(1) liquids shall be evaluated on an individual basis.

Foam systems (including any necessary foam dams) for storage tanks shall comply with the requirements of [NFPA 11](#) or equivalent. All inlet connections shall be compatible with the national design code applicable to the country of operation.

For fixed or semi fixed systems, the battery limits for foam feed shall be in a safe location outside the bund wall. Piping shall allow supply of all foam chambers from a single source. The battery limit piping shall terminate in a single foam solution inlet connection and all valves controlling the routing of foam solution supply shall be located downstream of the foam solution connection, outside of the bund wall.

Manifolds and valving, required to supply more than one tank from a single foam inlet, shall be located outside of the bund wall. All piping runs within the bund area should be as short as is reasonably practicable.

Clear signs should be installed at the foam inlet point giving the operating conditions required for foam making, and, in the case of manifold feeds, indication of which valve corresponds with which tank.

Strainers shall not be used on the inlets of foam makers in order to minimise the possibility of clogging. The air inlets of foam makers shall be arranged to prevent rain and debris falling into them and to prevent blockage by snow.

Accessibility for maintenance of foam equipment/pourers must be considered during the design phase.

17.4.3 Loading/Unloading Racks (Class I Petroleum and petrochemical Liquids) and Enclosed Process Areas.

Permanent protection for loading/unloading racks or enclosed process areas shall comprise fitted foam and water spray system. The design shall cater for a spill covering an area extending 1.5 m in all directions from the edge of the trucks or rail cars serviced by the rack, or the equipment within an enclosed area. Unloading racks need only be protected on the side of the valve assembly.

When drainage and/or containment is provided, the entire containment or drainage area shall be protected if it exceeds the area defined above. When no drainage or containment is provided, the spray shall be arranged to discharge over the area required, but the application rate and quality of foam required shall be based on a spill area that extends 6 m in all directions from the edge of the trucks or rail cars serviced by the rack.

The piping to the spray system shall be laid below ground to minimise fire exposure.

For incidents involving polar solvents, alcohol resistant foams shall be used. For non-polar solvents, non-aspirated foam types are preferred.

The density and duration of foam application shall as a minimum equate to 6.5 l/min/m² of protected area for 10 minutes. Activation of the system shall shutdown all loading/unloading pumps, associated valves within the effected area, and enclosed process plant.

Water and foam supplies to these dry pipe systems shall normally be held closed by a clack or flexible sleeve valve. Operation of the valve(s) may be automatic or manual, remote or local, dependent upon the risk. The valve(s) and foam stock shall be positioned to permit safe access during a fire situation.

17.4.4 Class 0 Petroleum and Petrochemical Liquid Spill

The following design criteria shall be used for medium expansion foam protection of spill retention basins, pump pits, and other confined areas.



- (a) The medium expansion foam liquid concentrate and foam generators shall be approved by a recognised certification authority.
- (b) The expanded foam produced shall have an expansion ratio of approximately 150:1.
- (c) The expanded foam solution application rate shall be double the rate for normal hydrocarbons.
- (d) Foam generators shall be located to ensure delivery of medium expansion foam to the area under prevailing wind conditions.
- (e) The quantity of foam concentrate and water required shall be determined based on the required density of foam to cover the spill area and the time required for the liquid spill to vaporise.

17.4.5 Marine Facilities Protection

Foam installations shall incorporate a bulk foam concentrate tank of at least 2.25 m³ capacity. However, if fixed or mobile monitors are included, the tank should be sized for a minimum of 20 minutes supply for all items of equipment required to operate simultaneously. Foam concentrate may be induced or injected depending upon the availability of equipment and the reliability of the power supplies. The tank shall be located at the shore end of a jetty or landing stage, with access to permit refilling from a bulk foam carrier. Proportionators may be located on the shore or on the jetty head. For an island berth the tank shall be located remote from the main fire risk areas. A foam concentrate or solution line should be provided from the tank to the berths. Similar offtakes as required for the fire main, should be provided at intervals not exceeding 45 m on the berth and jetty approach arm if using a foam solution line.

Consideration should be given to fixed or mobile foam generating and distribution systems according to local conditions. Mobile extendible booms or hydraulic platforms (snorkels) are preferred to fixed tower monitors, when land access permits, and/or fire tugs can approach from one side of the berth only. At those locations where fire tugs are available at all times and can approach from both sides of the berth, fixed foam or water monitors may not be required.

In general, fire fighting facilities on berths are provided for the protection of the installation and not for ship fire fighting. However, this division of responsibilities should be confirmed.

17.5 Gaseous Extinguishants

* 17.5.1 Halons

Usage of halons is controlled by the Montreal Protocol and/or European Commission Regulations and signatory countries are expected to cease production and usage by the year 2000. In the interim, supplies for existing fixed systems will become difficult to obtain and expensive. Proposals for new facilities shall be restricted to essential use (see Appendix A for definition) and subject to approval by the Client.

There are no immediate replacements for halons traditionally used for fire extinguishing purposes. While alternatives are coming onto the market, these are being subjected by users, government authorities, licensing approvers and manufacturers to physiological, environmental and fire extinguishing tests. Updated information is available from BP (Custodian).

17.5.2 Carbon Dioxide (CO₂) Systems

17.5.2.1 Fixed CO₂ systems shall only be used when no alternative solutions are available. No total flood system shall be capable of automatic discharge while persons are within the enclosure.

CO₂ release may be damaging to the environment and it's continuing use is subject to governmental debate. Concentrations required for fire extinguishing purposes can cause asphyxiation.

CO₂ as an extinguishing agent possesses low electrical conductivity is non-wetting, and does not cause damage to equipment.

The primary use of CO₂ is the suppression of Class 0, I and II petroleum and petrochemical products and electrical fires. CO₂ shall only be used where the use of water, foam or dry powder would damage the equipment and result in significant business loss or capital replacement cost. CO₂ shall be used in either:-

- (a) portable and wheeled fire fighting equipment or,
- (b) fixed total flooding systems (enclosure protection). These may be initiated automatically or by remote manual action.

The installation of fixed carbon dioxide systems shall be based on a risk analysis founded on the criteria of Section 5 of this document.

17.5.2.2 CO₂ systems can be considered for the following applications:-

- transformer rooms
- engine control centres



- enclosed machinery
- vents which release flammable gases to the atmosphere
- flammable liquids stored in open containers
- basements of computer rooms
- switchrooms containing oil-filled switchgear.

17.5.2.3 The design of the system shall be governed by [BS 5306](#) Part 4, [NFPA 12](#), or an equivalent standard. The minimum acceptable standards shall be:-

- a design concentration of not less than 34% by volume of CO₂.
- the minimum design concentration should be achieved in a maximum time of 1 minute.

In cases of combustible materials that sustain deep-seated fires or equipment needing a significant run down period, the minimum design concentration should be reached in a maximum of 7 minutes, but the discharge flow should ensure that a concentration of 30% is achieved within 2 minutes. This concentration shall be capable of being retained for up to 30 minutes.

17.5.2.4 Where a total flood system is fitted to an enclosure which can be entered, then personnel should be protected by the following:-

- (a) local alarms, both audible and visible
- (b) positive isolation
- (c) warning signs

Means to indicate the state of the system shall be provided in accordance with BP Group [RP 30-5](#) Section 4.

Following a CO₂ discharge and/or an extinguished fire, personnel should only be allowed to enter an enclosure if:-

- (a) *They are equipped with self contained breathing apparatus and,*
- (b) *The ventilation system has been operating for a sufficient period of time to clear the atmosphere. In enclosures without installed ventilation and areas such as voids, portable mechanical air movers should be used to clear the atmosphere. Test equipment should be used to ensure that the oxygen content of the atmosphere has returned to normal.*

17.5.3 Steam Systems



Steam is not an efficient fire fighting agent, however, when an installation has steam for operational purposes then it may be utilised for fire protection.

Steam flooding systems can, according to the risk, be considered for:-

- compressors and associated equipment,
- flammable gas purging,
- pumps with products at high temperature,
- flanges in hydrogen rich streams,
- enclosures processing molten sulphur,
- ovens and furnaces,
- sumps that may contain oil or flammable liquids sited in or adjacent to high risk areas.

Because of their ability to produce static electricity, systems employed for purging flammable gas clouds should be designed to eliminate any accumulations.

No complete standards have been developed for steam smothering systems.

17.5.3.1 Local Application (Manual)

For personnel safety reasons the steam needs to be visible saturated and not more than 7 bar(ga) pressure.

Systems comprise of a pipe connected to a reliable source of steam which will supply hoses, for discharge through a hand held lance, or a fixed ring about a pump or flange.

Pipework shall have automatic steam traps at low points. Connection to the hose points shall be:-

- isolated with a gate valve,
- located to permit easy access to the protected equipment, and
- the hose length shall be selected accordingly.

Hoses shall be light weight, non-rollable type, rated for the pressure and temperature of the steam, resistant to contact with hydrocarbons, electrically continuous and earthed against static electricity.



The steam discharge nozzle shall be made of metal and coated with a thermal insulation that permits handling by the operator without risk of burns. See Figures 10 and 11 for details of steam lance typical arrangements.

17.5.3.2 Total Flood Systems

Fitted steam systems shall only be used where they cannot injure personnel. They shall comprise pipework fed from a suitable steam main with nozzles to direct steam towards the protected equipment.

The pipework should be sized to supply the largest steam flooding demand and shall be as a minimum NPS 4.

Steam pressure shall not exceed 14 bar (ga). The steam flooding header should be located no less than 15 m from the risk to be protected. In open areas, the prevalent direction of the wind shall be taken into account.

See NFPA 86 Appendix F for details.

17.6 Chemical Dry Powder

The use of dry powder should normally be limited to portable and mobile equipment with a maximum capacity of 250 kg. Chemical dry powder systems can be considered for the following:-

- open containers with flammable or combustible liquids
- electrical risks - other than where chemical dry powder can damage components or elements
- Restaurant and commercial hoods, ducts and associated cooking appliances
- release of flammable gases

Extinguishment of an uncontrolled discharge of flammable liquids or gases may result in a subsequent explosion hazard.

The discharge of large amounts of dry chemical may create hazards to personnel such as reduced visibility and temporary breathing difficulty.

The design of fixed systems shall be in accordance with [NFPA 17](#) or equivalent.

17.7 Fine Water Spray

Fixed 'fine water' spray systems are recent developments (1993) designed to replace halon. An example is the BP/Ginge-Kerr 'Firespray', which has a demonstrable ability to extinguish pressurised hydrocarbon fires in enclosures (e.g. engine rooms, pump rooms, gas turbines) and on pumps in open locations.

Extinguishment is achieved in seconds. The device only needs a small amount of water, which minimises secondary damage. In addition to extinguishment the spray reduces surrounding temperatures, suppresses smoke and absorbs toxic gases. The system has licensing authority approval.

Cost of a fitted system is comparable to a CO₂ system of similar duty. Updated information is available from BP (Custodian).

17.8 Others

Though not commonly recognised, nitrogen has a defined place as a fire extinguishing agent. It is recommended for fire protection of hot bitumen storage tanks and has also been used for hot oil furnace stacks. No complete systems for nitrogen smothering systems have been developed. The nitrogen requirement should be calculated in order to reduce the oxygen content in the tank or stack to below 12%.

Systems have been developed using engine exhaust gases but little is known of their effectiveness or design parameters.

18. PASSIVE FIRE PROTECTION

18.1 General

18.1.1 Fire resistant materials can afford primary protection of:-

- (a) structures directly or indirectly supporting significant hydrocarbon inventories or emergency systems.
- (b) structures supporting heavy loads which, if they were to fail, would lead to a significant hydrocarbon release, or catastrophic failure, loss or damage to a control centre or emergency system.
- (c) Class 0 hydrocarbon storage vessels or other plant that could fail catastrophically or lead to further significant releases.

In addition, they may be applied to critical equipment and structures in order to protect investment and production.



- 18.1.2 The quantity and quality of fire proofing material applied for protection of unpressurised storage vessels shall ensure that carbon steel plate sections in the vessel vapour space do not exceed 593°C through the predicted duration of the fire. For pressurised storage vessels the maximum temperature shall be 400°C. For alloy materials a more appropriate maximum should be established. For structural columns and beams the quantity of applied fire proofing material shall ensure that the permitted deflections identified in [BS 5950 Part 8](#) are not exceeded through the predicted duration of the fire.

In hydrocarbon areas, fire resistance ratings for jet or engulfment fires or radiative heat shall be determined by means of an internationally approved high intensity hydrocarbon test. In non-hydrocarbon areas the fire resistance rating may be selected from a standard time versus temperature test programme.

