

PETRONAS TECHNICAL STANDARDS

DESIGN AND ENGINEERING PRACTICE

TECHNICAL SPECIFICATION

WATER-BASED FIRE PROTECTION SYSTEMS FOR OFFSHORE FACILITIES

PTS 80.47.10.12

JANUARY 2011



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PTS Title:	Water-based Fire Protection Systems For Offshore Facilities

This revision of **PTS 80.47.10.12 – Water-based Fire Protection Systems for Offshore Facilities** has been updated *either* to incorporate PETRONAS Lessons Learnt, Best Practice *and/or* new information issued by relevant industry code and standards. All updates in the document are highlighted in *italic* font.

The previous version of this **PTS 80.47.10.12 – Water-based Fire Protection Systems for Offshore Facilities (November 1997)** will be removed from PTS binder / e-repository from herein onwards.

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PREFACE

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1.0 INTRODUCTION

1.1 SCOPE

This PTS specifies requirements and gives recommendations for the use of water-based fire systems on offshore facilities. It is based on the International Standard ISO 13702 which should be referenced for further guidance. The PTS includes details on all main elements of a firewater system including firewater pumps, the firewater main system, deluge systems, sprinkler systems, foam systems, water mist systems and ancillary items (monitors, hydrants, etc.). The document assumes the reader has some knowledge of firewater systems design.

The requirements for fire protection are detailed in the Fire and Explosion Strategy (FES) developed during the process of evaluation and risk management within the Hazards and Effects Management Process (HEMP).

This PTS gives guidance on the design of firewater system elements and where prescriptive rules are laid down they represent the best current practice at the time of publication, which could change. This is particularly applicable to new technology developments in firewater mist sprays and the use of deluge systems in explosion suppression. If compliance with the prescriptive rules causes problems, then discussions should be held within the project.

This PTS is applicable to a very wide range of offshore facilities operating in different environments, from simple unmanned structures which may not justify firewater systems to complex platforms where there are many personnel present at all times and a firewater system may have a major role as a life-saving measure.

The decision to use a particular type of firewater system element should be based on the FES rather than information provided in design codes of practice. Industry standards such as National Fire Protection Association (NFPA) codes tend to relate to specific elements of firewater systems. They do not normally give guidance on the overall firewater system as defined here. Such documents may, however, give useful design guidance once a particular firewater system element has been selected on the basis of the hazard assessment.

This PTS is a revision of the PTS of the same number dated November 1997; a summary of the main changes is given in (1.6).

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

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

This PTS is intended for use in offshore exploration and production facilities.

When PTSs are applied, a Management of Change (MOC) process should be implemented; this is of particular importance when existing facilities are to be modified.

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

1.3 DEFINITIONS

1.3.1 General Definitions

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

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

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

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

1.3.2 Specific Definitions

- | | | |
|-------------------------------------|---|---|
| Active Fire Protection | - | The equipment, systems and methods which, may be used to fight a fire once it has started. |
| Area Protection | - | Fire protection aimed at covering a complete area rather than specific items or equipment. |
| Discharge elements | - | Those elements of the overall firewater system that discharge water into a fire-affected area (e.g. deluge systems, sprinkler systems). |
| Emergency Response Personnel | - | Those personnel who have a designated response role in an emergency. |
| Equipment Protection | - | Fire protection aimed at specific items or equipment rather than a complete area. |
| Fire and Explosion Strategy | - | The process that uses an assessment of the hazards of fires and explosions to determine the measures required to manage such hazardous events. |
| Fire and Gas Panel | - | The control panel at a Central Control Point monitoring and controlling signals from all field detection and protection systems. |
| Jet fire | - | An ignited release of pressurised, flammable fluid. |
| Passive Fire Protection | - | A coating, cladding arrangement or free-standing system which in the event of a fire will provide thermal protection to restrict the rate at which heat is transmitted to the object or area being protected. |
| Pool fire (Spill fire) | - | Combustion of flammable liquid spilled and retained on a surface. |