- 18.1.3 Where the predicted fire duration in hydrocarbon areas is greater than 10 minutes, structures and equipment outside the flame but exposed to high radiation levels may also require passive protection. Critical plant receiving less than 44 kW/m² for 60 minutes does not generally need protection.

Fires which are likely to cause damage to structures or equipment are those resulting from significant release of flammable materials due to equipment failure, such as a major flange leak, pump seal collapse or broken pipe, or due to operational error or malfunction.

The positions of possible pool fires are largely predictable as spilt liquids will flow to the low points of a slab drainage system, collect in gullies, or be retained behind bund walls (see BP Group [RP 4-1](#)).

Damage from sustained pool fires will be due to radiation and contact with flame. Radiation is directional and unaffected by wind. Flames which have low density and momentum are easily diverted, even by low winds, and can engulf adjacent equipment.

The positions of burning jets are not readily predictable as they will arise from random failures. Where positions can be predicted, as for emergency vents discharging flammable materials, shields can be fitted to protect adjacent cables and equipment.

An initial fireball (duration a few seconds) can flash back to the source of the leak. The leak may continue to burn as a pool fire or as a vapour jet at the point of release. Provided that the initial fireball or flash fire is of sufficiently short duration much equipment, including power and instrument cables, may still be capable of safe and effective operation.

18.2 Steel Structures

18.2.1 Multi-level Structures (Excluding Piperacks)



Where predictable fire loadings can cause collapse, fire proofing materials should be applied to:-

- structures which support high or medium fire potential equipment (API 2218). Vertical and horizontal primary support members from grade to the highest level at which the equipment is supported (Figure 3).
- elevated floors and platforms that can accumulate significant quantities of liquid hydrocarbons (Figure 4).
- structures, the collapse of which would result in substantial damage to nearby control centres and/or emergency systems, or lead to an escalation of the incident. Primary horizontal and vertical support members up to and including the level that is nearest to 9 m above grade or where a fire loading exceeds 44 kW/m² (Figure 5).
- knee and diagonal bracing that contributes to the support of vertical loads or to the horizontal stability of columns. However, knee and diagonal bracing that is used only for wind, earthquake, surge or transportation loading need not be fire proofed (Figure 3).
- *It is advisable to remove bracing that is required only for transportation purposes when the equipment is finally located.*
- brackets, lugs or skirts of structures supporting reactors, towers or similar vessels (Figure 3). The insulating effect of fire proofing materials shall be considered in the design of support for vessels that operate at high temperatures.
- beams that support equipment, except for the upper surface of the top flange.

18.2.2 Supports for Piperacks and High Level Air Coolers

All primary vertical and horizontal support members up to and including the first level of piperacks, within a fire exposed envelope of sufficient intensity and duration, should be considered for fire proofing. (Figure 7). In addition, consideration shall be given to protection of vertical and horizontal members where piping containing hydrocarbons, or toxic materials, or corrosive products, of greater than NPS 6 is at levels above the first horizontal beam, or where high fire risk potential hydrocarbon pumps are installed beneath the piperacks. Such protection should be up to the level nearest to 9 m or 44 kW/m²

elevation (Figure 6). Wind, earthquake, transportation and non-load bearing beams that run parallel to piping shall not be fire proofed.

Air coolers which handle flammable fluids and are installed on top of piperacks, or which have high or medium fire potential equipment located beneath them, shall have all vertical and horizontal support members fire protected, up to the base of the cooler regardless of their elevation above grade (Figure 8). In addition, consideration shall be given to providing a firewall directly below the coolers.

In order to decide on the provision of a fire wall, account must be taken of the proximity of air cooled heat exchangers to fire hazards, whether there is a sprinkler system, and how quickly the exchanger fans can be shut down. If a fire wall is not required, then it is probably unlikely that a fire can be sustained at the air cooler level and additional fire protection may not be required.

Fire proofing shall be considered for knee and diagonal bracings that contribute to the support of vertical loads (Figures 6 and 9). Knee or diagonal bracing that is used for wind or earthquake loading need not be fire proofed.

Auxiliary pipe supports outwith the main piperack, holding piping greater than NPS 6, or on essential duties i.e. (flare, relief, blowdown and pump suction from accumulators or towers) shall be fire protected if within a fire exposed envelope. Consideration should be given to installing a fire proofed catch beam or bracket beneath piping greater than NPS 6 that is supported by exposed steel spring hangers or rods. When such provisions are made then sufficient clearance should be provided between the pipe and additional structure to permit free movement in normal operation.

18.2.3 Supports for Low Level Air Coolers

All supports for low level air coolers in hydrocarbon service shall be fire protected.

18.2.4 Supports for Vertical Towers And Vessels

Exterior surfaces of skirts supporting towers or vertical vessels containing hydrocarbons and located within a fire exposed envelope of sufficient duration and intensity shall be fire proofed. Skirt interior surfaces shall be fire proofed when there are flanges or valves within the skirt or if there are manway openings greater than 600 mm diameter. Skirts of vessels less than 760 mm (30") diameter need not be protected on the inside. Pipe penetrations and other small openings should be plugged where possible. Manholes in skirts shall be left clear and, where necessary, additional reinforcement should be provided



around the periphery of the manhole. Vent holes at or near the top of vessel skirts shall be kept clear.

Brackets or lugs used to attach vertical reboilers or heat exchangers to towers or tower skirts should be fire proofed. The earthing lug should be kept clear of the fire protection.

Anchor bolts shall be fire protected unless otherwise specified. Particular attention shall be paid to the detailing around bolts anchored in epoxy resin, where there is a danger of conducted heat affecting the anchorage.

Elevated exposed legs supporting towers or vessels shall be fire proofed to their full load bearing height.

18.2.5 Supports for Horizontal Exchangers, Receivers and Accumulators

Steel saddles supporting horizontal exchangers, condensers, drums, receivers and accumulators which have a diameter of 760 mm or greater, and which have a vertical distance between the concrete pier and shell exceeding 460 mm, shall be fire protected if within a significant fire envelope.

The protection of vessel saddles, which have provision for sliding on a bedplate, should include covering the bolts in Denso paste or tape or equivalent and keeping the elongated holes free of concrete. It is important to check before commissioning and periodically thereafter that the appropriate supports are free to slide.

18.2.7 Supports for Fired Heaters

Fire proofing shall be applied to all supports for fired heaters in hydrocarbon service up to the point where the steel supports are attached to the steel floor plate of the firebox.

If structural support is provided to elevated fired heaters by horizontal beams beneath the firebox, fire proofing shall be applied to the beams except where one flange face is in continuous contact with the firebox.

Where common stacks handle flue gas from several heaters, structural members supporting ducts between heaters and stacks shall be fire proofed.

18.3 Concrete Structures

Reinforced concrete structures should not normally require fire proofing unless specified otherwise.

Pre-stressed concrete structures located in fire exposed areas should be given fire proofing to prevent relaxation.

Reinforced and pre-stressed concrete members shall be designed in accordance with [BS 8110](#) : Part 1 or agreed equivalent.

*** 18.4**

Vessels

Passive fire protection of vessels on process plant is not generally required. Where relief cannot ensure integrity of the vessel in a fire situation or, where fire conditions result in relief capacity requirements in excess of that from any other emergency condition, passive fire protection of selected vessels shall be applied, where economical, to reduce the discharge rate and the size of any closed relief system (see BP Group [RP 44-1](#)).

Where a pressure relief valve on a vessel is sized on the above basis, the passive fire protection system shall be specifically designed to resist the forces of fire hose streams and to maintain its insulation properties for an extended period, which will be specified by the Client. This period will depend on the fire fighting facilities available and the nature of the installation, but should be not less than 2 hours.

Only passive protection will afford satisfactory protection against jet and engulfment fires which are characteristic of Class 0 petroleum pressurised storage vessels. Where a vessel is to be fire protected, the whole vessel shall be insulated. Pipework and its supports leading from the vessel up to the first ESD valve shall be protected. The support legs of spherical storage tanks shall be fire protected to the full load bearing height.

Although the top of a vessel is apparently less at risk in a fire, in fact it is often the most vulnerable, since it is not cooled by evaporation of any liquid contents. There are well known examples of vessels failing during a fire, even though pressure relief valves were probably limiting the pressure to the vessel design pressure, because high temperature had reduced the material strength below the design code safety factors, (e.g. the Feyzin Refinery disaster in France, 1966).

18.5

Piping

Piping generally requires no fire proofing and may be expected to withstand considerable exposure to fire without failure because of normally low stress levels, external insulation and the cooling effects of the contents. However, certain flanged lines carrying flammable process materials should also be considered for fire protection.

Flare, critical duty (e.g. breathing air) and high hazard toxic material (e.g. ammonia, chlorine, hydrofluoric acid, hydrogen sulphide) pipelines

and their supports, identified at risk during the FRA, and which cannot be made safe by location, shall be fire protected.

18.6 Electrical Power and Control Cables

Power and control cables associated with critical operating equipment or loss prevention devices located within an area where they may be exposed to flame shall be fire protected. Primary methods to avoid early cable failure include:-

- Burying below grade.
- Routing around, or high above, areas of high fire potential.
- Providing water spray protection.

If none of the above methods are available, and prolonged cable service is desirable within an area exposed to flame, the following options should be considered:-

- Cables rated for high temperature.
- Fire retardant cable trays.
- Passively fire protected cable trays.
- Wrap around, foil-backed insulating systems.
- Direct application of fire proofing material to exposed cable jacketing.
- Preformed pipe insulation rated for service at 650°C.

The protection system selected should keep the temperature of the cable within acceptable limits for the time period necessary to carry out critical control functions.

Fire proofing systems for cables can result in cable operating temperatures that are higher than normal and the cable may need to be derated.

18.7 Pneumatic and Hydraulic Control Lines

Pneumatic and hydraulic control lines associated with double actuating, critical operating equipment or loss prevention devices, sited within an area where they may be exposed to flame shall be protected. The methods described for electrical cable are equally applicable to pneumatic and hydraulic control lines.

Hydraulic systems using type 304, 316 and 321 stainless steel tubing may not require fire protection provided all parts of the system are provided with pressure relief. Other types of control tubing are liable to rapid failure, and fire proofing with preformed pipe insulation should be considered. The assembly should be weather protected with

stainless or galvanised steel sheeting held in place with stainless steel bands and screws.

Use of galvanised steel sheet can cause embrittlement of stainless steel particularly in intimate contact.

Aluminium cladding fails quickly in a fire and can generate flaming particles which can travel and cause ignition outside of the fire envelope.

Passive fire protection applied to control systems shall be compatible with operational and maintenance requirements.

18.8 Emergency Valves

18.8.1 Where continued power is required to operate valves, which are critical for safe shutdown, depressurisation or isolating the feed of a unit, the valve and its associated power supply shall be afforded fire protection if within a significant fire exposed envelope. Protection shall be provided to power and signal lines and the motor or actuator. The valve body and pipework 3 m either side of the valve may also require protection.

The protection shall be designed such that adequate time is allowed for the valve to travel from the fully open to the fully closed position (or vice versa) when exposed to a hydrocarbon jet fire. Valves that fail to a safe position need not be fire proofed.

Power and control cables shall be protected as described in 18.6 above. The motor actuator may be protected by preformed fire resistant material, specially designed lace-up fire resistant blanket, or assemblies that use mastic materials.

When specifying emergency valves and protective covers the following items require special consideration:-

- (a) Thermal limit switches built into electric motors that may cause the motor to fail during a fire.
- (b) The valve hand wheel and engaging lever shall not be fire proofed to an extent that the valve is inoperable.
- (c) The valve position indicator shall not be covered.
- (d) The diaphragm housing on diaphragm operated valves should not be fire proofed if the valve is designed to fail to the safe position.

18.8.2 *The passive fire protection of valves has in recent years been approached largely by establishing conformity with standard fire tests (unwisely often referred to as*

'fire-safe' tests) for soft seated ball valves. This general policy has a number of disadvantages, e.g:-

- (a) For many soft seated valves, behaviour during a fire is not a significant factor compared with other issues.
- (b) For certain critical duties it is necessary to distinguish between valves that must remain operable for some period during a fire, and those that are required to remain closed.
- (c) The performance during a fire of the motor, actuator and cabling, etc., is just as important as that of the valve itself.
- (d) Fire tests of large valves (say NPS 8 and above) have required unrealistically long fire durations for test completion.
- (e) Many valves, sold as fire tested to a published standard, when checked have not conformed to the standard.

BP Group [RP 62-1](#) provides some general guidance for valves that are on critical duty.

18.9 Selection of Fire Resistant Materials and Systems

18.9.1 Selection of fire resistant materials and systems requires care to obtain the desired degree of protection during the service life. Besides fire resistance, a variety of other characteristics are required to ensure proper performance in the field. (See Table 11). Fire protection systems shall be subject to approval by a third party inspectorate (DNV, UL, Lloyds or equivalent).