1.4 ABBREVIATIONS

AFFF	-	Aqueous Film Forming Foam
AFP	-	Active Fire Protection
BLEVE	-	Boiling Liquid Expanding Vapour Explosion
BOP	-	Blow-out Preventer
CAA	-	Civil Aviation Authority
EER	-	Evacuation, Escape and Rescue
ESD	-	Emergency Shutdown
ESSA	-	Emergency Systems Survivability Analyses
FES	-	Fire and Explosion Strategy
FFFP	-	Film Forming Fluoroprotein
FGP	-	Fire and Gas Panel
HEMP	-	Hazards and Effects Management Process
HLO	-	Helicopter Landing Officer
HSE	-	Health, Safety and the Environment
HV	-	High Voltage
HVAC	-	Heating, Ventilation and Air Conditioning
LAT	-	Lowest Astronomical Tide
ILBP	-	In-line Balanced Pressure Proportioning
MOPO	-	Manual Of Permitted Operations
NDE	-	Non-Destructive Examination
NUI	-	Normally Unmanned Installation
PEFS	-	Process Engineering Flow Scheme
PFP	-	Passive Fire Protection
P&ID	-	Process and Instrument Diagram
QRA	-	Quantitative Risk Assessment
TR	-	Temporary Refuge

1.5 CROSS-REFERENCES

Where cross-references to other parts of this PTS are made, the referenced section number is shown in brackets. Other documents referenced by this PTS are listed in (13).

1.6 SUMMARY OF CHANGES

The previous edition of this PTS was dated Dec 2004. Summary of changes made to the last edition is given below:

Section	Changes
1.2	Add the clause "When PTSs are applied, a Management of Change (MOC) process should be implemented; this is of particular importance when existing facilities are to be modified."
4.0	Add the clause "Firewater pumps shall be in accordance with PTS 37.29.01.30".
10.2.1	Add Clause "ISO 13702 Clause 11.3.4"
13	"PTS 37.29.01.10 Firewater pumps for offshore installations" is being added in the reference list
13	Note is added "EP 95-0000 documents are being replaced by the EP 2005-0000 series. Check for updates before use"
13	Standards EP 95-0300 is being replaced with EP 2005-0300.
13	NFPA 20 title "Centrifugal fire pumps" is being replaced with "Installation of stationary pumps for fire protection"
13	MIL-F-24385 title "Military Specification, Fire Extinguishing Agent AFFF for fresh and sea Water" is changed to "Fire extinguishing agent AFFF for fresh and sea water".

2. HAZARDS AND EFFECTS MANAGEMENT PROCESS (HEMP)

2.1 INTRODUCTION

All companies associated with the offshore oil and gas industry shall have an effective management system which addresses the health, safety and environmental (HSE) issues that are relevant to its activities. A key element is a process of evaluation and risk management, called in PETRONAS the Hazards and Effects Management Process (HEMP). This process is described in general in EP 95-0100 with more detailed information given in EP 2005-0300. Guidance on fire control and recovery is given in EP 95-0351.

2.2 FIRE AND EXPLOSION STRATEGY

The results of the evaluation process and the decisions taken with respect to the management of fires and explosions are recorded in a FES which summarises the key aspects of the hazardous events, the associated risks, measures to minimise the consequences and measures to prevent fires and explosions arising. The measures required may include elements detailed in (3) and (4).

The level of detail in the FES will vary depending on the scale and complexity of the offshore facility and the stage in the offshore facility's life-cycle when the risk management process is undertaken.

The FES should also describe the role and essential elements (or Performance Criteria, see 2.4) for each of the systems required to manage possible hazardous events on the offshore facility.

2.3 THE ROLE OF FIREWATER SYSTEMS

A number of different systems might be considered as part of the FES to reduce the risk of a fire or explosion. Firewater systems are one such system in the category Active Fire Protection (AFP). They are usually operated only after the initial hazardous event (e.g. hydrocarbon liquid release) and ignition have occurred. They are intended to mitigate the consequences of the event by extinguishing or limiting the spread of fire. Therefore they must be regarded as a **recovery** measure within the FES and so should only be put in place after it is shown that **control** measures cannot reduce risk to a tolerable level and one which is as low as reasonably practicable.

In addition, it should be recognised that other recovery measures such as shut-down, inventory control, plant layout, drainage, Passive Fire Protection or other AFP measures (extinguishers, carbon dioxide systems etc.) may be more appropriate than water-based systems to reduce risk levels. AFP, in general, because of the inherent maintenance requirements and reliability issues, should be regarded as one of the last "lines of defence" of recovery rather than the "first".

The purposes of installing AFP systems on offshore facilities include the following:

- to protect personnel at a Temporary Refuge (TR);
- to minimise fire damage and thus enable the facility to return to operational status as soon as possible after a fire;
- to minimise escalation, which could lead to widespread damage and pollution of the environment;
- to meet legislative or other mandatory requirements.