Unapproved systems can lead to a significant reduction in fire performance, explosion resistance and corrosion resistance.

18.9.2 Fire Performance

Fire proofing materials and systems used in buildings should satisfy furnace test programmes: [BS 476](#), [ASTM E119](#) or equivalent. Where the system is to protect against a hydrocarbon fire then it must satisfy internationally approved high rise hydrocarbon fire curve criteria: [UL1709](#), DEn fire resistance tests or equivalent for the duration of predicted fire exposure.

18.9.3 Weight Limitations

Weight of the fire proofing materials should be considered in the design of pipe racks, multilevel structures and pressurised storage vessels.

Densities of various products to achieve a two hour hydrocarbon pool fire protection rating for steel structures vary and are approximately:-

Dense Concrete 2225 - 2400 kg/m³(140 - 150 lb/ft³)

Light Concrete 560 - 1200 kg/m³ (35 - 75 lb/ft³)

Intumescent/	)	
Subliming	)	960 - 1290 kg/m ³ (60 - 80 lb/ft ³)
Compounds	)	

18.9.4 Adhesive Strength and Durability

Bonding of the fire proofing material to the protected surface should be strong enough to resist mechanical impact damage, vibration and differential expansion caused by changes in operating temperatures.

Poor bonding will reduce the service life of the fire resistant material and make the system subject to failure if exposed to a fire hose stream. Poor impact resistance may lead to the degree of fire resistance being impaired due to mechanical damage in normal service conditions.

The selected material shall be subject to a hose stream test to confirm its ability to withstand hydraulic erosion and thermal shock.

18.9.5 Weatherability

Humidity, rain, sunlight and ambient temperatures can influence the coating integrity and fire performance. Breakdown of the coating can lead to corrosion of the substrate and the coating reinforcing mesh.

Materials and their systems shall be selected in accordance with international weathering and fire performance test standards:- [UL 263](#), [UL 1709](#), [ASTM G26](#), [BS 476](#) Part 5 or equivalent.

Leachable chlorides or sulphides in the material should be negligible.

Where a fire proofing material is located outdoors and is water absorbent it shall be sealed to prevent moisture from reaching the fire proofed surface. Seals at junction points between the fire proofing and exposed steel structure should be inspected regularly. In cases of high vibration levels, inspection should be every two years.

Weather protective coatings required to seal lightweight concrete and similar materials should have a life expectancy of 5 to 7 years depending on the environment.

Existing coatings which are peeling or cracked should be removed and repaired as approved by the coating manufacturer.

It is difficult to provide meaningful data as to the life expectancy of passive fire protection systems. Good examples of concrete and brick systems lasting more

than 70 years and of the newer materials (light weight concrete, subliming and intumescent mastics) lasting 30 years are known. On the downside there are examples of systems deteriorating within 1-2 years of application.

18.9.6 Chemical Tolerance.

Materials and their systems should be selected with regard to their chemical tolerance to acids, bases, salts and solvents present on the plant.

Vapour permeability and porosity can lead to corrosion of the substrate. A significant amount of free water can cause the fire proofing to spall when subjected to a high temperature hydrocarbon fire.

The selection of fire proofing material and installation techniques should be based on the substrates' normal range of operating temperatures.

18.9.7 Combustibility

Intumescent (organic) fire proofing materials generate smoke when exposed to fire. Organic fire proofing material selection should be limited to combustibility levels as defined in [NFPA 101](#), [BS 476](#) or equivalent.

18.9.8 Mechanical Hardness

Harder materials may be required for areas where rigging and maintenance operation may be regular events.

Damaged systems will lead to a lowering of fire resistance and an increased repair programme.

18.9.9 Repair of Existing Equipment

No repair work should be undertaken without vendor consultation.

Material selection for the repair of existing installations should be treated with caution. Even when using identical or similar generic materials there will always be differences in the properties of the new and old material due to age and weathering.

18.9.10 Ease of Application

Material selection should be based on the following application requirements:-

- Vendor approved techniques which have been proven in the field

- Shelf life of the components
- Quality of surface preparation and any difficulty in working within the area.
- Thinner to be used. Some materials are water based; others contain hydrocarbons. Solvents may be toxic and/or flammable and therefore hazardous if used improperly. Saline and brackish water can effect the durability of the final product.
- Temperature and humidity. Many materials can be applied only within limited ranges.
- Vendor approved priming, adhesion coating, top coat and joint sealing systems must be used.
- Steel preparation should be in accordance with BP Group [GS 106-2](#).
- Licensing authority approval and system fire test certification requirements.

18.10 Specification of Fire Proofing Materials

18.10.1 Cementitious

*** 18.10.1.1 Dense (formed) Concrete**

Dense concrete is a traditional fire proofing material. Concrete in itself does not promote corrosion due to its alkaline nature. However, the pH changes to neutral over a period of years. On setting, concrete shrinks and a small gap can be left against the steel which will allow water ingress. In areas subject to acid rain, such ingress can accelerate corrosion and it is important to seal gaps. Dense concrete is liable to spall in a hydrocarbon fire resulting in loss of thickness and lower protection. Concrete fire proofing cast in situ can be expensive.

Dense formed concrete shall conform to [ASTM C150](#) (type 1A) or equivalent.

When applied to columns where water could penetrate between steel and concrete, it shall be weather proofed with a caulking bead or other approved mastic application.

Client approval shall be obtained prior to installation of pneumatically applied concrete within 15 m (50 ft) of operating equipment.



In areas of high maintenance activity, where fire proofed structures could be subject to impact and abrasion, concrete fire proofing offers good mechanical resistance.

Prior to installation of concrete, the steel substrate shall be prepared in accordance with BP Group [GS 106-2](#).

* 18.10.1.2 Lightweight Concrete (Vermiculite)

Lightweight concretes do not spall in hydrocarbon fires. However, they have a high porosity and will absorb liquids if unprotected, leading to lower impact resistance, adhesion to steel and pH. A mesh system is essential for hydrocarbon fire protection systems, offering good protection against engulfment and jet fires. Certain brands of lightweight concretes have a neutral pH.

Insulating concrete, fire proofing cements and plasters made with lightweight or special aggregates, may be used when weight becomes a limiting factor in the design.

Lightweight concretes or fire proofing cements have a density of 560 to 1200 kg/m³, installed and dried. Densities may be increased by 20% if concrete is applied by pneumatic gun.

Finished lightweight concrete normally requires two coats of a sealer for weather protection when used in extreme climates. The seal coat shall be in accordance with the concrete manufacturer's recommendation.

Steel should be prepared in accordance with BP Group [GS 106-2](#) prior to application.

Columns protected with lightweight concrete, and which lie within 1.5 m of an access way for vehicles and maintenance equipment, shall be protected from mechanical damage. The type of protection shall be subject to approval by the Client.

18.10.1.3 Magnesium Oxychloride Plaster

Magnesium oxychloride plasters shall not be used for fire proofing.

Field experience has indicated that corrosion of the substrate steel occurs as the topcoat (over the fire proofing) weathers and moisture combines with the chloride present in the plaster to form hydrochloric acid. The fire proofing flakes and falls off due to moisture entrapment and causes corrosion to the steel lathing and wire mesh used for anchoring and reinforcement.

18.10.1.4 Preformed/Inorganic Panels



This material has poor weatherability and is suitable for internal use only.

The panel system shall pass [UL 1709 \(P\)](#) test or equivalent fire tests.

Precast or compressed fire resistant panels need to be attached to the substrate by mechanical fasteners designed to withstand fire exposure without appreciable loss of strength.

18.10.1.5 Concrete Masonry

This material is not commonly used because of high installation costs and extensive maintenance requirements.

Assemblies are prone to cracking and admitting moisture with serious corrosion and spalling problems.

Concrete blocks shall contain lightweight expanded blast furnace slag as the coarse aggregate. The blocks shall provide a 1 hour minimum hydrocarbon fire resistance rating or equivalent. Blocks shall be laid with thin, staggered joints of 6.4 mm (1/4 in) maximum thickness, and a fire resistant mortar. The annular space between the blocks and the steel member shall be filled with a lean cement to prevent moisture or hot gases from reaching the steel during a fire. A bead of caulking shall be applied at the junction of the blocks for weather protection.

Prior to installation of masonry, the steel substrate shall be prepared in accordance with BP Group [GS 106-2](#).

18.10.1.6 Asbestos

Spray applied or wrap around asbestos shall not be used.

18.10.2 Intumescent/Subliming

Intumescent/subliming coatings may be used in appropriate applications. Specific attention should be given to the possibility of a fume or smoke hazard arising from exposure of intumescent coatings to fire.

Subliming materials behave by a phase change from a solid to gas without going through the liquid stage. These agents are incorporated into organic matrices of a plastic or elastomeric nature. Intumescence is an expansion or foam process whereby an insulating char is formed at the fire surface.

These materials provide high adhesion to steel, protect steel from corrosion, resist impact damage and dislodgement by vibration, and have a low absorption rate for liquids.

It is important to include mesh reinforcement in these systems for two reasons. Firstly the thermal expansion characteristics are thereby modified to come nearer that of the steel substrate. Secondly the mesh holds the coating in place during a fire when it's bond to the primer eventually fails, To achieve satisfactory protection in jet fires, the thickness of the coating needs to be increased and the mesh should be carbon or glass fibre.

One product used is manufactured as a 25% water extended premix and sets due to evaporation. This product is prone to slumping during the setting period, and is highly porous.

Mastic fire proofing materials shall be applied by spraying or troweling. Surface preparation for application of a paint primer shall be in accordance with manufacturer's recommendations.

For previously painted and/or fire proofed surfaces, the mastic manufacturer should be consulted to assure compatibility. New galvanised surfaces shall be mechanically abraded to ensure adherence of the coating. When existing structural steel is being fire proofed preparation shall be in accordance with BP Group [GS 106-2](#).

Mastic fire proofing materials have a density of approximately 960 to 1290 kg/m³.

Intumescent and subliming mastic coatings shall be sealed in accordance with the manufacturer's recommendations for possible extreme weather conditions. In locations where there is exposure to high levels of ultraviolet radiation (from sunlight), premature ageing should be considered.

UV protection can be provided by applying a thin top coat of aliphatic polyurethane.

Spray equipment operators, responsible for the application of fire proof mastic, shall be under the direct supervision of a trained applicator who is qualified by the mastic manufacturer or supplier in writing.

18.10.3 Fibrous

Where there is a need for thermal insulation of process vessels and/or pipework and there is also a need for fire protection of this equipment the materials shall be rated for 650°C minimum surface temperature and selected from the following types:-

- (a) Calcium silicate, block or preformed.
- (b) Mineral wool block with a minimum density of 192 kg/m³.
- (c) Perlite, block or preformed.

- (d) Expanded aluminium silicate fibre blanket with a minimum density of 96 kg/m³.
- (e) Foam glass with additives.
- (f) Ceramic fibre.

All fibrous materials are highly absorbent of water. Silicone treatments will give an element of water shedding, however, water uptake can still be high. They are only recommended for internal use, except when adequately clad with metal sheeting and with joints sealed.

Materials will not give protection against a sustained jet fire unless specifically designed for this duty. When insulation is used on steel that will be at or below ambient temperature, precautions need to be taken to prevent corrosion of the steel caused by condensation of water vapour trapped by the insulation.

Before using on carbon steel with a surface operating temperature between 0°C and 93°C the steel shall be prepared and painted in accordance with BP Group [GS 106-2](#). A vapour barrier shall be provided over the outer layer of the insulation.

The minimum thickness of insulation for fire proofing shall be 50 mm. Precautions shall be taken prior to installation to ensure the insulation is moisture free.

Insulation used for fire proofing shall be held in place by pinning and/or stainless steel banding and shall be jacketed with stainless steel, vinyl clad galvanised steel, or uncoated galvanised steel. The cladding shall be in accordance with BP Group [RP 52-1](#). Uncoated galvanised steel sheeting shall not be used when the service temperature is below ambient temperature due to the potential for accelerated corrosion.

18.11 Specialist Applications

Instances exist where structures or vessels are subject to thermal shock conditions. Examples of these are refrigerated vessels and furnace burner supports where the burner is integral with the furnace. For these applications composite arrangements of alternate layers of thermal insulation and a passive fire proofing would be appropriate.

Irregular shapes such as flanges, valves, pipes, cable trays, etc., present difficulties in application techniques and create conflict with the access requirements for routine maintenance.



Proprietary systems including preformed and/or sculptured sections, designed boxes, etc., are available. The range of products is expanding as awareness of the severity of fires and explosions is increasing.

When applications requiring proprietary systems or composite arrangements are identified advice should be sought from the Custodian of this document.



Unit or Area _____

Item	I.D. No.	Hydrocarbon Type	Capacity (kg)	Pressure (bar g)	Fire Type	Enclosure Type	Other Hazards
Vessel	00000	Gas/Oil	20000	150	Jet/ Pool	Open	Smoke
	00001	Gas	1000	80	Jet	Enclosed	Explosion

TABLE 1
HAZARD IDENTIFICATION (EXAMPLE DATA)

Unit or Area _____

Item	I.D No	High Probability Hazards	Low Probability Hazards
Vessel	0000	Escalation to other vessels causing further losses	Widespread fires if process fire preceded by an explosion
		Failure of pipework and vessel supports	BLEVE
		Structural failure resulting in partial or total collapse under the vessel	Complete obstruction of local escape routes by smoke
		Reduction in escape route availability	

TABLE 2
ASSOCIATED HAZARDS (EXAMPLE DATA)



Unit or Area _____

Release Number		1
Location /I.D. Number		V 301
Pressure (barg)		5.5
Temperature (°C)		80
Release Diameter (mm)		50
Material		C ₅
Release Rate (kg/s)		8.7
Release Frequency (yr⁻¹)		4.6 x 10 ⁻⁴
Fire Type See note 1		P
Release Duration (min) see note 2	Base	60
	Comparative	15
Fire Exposed Envelope	Length/Diameter (m)	14
	Overpressure (mbar)	
Max Heat Flux(kW/m²) - See note 3		120
Critical Equipment - See note 4		V 201, V 101

- Notes:
- Fire types may be categorised as
 - J= Jet Fire
 - P=Pool Fire
 - F=Flash Fire
 - E=Explosion
 - S=Solid Combustible
 - Base = inventory with no shut down, depressurisation or isolation
Comparative = inventory after shut down, depressurisation or isolation.
 - Calculated from BP CIRRUS program or equivalent.
 - Critical equipment which is subject to radiated heat or direct flame impingement.

TABLE 3
HAZARD QUANTIFICATION (EXAMPLE DATA)





TABLE 4
EXPOSURE PROTECTION METHOD
RISK SOURCES: EQUIPMENT HAVING FIRE POTENTIAL

Equipment		Protection		Comments	Design Standard
		Jet/Spray Fire	Pool Fire		
Fired Heater		Steam Inert gas	Water Spray Passive	Fixed System Fixed System High Pressure Exstinguishing Primary/Secondary Structures	NFPA 86 NFPA 12 NFPA 15 see sect. 18
Hydrocarbon Pump		Steam or Water Spray	Water Spray Passive	Fixed or Hand Held Systems (Low Pressure) Fixed Systems (High Pressure) Fixed Systems or Water Wall Primary/Secondary Structures	NFPA 86 NFPA 15 NFPA 15 See Section 18
Reactor	Internal Fire	Steam Inert Gas		Fixed System Fixed System	NFPA 86 NFPA 12
	External Fire	Steam or Water Spray	Water Spray Passive	Fixed System or Hand Held Fixed System Fixed System or Hand Held Primary/Secondary Structures	NFPA 86 NFPA 15 NFPA 15 See Section 18
Compressor	Enclosed	Steam or Water Spray Inert Gas	Water Spray	Fixed Systems Fixed Systems Fixed Systems Fixed Systems	NFPA 86 NFPA 15 NFPA 12 NFPA 15
	Open	Water Spray	Water Spray	Fixed Systems or Hand Held Fixed Systems or Hand held	NFPA 15 NFPA 15
Accumulator, Feed Drums (as a result of Broken gasket)		Steam Spray Water Spray Passive	Water/Foam	Fixed System or Hand Held Fixed System or Hand Held Primary/Secondary Structures Hand Held	NFPA 86 NFPA 15 See Sect 18 NFPA 11
Tower (as a result of broken gauge glass)		Steam Water Spray Passive	Water/Foam Passive	Steam for Hydrogen Duty Primary /Secoundary Structures Hand Held	NFPA 86 NFPA 15 See Sect. 18 NFPA 11 See Sect. 18

Tank Type	Tank Diameter (m)	Fire Protection Requirements
Fixed Roof	≤18	Mobile or portable foam monitors (for use after roof has failed)
Fixed Roof	> 18	Sub-surface injection for hydrocarbon liquids. Top pourers for foam destructive liquids and Class I hydrocarbon liquids using fixed or semi fixed system designed for full tank surface area.
Fixed Roof with Metal Pan Type Cover	All	Fixed or semi fixed top pourer system for protection of the full tank surface area.
Fixed Roof with Combustible Cover	All	Sub-surface, or fixed or semi fixed top pourer, system for protection of the full tank surface area.
Fixed Roof with Thin Skin Steel or Aluminium Cover on Floats or Aluminium Honeycomb Cover.	All	None unless required by local code. If provided, a fixed or semi fixed top pourer system for rim seal protection should be installed.
Open Top Floating Roof	≤18	Portable foam hose lines or monitors
Open Top Floating Roof	>18	Fixed or semi fixed top of seal application for rim seal protection

Note: A fixed or semi fixed proprietary system for rim seal protection should be provided if the tank does not have a wind girder with hand rails.

TABLE 5
MINIMUM FOAM REQUIREMENTS FOR EXTINGUISHING
ATMOSPHERIC STORAGE TANKS CONTAINING
CLASS I, II OR III (1) LIQUIDS



Equipment	Fire Type	Method	Design Standard
Fire Pumps	Running, pool or deep-seated fire	(c)	NFPA 16
Pressurised Bottle Store	Gas jet fire	(b)	NFPA 13
Methanol/Chemical Store	Pool or chemical fire	(b)	NFPA 13
Fuel Gas	Gas jet fire	(a)	NFPA 15
Power Generators	Electrical/Oil deep-seated fire	(d) (e)	NFPA 12 -
Compressors	Running, jet, pool or deep-seated fire	(d) (e)	NFPA 12 -
HVAC Rooms	Electrical or deep-seated fire	(d)	NFPA 12
Lube Oils	Pool fire	(d)	NFPA 12
Paint Store	Pool fire, exploding cans	(b)	NFPA 13
Lagging	Deep-seated fire	(a)	NFPA 15

NOTE: Method relates to section 14.3.4 of the text.

TABLE 6
CHOICE OF ACTIVE PROTECTION METHODS - UTILITIES

Application	Water Demand (m³/h)
Atmospheric or vacuum distillation, or combination rated up to 100,000 bpd throughput; treating plants; asphalt stills.	1,100
Atmospheric or vacuum distillation, or combinations rated above 100,000 bpd throughput; catalytic cracking unit.	1,600
Light end units containing volatile oils or hydrogen, such as reformers, catalytic desulphurisers, fluid catalytic crackers, high pressure units over 70 barg (1000 psig).	2,000
Lube oil units and blending (excluding propane extraction units).	900
Class I and Class II storage (see)	1,300
Railcar terminals (5 cars)	500
Jetties (VLCC)	600
Offices/Administrative areas	100

TABLE 7
TYPICAL FIRE WATER DEMANDS





TABLE 8
FIXED WATER SPRAY APPLICATIONS

Duty	Area of Application	Water Rate (l/min/m ²)	Initiation	Duration (Hours)	Comments
Tank adjacent to Class I, II or III Product Tank	Roof and Shell	9.8 max	M	6	Required when <D/3 separation. Tank on fire not protected. Water rate reduces as level of radiant heat diminishes.
LPG Storage (Pressurised or Refrigerated)	Exposed surface area of vessel, pipelines, relief valve	9.8	A or M	2	Required for vessel on fire plus adjacent vessels. Water management systems. Passive systems preferred
LNG Storage	Exposed surface area of tank, associated pipelines and vessels	Determine for each installation	A or M	2	Water maintains surface temperature below 100°C
General Chemical and Large Paint Stores and Special Process Units	High value stock or where vital for continued operation	To be determined	A or M	To be determined	Ratings: Ordinary or high hazard
Effluent Separators		To be determined	M	To be determined	Alternatives: fixed foam or steam snuffling.
Oil Pumping Stations	Remote locations of strategic importance	To be determined	A	To be determined	Alternatives: fixed CO ₂ or foam systems.
Loading Racks	Class 0,1 Petroleum Products	9.8	A	2	Class 0: Use water for cooling Class 1: Use foam for extinguishing
Petroleum Production area	High value stock	To be determined	A or M	To be determined	High pressure water monitors. Fixed foam sprays
Marine Facilities	Equipment protection	9.8	A or M	To be determined	Discuss and agree with Client
	Underside protection (wooden jetties)	9.8	M		
	personnel escape	6	A		
Large Computer Suites	Critical Units	6	A	To be determined	Sprinkler systems, CO ₂ below raised flooring Early smoke detection.
Libraries, Telecommunications rooms	High Value Stock	6	A	To be determined	Sprinkler systems optional Early smoke detection

A= Automatic

M= Manual

Fire/Spill Situation	Type of Foam				
	FP	AFFF	FFFP	Alcohol Resistant	Medium Expansion
Process Area Spill Fire	P	A	P	P	N.S.
Storage tank fire : Surface application (up to 10% polar solvents)	P	A	A	A	N.S.
Storage tank fire : Sub-surface application (up to 10% polar solvents)	P	N.S.	N.S.	N.S.	N.S.
Storage tank fire : Surface application (>10% polar solvents)	N.S.	N.S.	A	P	N.S.
Storage tank : Sub-surface application (>10% polar solvents)	N.S.	N.S.	N.S.	N.S.	N.S.
Loading rack fire : (<10% polar solvents)	A	P	P	P	N.S.
Loading rack fire : (>10% polar solvents)	N.S.	N.S.	N.S.	P	N.S.
LNG Spill or Fire	N.S.	N.S.	N.S.	N.S.	P

P = Preferred
 A = Acceptable
 N.S. = Not Suitable

TABLE 9
SUITABILITY OF TYPES OF FOAM



Hazards and Type of Protection	Foam Solution Application Rate (l/min/m ²)		Minimum Duration of Water and Foam Supply (minutes)
	FP	AFFF or FFFP	
Open Process Area Spill Fire (Portable Equipment)	6.5	4.1	15
Enclosed Process Area Spill Fire (Foam-water spray system)	6.5	4.1	15
Fixed Roof Storage Tank (over-the-top with fixed outlets)	4.1	N.A.	30 (Class II or III liquids)
Fixed and Floating Roof Storage Tank (Portable Discharge Devices)	6.5	N.A.	50 (Class II or III liquids) 65 (Class I or crude oil)
Fixed Roof Storage Tank (Sub-surface Injection)	4.1	N.A.	55 (Class I or crude oil)
Floating Roof Storage Tank (Fixed above seal discharge devices with foam dam)	12.3	N.A.	20
Floating Roof Storage Tank (Fixed under seal discharge devices without foam dam)	20.5	N.A.	10
Loading Rack (Foam-water spray systems)	6.5	6.5	10

N.A. = Not applicable

TABLE 10
FIRE WATER AND FOAM SUPPLY REQUIREMENTS
(HYDROCARBON LIQUID, MAXIMUM POLAR SOLVENT CONTENT 10%)





TABLE 11
COMPARISON OF PASSIVE FIRE PROOFING MATERIALS

CRITERIA	CEMENTITIOUS			INTUMESCENT	SUBLIMING	FIBROUS **
	VERMICULITE CEMENT	MAGNESIUM OXYCHLORIDE	CONCRETE*			
Weight	Medium	Medium	Very high	Low	Low	Low
Resistance to Mechanical Damage	Low	Medium	High	Very High	Medium	Low
Porosity	High	Medium	Low	Very Low	Low	Very High
Need for Topcoating	High	High	Medium	Very Low	High	Very High
Ease of Installation	Medium	Medium	Low	Medium	Low	High
Curing Time	Long	Long	Long	Short	Long	Zero
Bond Strength	Low	Low	Low	High	Low	Zero
Aplicability to all Areas	Medium	Medium	Low	Medium	Medium	Very Low
Cost	Medium	Medium	High	High	Very High	Medium

* At 50 mm minimum thickness only

** Without protective cover

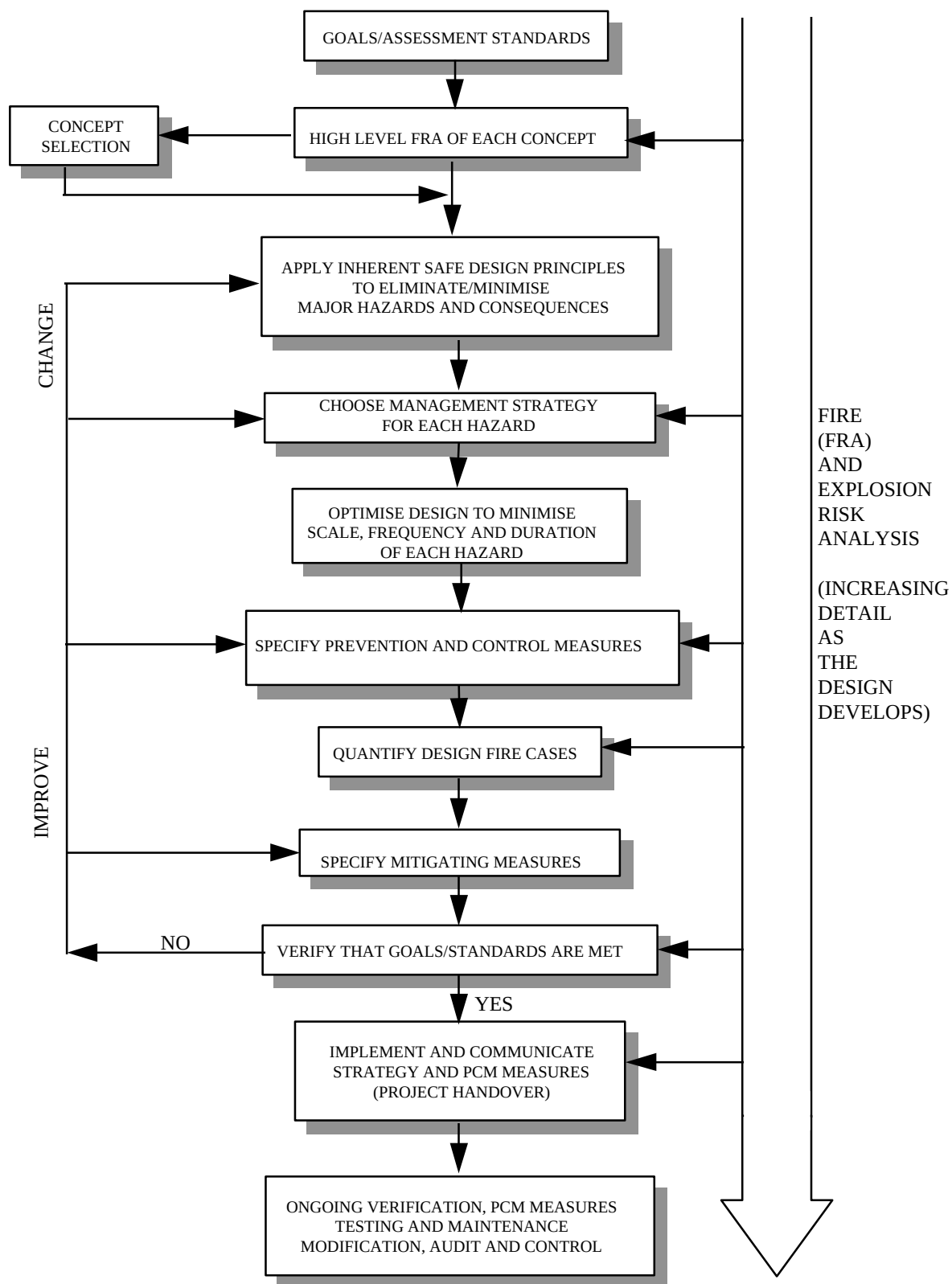


FIGURE 1
HAZARD MANAGEMENT PROCESS OUTLINE

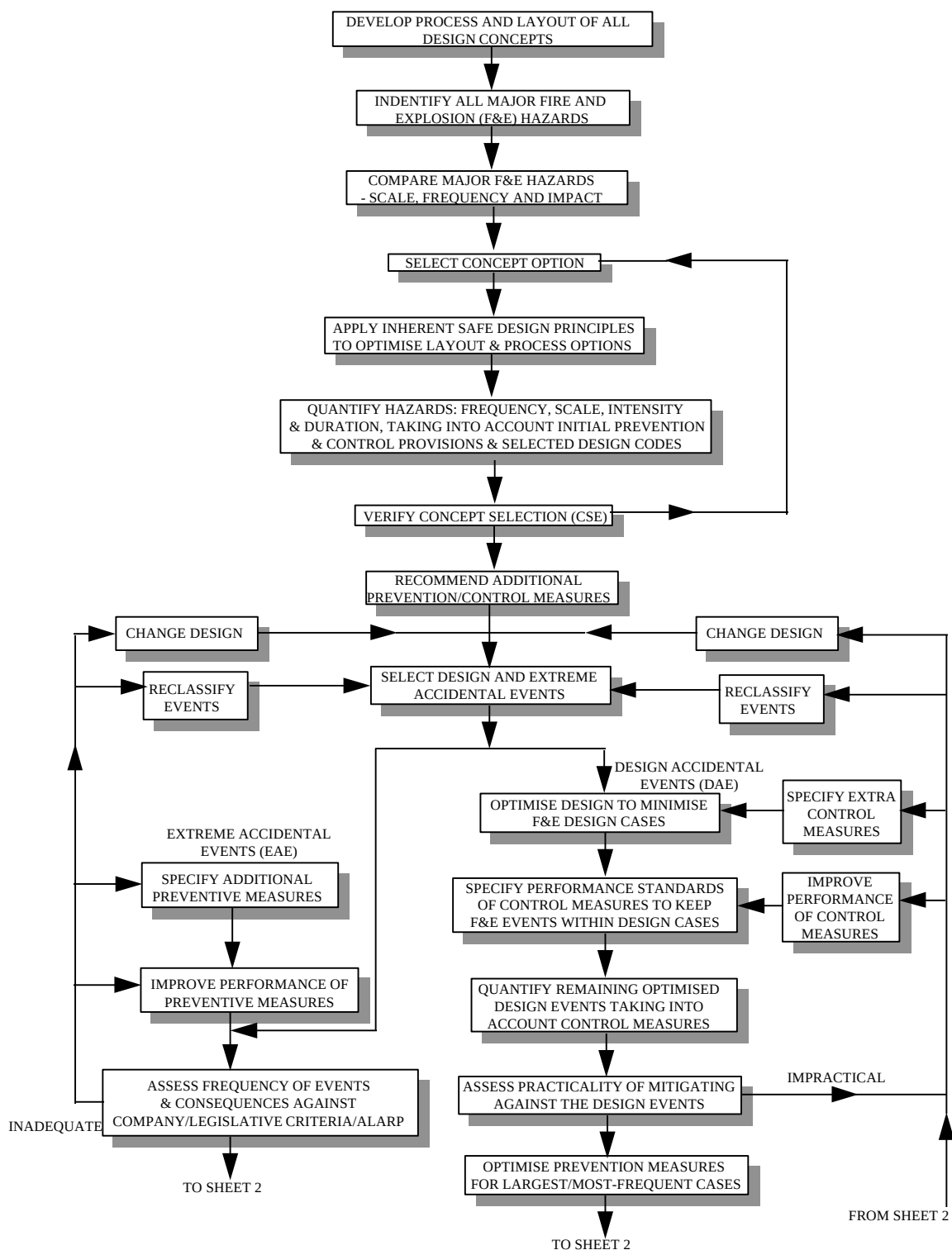


FIGURE 2 (SHEET 1)
HAZARD MANAGEMENT PROCESS DETAIL

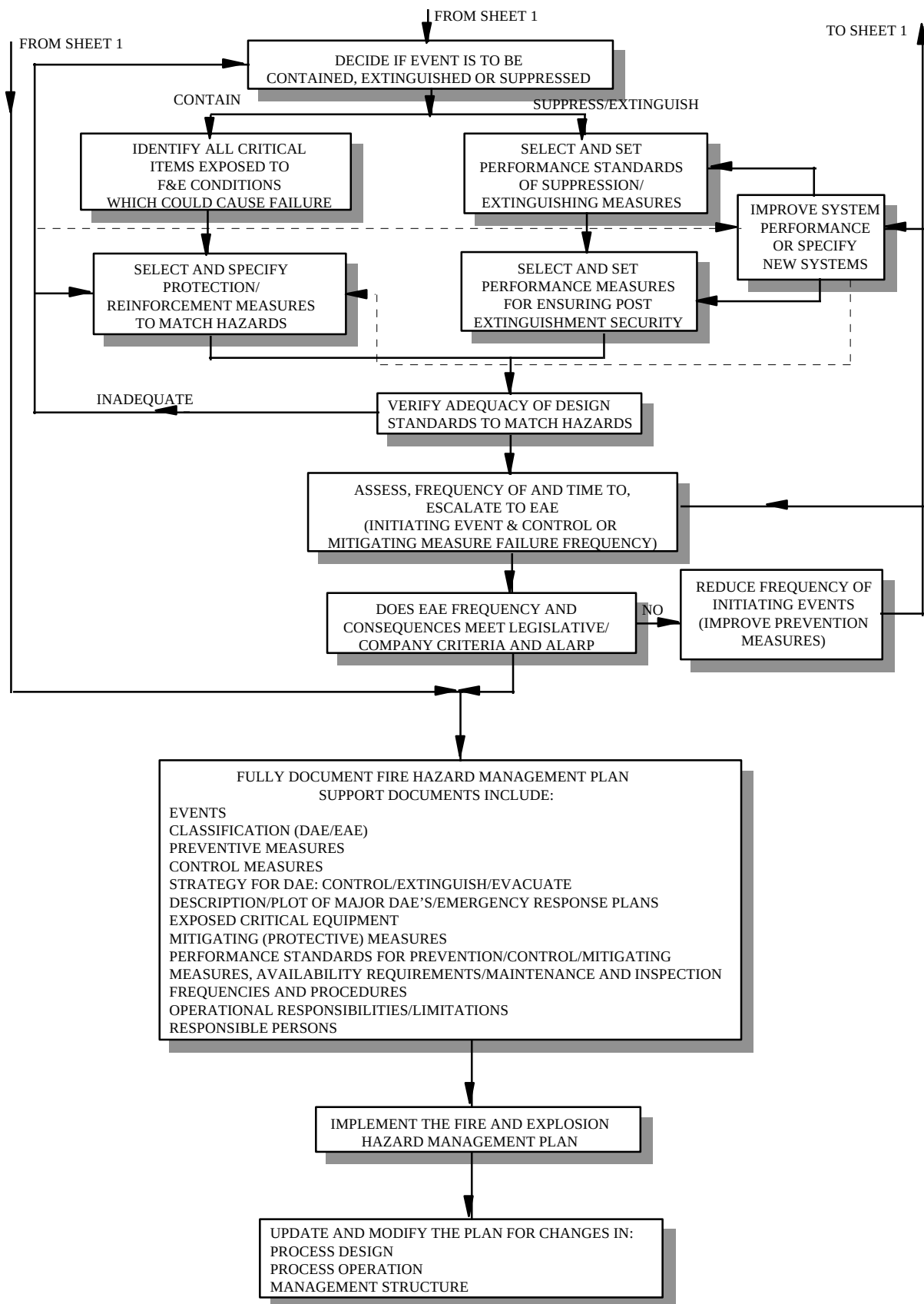
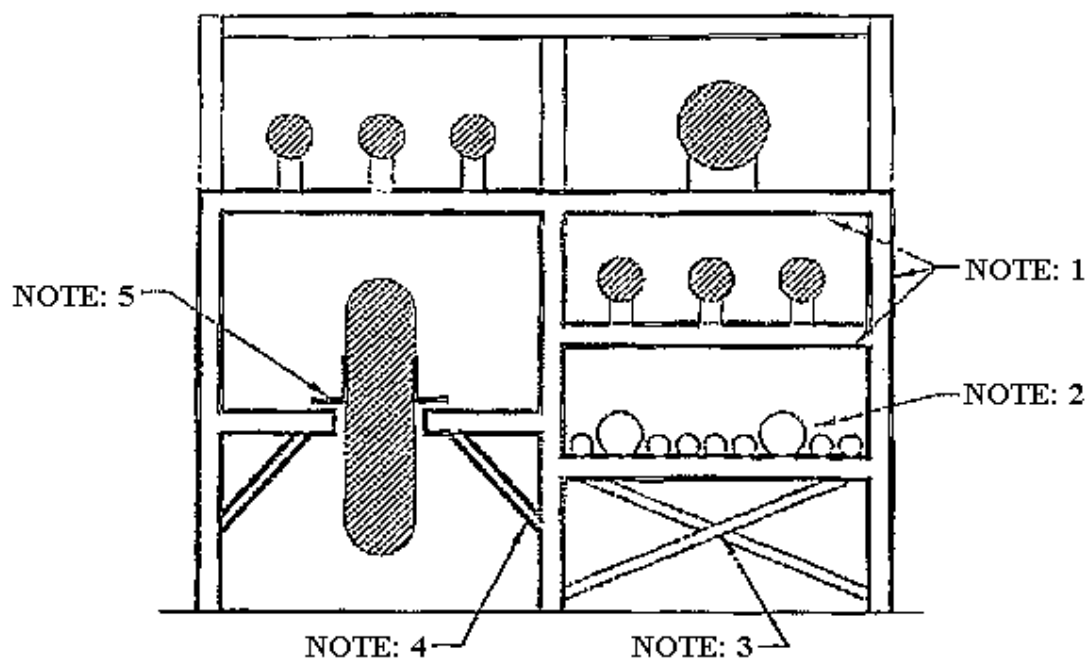


FIGURE 2 (SHEET 2)
HAZARD MANAGEMENT PROCESS DETAIL



NOTES:

- | | |
|---|--|
| <p>1. FIRE PROOFING REGARDLESS OF ELEVATION ABOVE GRADE</p> <p>2. FIRE PROOFING ALL LEVELS BELOW FIRE POTENTIAL EQUIPMENT</p> <p>3. NO FIRE PROOFING ON BRACING WHICH IS NOT LOAD BEARING</p> | <p>4. FIRE PROOFING KNEE OR DIAGONAL BRACING WHICH SUPPORTS VERTICAL LOAD</p> <p>5. FIRE PROOFING REACTOR SKIRT, BRACKETS, OR LUGS</p> |
|---|--|

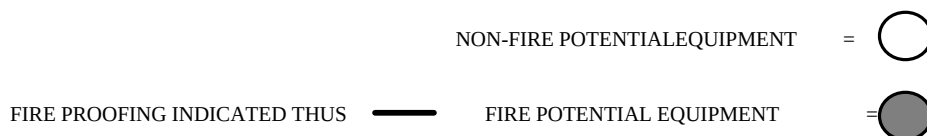


FIGURE 3
FIRE PROOFING OF STRUCTURAL STEELWORK
SUPPORTING FIRE POTENTIAL EQUIPMENT

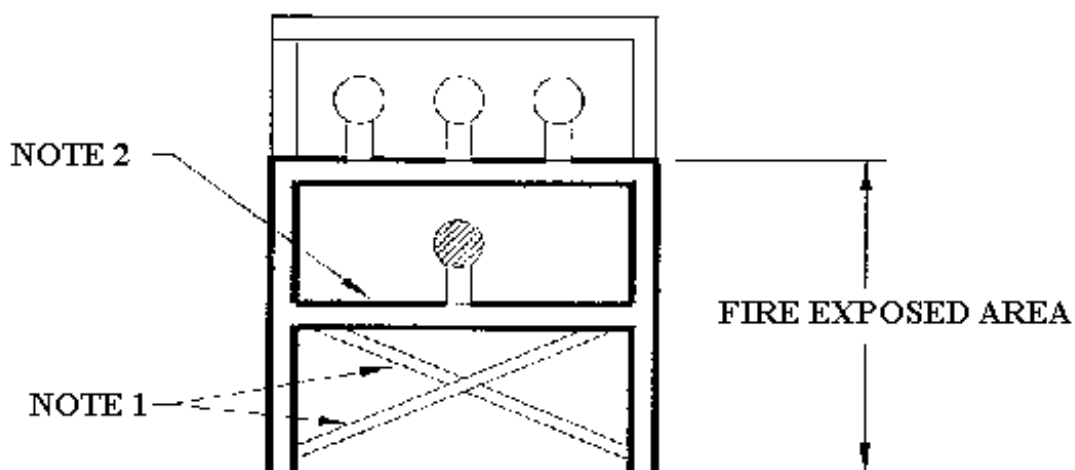


FIGURE 4
FIRE PROOFING OF STRUCTURAL STEELWORK SUPPORTING
FIRE POTENTIAL EQUIPMENT AND NON-FIRE POTENTIAL EQUIPMENT

NOTES:

1. NO FIRE PROOFING ON BRACING WHICH IS NOT LOAD BEARING.
2. FLOOR ON WHICH LIQUIDS CAN ACCUMULATE

NON-FIRE POTENTIAL EQUIPMENT = ○

FIRE PROOFING INDICATED THUS — FIRE POTENTIAL EQUIPMENT = ●

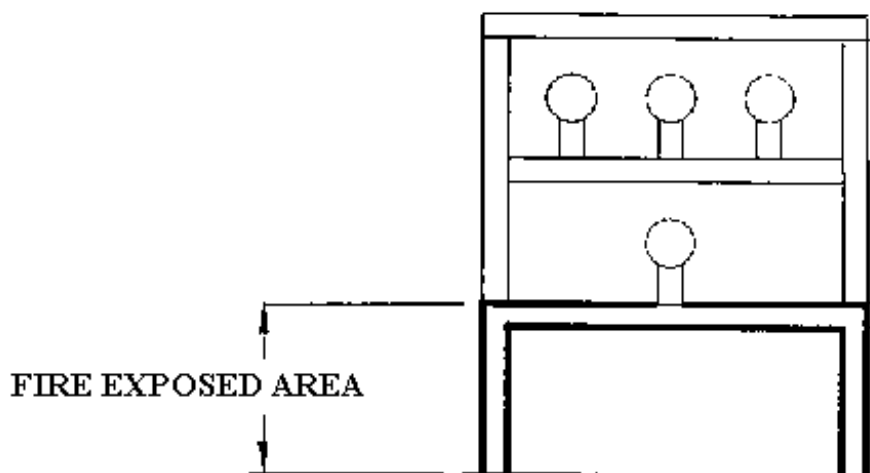


FIGURE 5
FIRE PROOFING OF STRUCTURAL STEELWORK SUPPORTING
NON-FIRE POTENTIAL EQUIPMENT

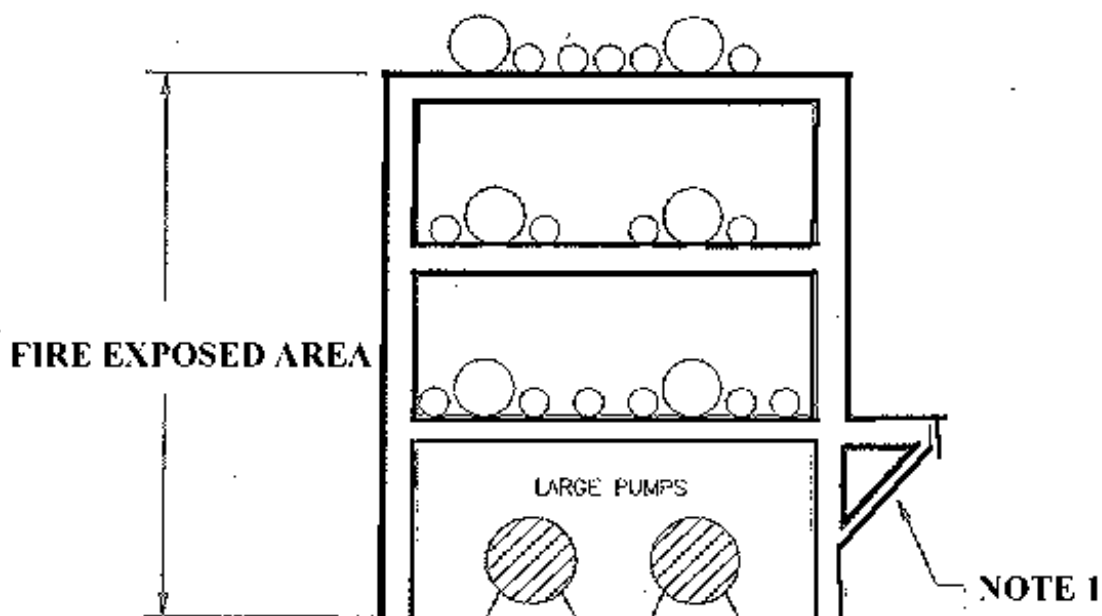


FIGURE 6
FIRE PROOFING OF PIPE RACKS WITH LARGE FIRE POTENTIAL
PUMPS INSTALLED BENEATH

NOTES:

1. FIRE PROOFING KNEE OR DIAGONAL BRACING WHICH SUPPORTS VERTICAL LOAD.

NON-FIRE POTENTIAL EQUIPMENT = ○
 FIRE PROOFING INDICATED THUS — FIRE POTENTIAL EQUIPMENT = ●

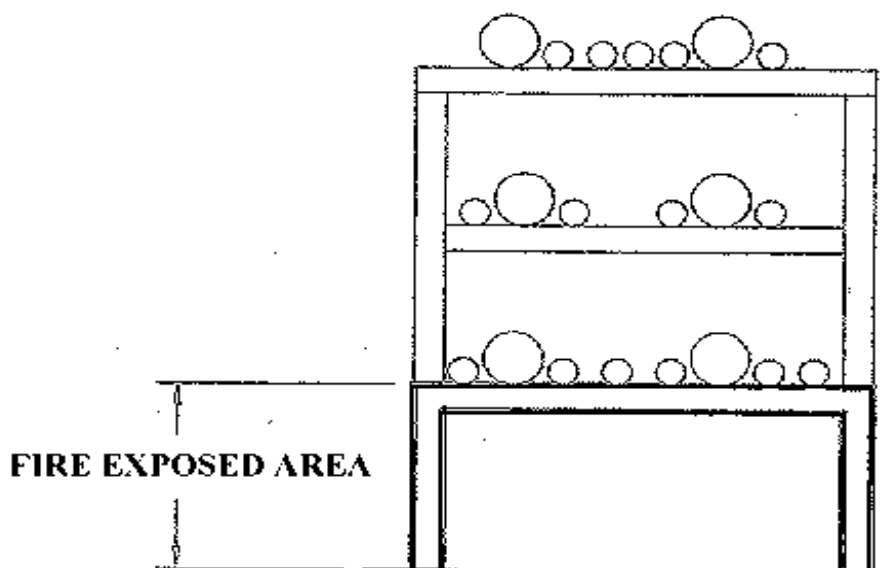
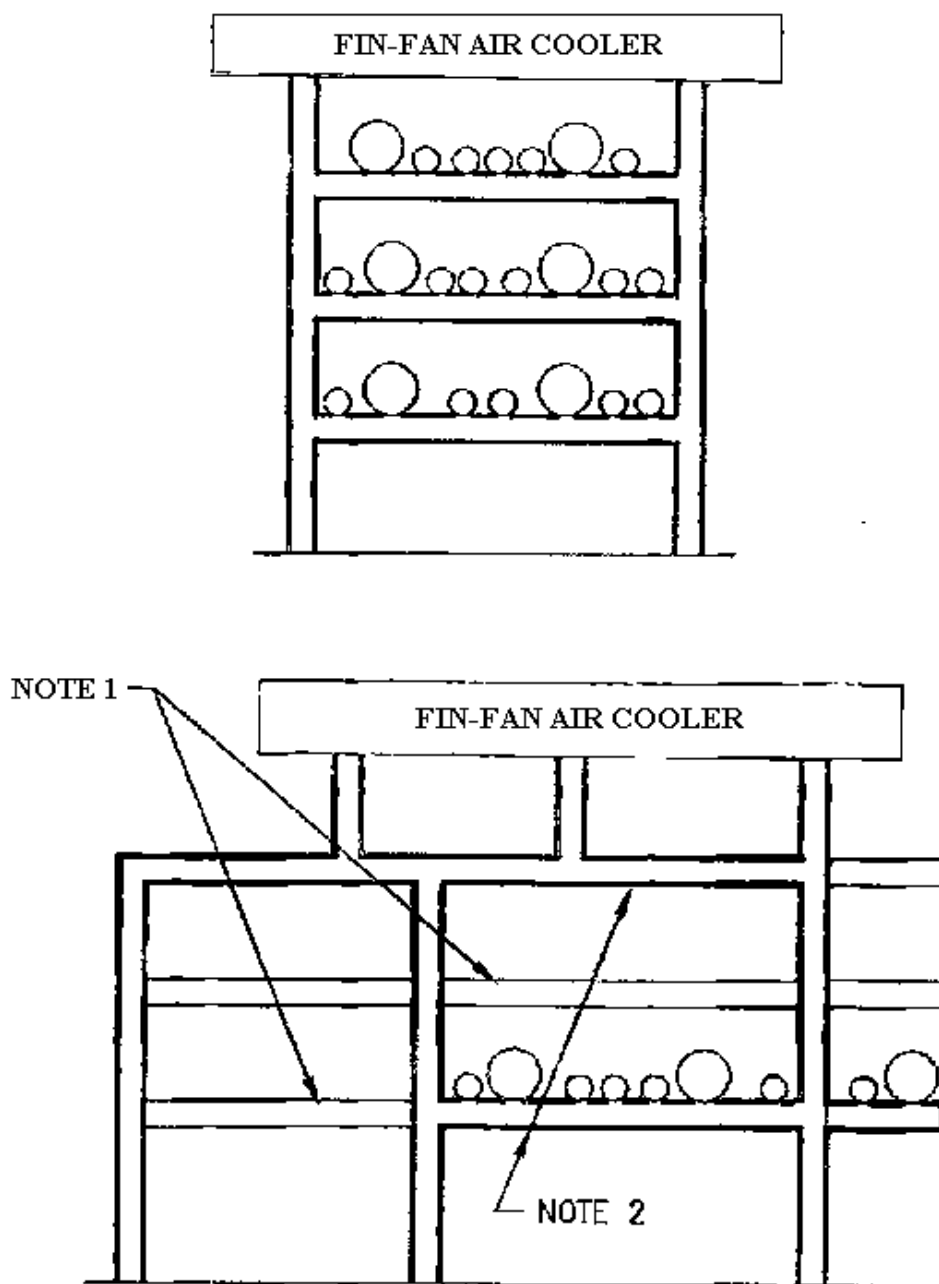


FIGURE 7
FIRE PROOFING OF PIPE RACKS WITHOUT PUMPS BENEATH



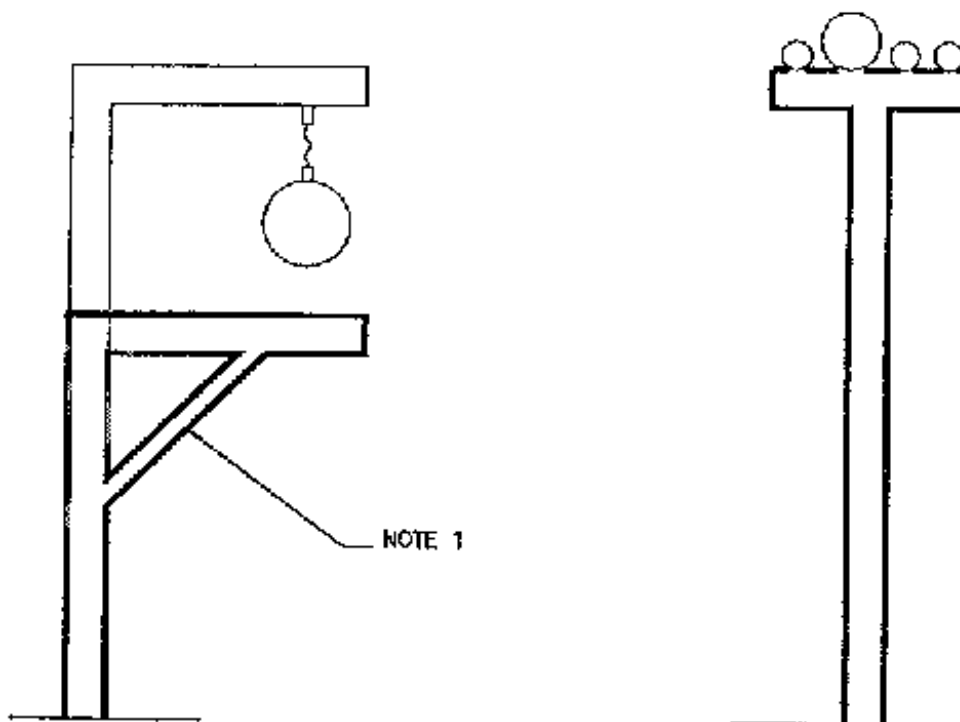
NOTES

1. NO FIRE PROOFING ON STRINGER BEAMS THAT DO NOT SUPPORT VERTICAL LOADS.
2. FIRE PROOFING ON STRINGER BEAMS THAT DO SUPPORT VERTICAL LOADS.

NON-FIRE POTENTIAL EQUIPMENT = ○

FIRE PROOFING INDICATED THUS: —

FIGURE 8
FIRE PROOFING OF STRUCTURAL STEELWORK SUPPORTING AIR COOLERS



NOTES

1. FIRE PROOFING ON KNEE BRACING

FIRE PROOFING INDICATED THUS: _____

FIGURE 9
FIRE PROOFING OF TRANSFER LINE SUPPORTS

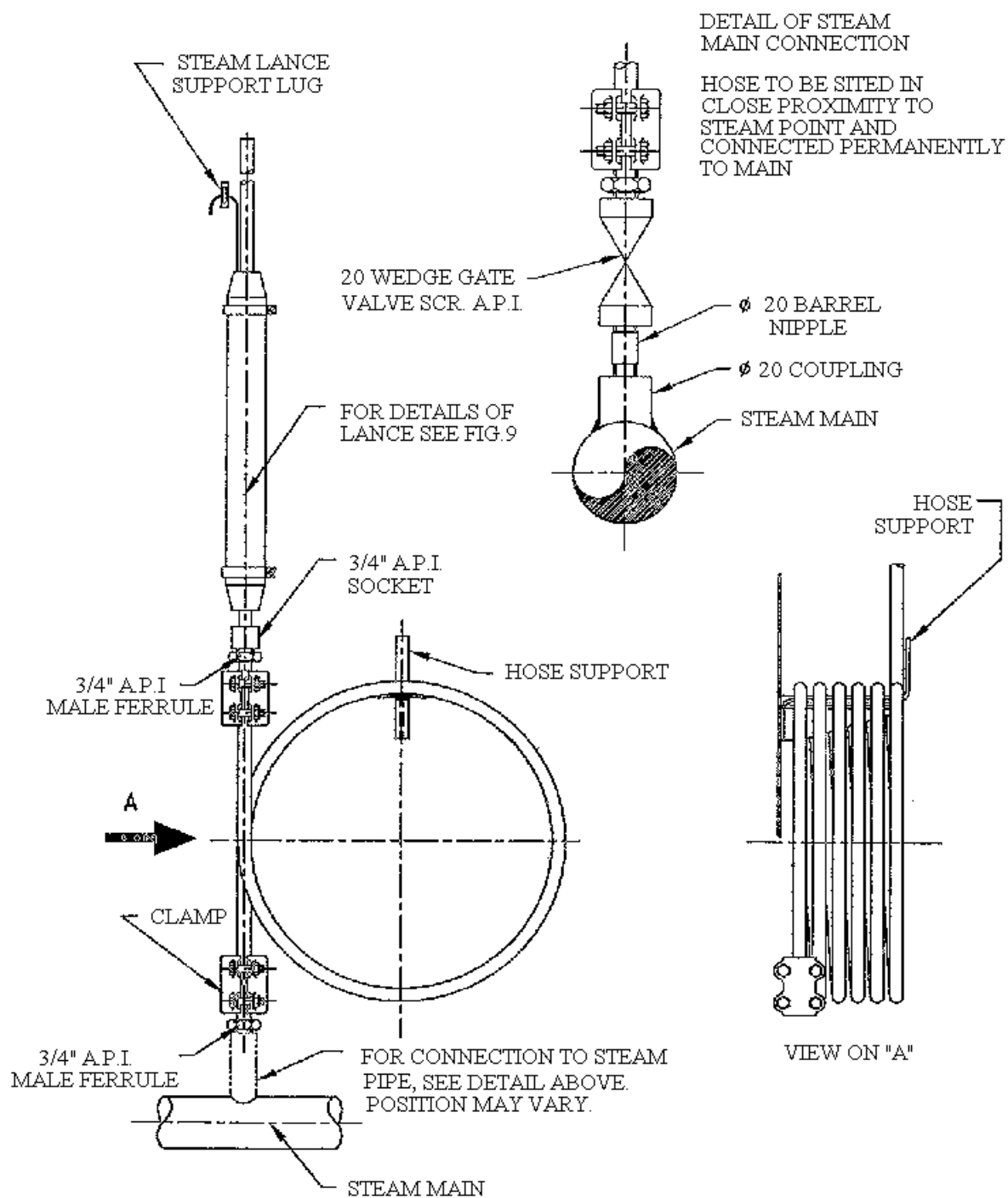
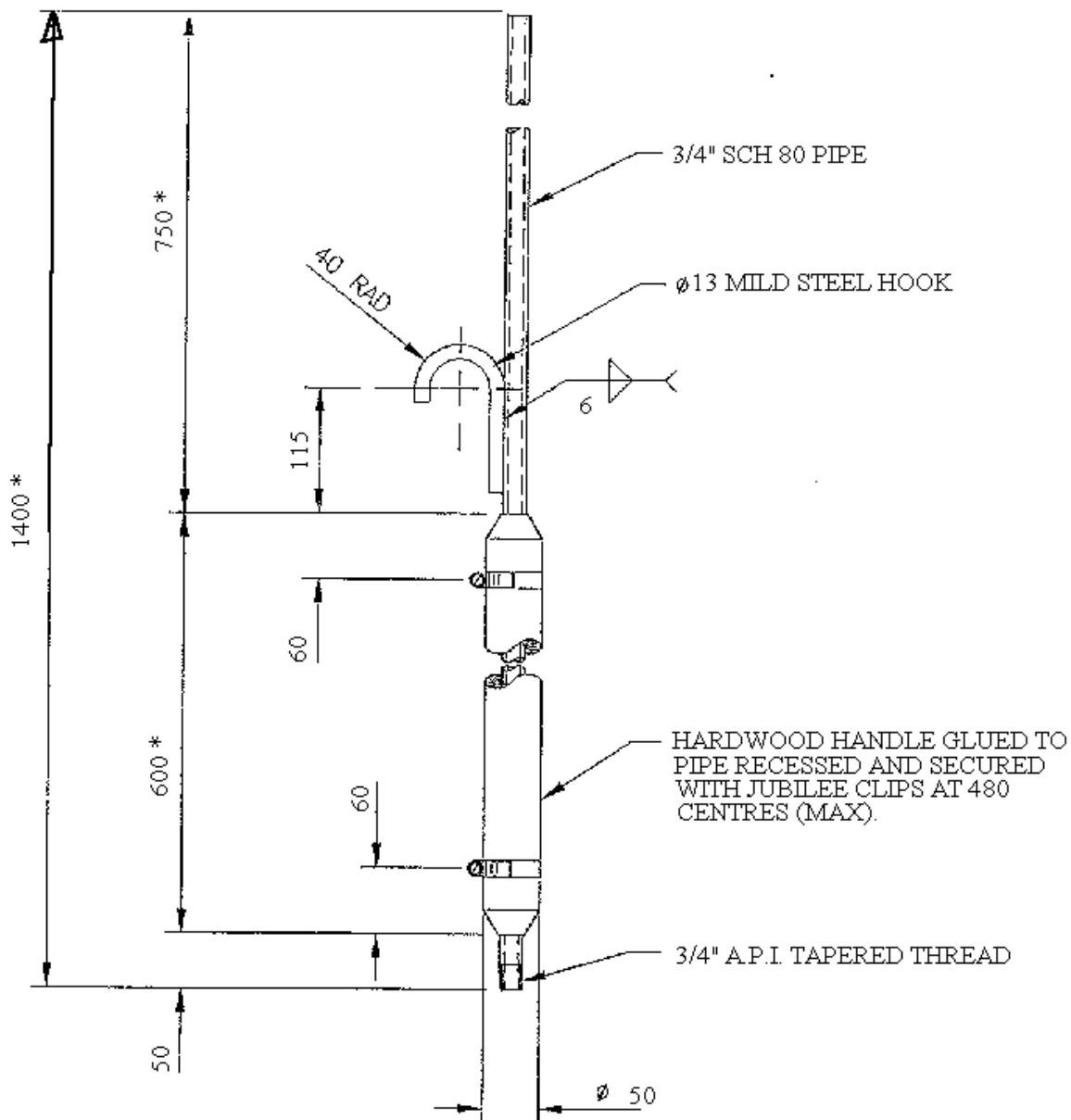


FIGURE 10
GENERAL ARRANGEMENT OF STEAM LANCE, HOSE AND SUPPORT

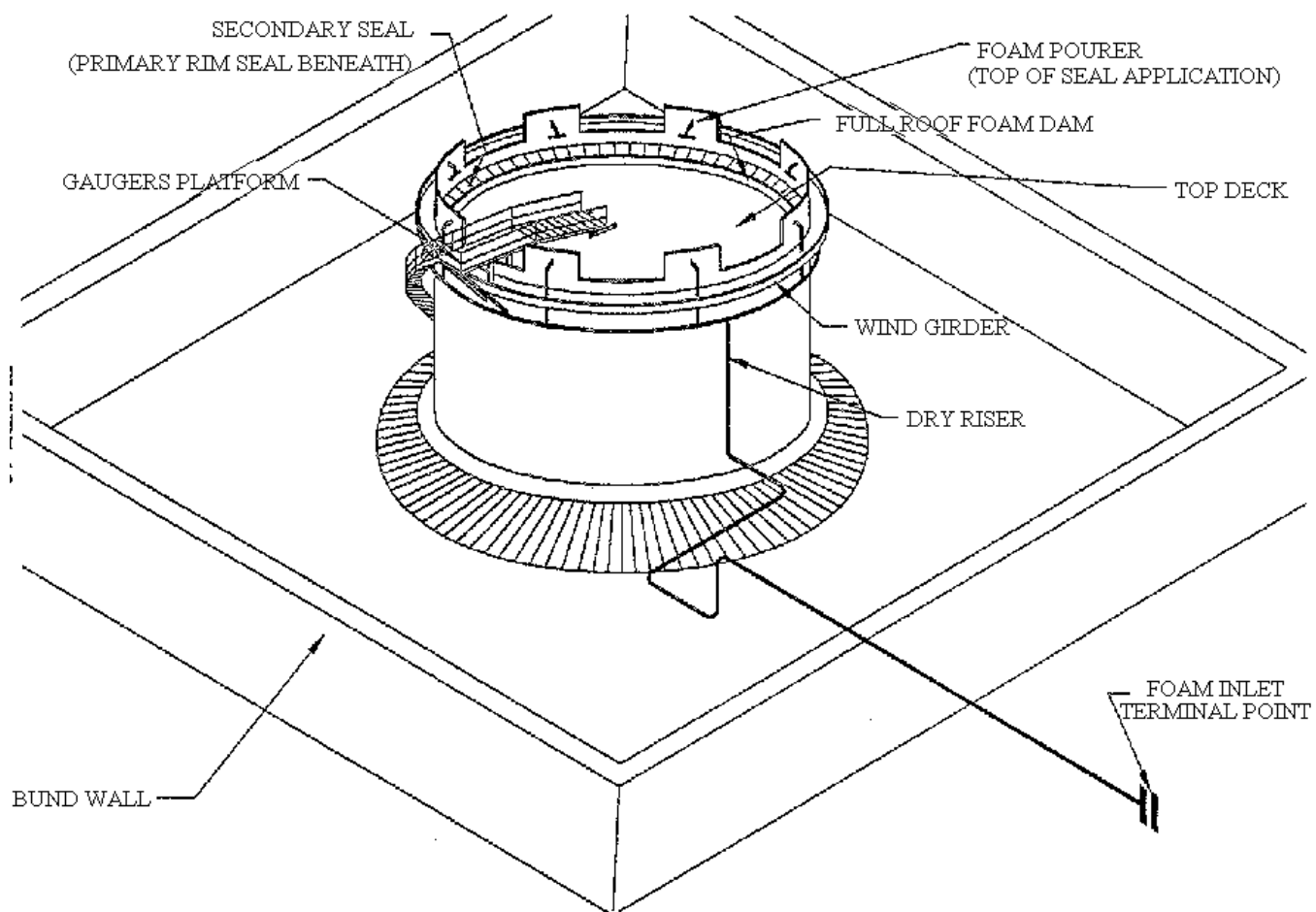


*THESE DIMENSIONS MAY
BE MODIFIED TO SUIT
LOCAL REQUIREMENTS

SEE FIGURE 10 FOR CENTRAL
ARRANGEMENTS OF LANCE
HOSE AND SUPPORT

FIGURE 11
TYPICAL PROCESS STEAM LANCE

FIGURE 12
TYPICAL ARRANGEMENT OF SEMI FIXED TOP FOAM POURERS
TO FLOATING ROOF TANK



DEFINITIONS AND ABBREVIATIONS

Definitions

Standardised definitions may be found in the BP Group RPSEs Introductory Volume.

Client	The organisation for whom fire protection facilities are provided. Within BP this can be a Business, an Associate or an Operating Unit.
Operator	The organisation responsible for safe operation of the Client's plant. Within BP this would be an Operating Unit.
Active Fire Protection:	The equipment, systems and methods required for the detection, alarming, control and extinguishing of fires using water, steam, dry powder or gaseous extinguishants. An example of this would comprise detection equipment for fire, smoke, gas or heat which will activate fixed extinguishing or control systems.
Passive Fire Protection:	The provision of non-combustible materials which in a fire will, for a defined period of time, protect equipment, prevent the collapse of structural supports or limit the spread of fire. In addition, passive systems embrace the basic requirements for area separation and classification.
Essential Use	Halon use shall be defined as essential in existing and future facilities where halons afford genuine protection from a significant risk of:- (a) loss of human life (b) traumatic injury (c) hazard to health e.g., toxicological effects of alternative agents, or (d) damage to the environment, e.g. due to a major catastrophe. and other means of protection (e.g. alternative systems, deleted systems, alternative agents) would increase the above risks or combination of risks to an unacceptable level.



Additionally, international, regional, national or state laws, regulations, etc. may demand that protection systems be installed for other reasons which cannot be fulfilled except through the use of halon systems (e.g. protection of equipment, materials, operations or installations of vital national interest).

Fire Exposed Envelope:	The space into which fire potential equipment can release combustible fluids that can cause substantial fire damage. Unless otherwise determined, a fire exposed envelope shall be considered as extending between 6 and 9 m horizontally and between 9 and 12 m vertically from the source of liquid fuel.
Fire Rating:	The fire resistance performance of the fire protection in terms of fire type, time and temperature. This is usually Hydrocarbon (H) or Cellulosic (A) rating.
Fire Resistance:	The ability to resist fire for a given time when tested under defined conditions.
Fire Potential :	Applicable to plant and equipment (but excluding pipework) which contain combustible fluids (See API 2218).
Fire Proofing:	Materials or application of materials to provide a degree of fire resistance to protect substrates.
Fixed Systems:	See section 17.4.1.
Flammable Liquid	Any liquid having a flash point below 37.8°C and a vapour pressure not exceeding 2.76 bar abs at 37.8°C.
Hydrocarbon Risk Area:	An area in which there is plant, equipment or storage containing hydrocarbon liquids, vapours or gases which may feasibly be released. These include crude oil, fuels, produced fluids, and utility fluids such as seal and lubrication oils, where their flash point requires that they be protected.
Integrated Safe Design:	The incorporation of design safety features on an inter-disciplinary basis, encouraging a co-ordinated approach to safety in the overall design process.



Petroleum Liquids:	Defined in IP Model Codes of Safe Practice.
Class 0:	Ethane, Ethylene, propylene, LPG and LNG.
Class I:	Liquids which have a flashpoint below 21 °C.
Class II:	Liquids which have a flashpoint from 21°C to 55°C inclusive.
Class III:	Liquids which have a flashpoint above 55°C up to and including 100°C.
Class II or III liquids can be further subdivided. Class II(1) or III(1) liquids are those which are handled below their flashpoints. Class II(2) or III(2) liquids are those which are handled at or above their flashpoints.	
Unclassified Liquids:	Liquids which have a flashpoint above 100°C.
Protectability:	The extent to which a given system lends itself to efficient protection by active/passive fire protection methods.
Portable Systems:	Systems whose components can be transported by hand or by tractor and used without need for mechanical handling equipment.
Radiant Heat Output:	The heat energy radiated from a fire (kW).
Semi Fixed Systems:	See section 17.4.1.
Source of Release:	Any Continuous, Primary or Secondary grade source of release as defined in BP Group RP 44-6 , i.e. a point from which flammable gas, vapour or liquid can be released into the atmosphere.

Abbreviations

AFFF	Aqueous film forming foam
ALARP	As low as reasonably practical
API	American Petroleum Institute
ASTM	American Society for Testing and Materials
BLEVE	Boiling liquid expanding vapour explosion
BS	British Standard
CBA	Cost benefit analysis



CDP	Computer data processing
CO ₂	Carbon dioxide
CSE	Concept safety evaluation
DAE	Design accidental event
DEn	Department of Energy (UK)
DNV	Det Norske Veritas
EAE	Extreme accidental event
ESD	Emergency shutdown
F&E	Fire and explosion
FEHMP	Fire and explosion hazard management plan
FFFP	Film forming fluoroprotein
FMEA	Fault free and failure modes and effects analysis
FP	Fluoroprotein
FRA	Fire Risk Analysis
GRP	Glass reinforced plastic
HAZID	Hazard identification
HAZOP	Hazard and operability
HVAC	Heating, ventilating and air conditioning
IP	Institute of Petroleum
LNG	Liquefied natural gas
LPG	Liquefied petroleum gas
NFPA	National Fire Protection Association
NPS	Nominal pipe size (inches)
NPSHA	Net positive suction head available
P&ID	Piping and instrument diagram
PCM	Prevention, control and mitigation
QRA	Quantitative risk assessment
RHO	Radiant heat output
UL	Underwriter's Laboratory
VLCC	Very large crude carrier



LIST OF REFERENCED DOCUMENTS

A reference invokes the latest published issue or amendment unless stated otherwise.

Referenced standards may be replaced by equivalent standards that are internationally or otherwise recognised provided that it can be shown to the satisfaction of the purchaser's professional engineer that they meet or exceed the requirements of the referenced standards.

ANSI B31.3	Chemical Plant and Petroleum Refinery Piping
API 2218	Fire proofing practices in petroleum and petrochemical processing plants
ASTM C150	Specification for portland cement
ASTM E119	Method for fire tests of building construction and materials
ASTM G26	Recommended practice for operating light-exposure apparatus (xenon-arc type) with an without water for exposure of non-metallic materials
BS 476	Fire tests on building materials and structures Part 5 - Method of test for ignitability Part 8 - Test methods and criteria for the fire resistance of elements of building construction
BS 5306	Fire extinguishing installations and equipment on premises Part 2 - Specification for sprinkler systems Part 4 - Specification for carbon dioxide systems
BS 5950	Structural use of steelwork in building. Part 8 - Code of practice for fire resistant design
BS 8110	Structural use of concrete Part 1 - Code of practice for design and construction
D En	Hydrocarbon fire resistance tests for elements of construction for Offshore Installations - Test specification - Test procedure
IP	Model code of safe practice in the petroleum industry. Part 9

Montreal Protocol	Montreal Protocol Assessment II of the Halons Technical Options Committee.
NFPA 11	Foam extinguishing systems
NFPA 12	Carbon dioxide extinguishing systems
NFPA 13	Installation of sprinkler systems
NFPA 15	Water spray fixed systems for fire protection
NFPA 16	Deluge foam-water sprinkler and spray systems
NFPA 17	Dry chemical extinguishing systems
NFPA 20	Centrifugal fire pumps
NFPA 24	Service mains and their appurtenances, private
NFPA 30	Flammable and combustible liquids code
NFPA 86	Ovens and furnaces
NFPA 101	Life Safety Code.
Steel Construction Institute	<i>Interim guidance notes for the design and protection of topside structures against explosion and fire.</i>
	<i>Fire and blast information group - updates.</i>
UL 263	Fire Tests of Building Construction and Materials
UL 1709	Standard for Safety Rapid Rise Fire Tests of Protection Materials for Structural Steel.
BP Group RP 4-1	Drainage Systems (replaces BP CP 6)
BP Group RP 4-6	Procedure for the design of Buildings Subject to Blast Loading (replaces Appendix B of BP CP 19)
BP Group RP 12-4	Power System Protection and Control (replaces BP CP 17, Part 4)
BP Group RP 24-2	Fire Protection - Offshore (replaces BP CP 15 and BP CP 16)
BP Group RP 30-5	Instrumentation and Control - Selection and Use of Equipment for Instrument Protection Systems (replaces BP CP 18, Part 5)
BP Group RP 30-7	Design Philosophy for Fire and Gas Detection and Control Systems
BP Group RP 42-1	Piping Systems (replaces BP CP 12)
BP Group RP 44-1	Overpressure Protection



	(replaces BP CP 14)
BP Group RP 44-6	Area Classification (replaces BP CP 39)
BP Group RP 44-7	Plant Layout (replaces BP CP 3)
BP Group RP 52-1	Thermal Insulation (replaces BP CP 13)
BP Group RP 62-1	Guide to Valve Selection
BP Group GS 106-1	Cement-Mortar Lined Pipe (replaces BP Std 106)
BP Group GS 106-2	Painting of Metal Surfaces (replaces BP Std 141)
BP Group GS 124-1	Fire Pumps and Drives (replaces BP Std 217)
BP Group GS 158-2	Vertical Storage Tanks for Non-Refrigerated Liquids - Tanks to BS 2654 (replaces BP Std 163, Part 1)
BP Group GS 162-1	Steel Wedge Gate, Globe and Check Valves. (replaces BP Std 150).
BP Group GN 91/16	<i>Risk Based Approach to Tank Layout (issued by Corporate Safety Services)</i>
BP Group GN 91/17	<i>Fires in Petroleum Storage Tanks (issued by Corporate Safety Services)</i>