Water can reduce the potential risk from fire by:

- extinguishing or reducing fire intensity by;
- cooling of solid combustible material fires or high-flashpoint liquids;
- excluding oxygen (air) when water is converted to steam in the fire area;
- excluding oxygen (air) if water is applied as foam to liquid spill fires.

- cooling smoke, flame and hot gases to limit the spread of fire by convection;
- cooling adjacent structures or facilities to prevent fire spread by radiation effects and thus maintain integrity;
- forming a heat absorbing barrier between a fire and facilities, including escape routes, outside the fire area.

2.4 PERFORMANCE CRITERIA

Performance Criteria record the essential features of the measures selected on a particular offshore facility to manage major accidents and any events requiring Evacuation, Escape and Rescue (EER). They provide the basis for monitoring the actual status of the measures throughout the life of the offshore facility.

In order to simplify the development of facility-specific Performance Criteria, templates for firewater-based systems are provided in (Appendix 1) as examples.

2.5 INTERDEPENDENCE WITH OTHER SYSTEMS

In order to make firewater systems more effective, it is sometimes necessary to have other systems or features in place. Typically these may include:

- Shut-down, isolation and blow-down to minimise fuel inventories.
- Ventilation shut-down to prevent removal of atmospheres with reduced oxygen levels (due to consumption of oxygen by the fire or due to steam formation).
- Power-down to reduce risk of electric shock problems, short-circuiting etc. and to remove a potential ignition/re-ignition source.
- Fire and Gas Detection and Control Panel logic including audible and visual alarms.
- Drainage and containment systems to remove product and firewater and/or contain it in one place so that the fire does not spread to other areas.
- Passive Fire Protection measures to contain an incident.

3. FIREWATER SYSTEMS

3.1 DESIGN GOALS

- Goal 1: To satisfy the Performance Criteria.
- Goal 2: To fulfil their functions during normal operations, maintenance and repair with sufficient reliability and availability.
- Goal 3: To be capable of operation under the emergency conditions that may be present when the system is called upon to operate.
- Goal 4: To be suitable for their operating environment throughout the required design life.
- Goal 5: To be capable of being operated easily, safely and effectively.
- Goal 6: To be capable of rapid reinstatement after operation and testing.
- Goal 7: To allow easy demonstration of compliance with the Performance Criteria.
- Goal 8: To provide sufficient documentation to facilitate safe operation, maintenance, testing, inspection and commissioning of firewater systems.
- Goal 9: To provide facilities at a Central Control Point to allow persons to monitor the status of and initiate automatic firewater systems.
- Goal 10: To provide adequate drainage within any area where firewater may be discharged to prevent escalation of a fire by carry-over of flammable liquid to adjacent areas.

3.2 SYSTEM OVERVIEW

3.2.1 Elements of firewater systems

Figures 1 and 2 show the different elements that make up a firewater system. Design guidance on specific elements is included in (Sections 4 through 11).

For any given fire scenario, it may be necessary to operate more than one water-based recovery system simultaneously. For example, it may be necessary to operate a foam system to extinguish a contained spill fire while simultaneously operating deluge systems to cool adjacent structures and also to have manually controlled hose lines available for system back-up. Therefore, in developing the FES it is necessary to determine those systems which may be required to operate simultaneously. Certain elements of the firewater system (supply source, pumps and firewater main) are common to all other elements (such as deluge systems).

Thus individual elements may have different availability requirements (see 3.2.2).

3.2.2 Overall system requirements

The justification for provision of a firewater system shall be based upon a formal hazard assessment, as documented in the FES.

The Performance Criteria for each individual firewater system element shall be defined. Application rates of water and/or foam solution shall be sufficient to meet the functional Performance Criteria.

The firewater system shall be such that when more than one element of it may be required to operate simultaneously, the goals of each operating element shall be met.

The availability of all elements of the firewater system shall be maximised as far as is reasonably practicable.

Equipment specifications including materials of construction shall take into account the operating environment of the firewater system and design life.

Firewater element design shall consider drainage requirements from any discharge area to ensure that the drains are adequate and appropriate.

Firewater shall not be discharged into areas containing significant quantities of water-reactive materials.

3.2.3 Overall system guidance

3.2.3.1 Design intent

As part of the hazard assessment a FES should be developed to justify the need for a water-based active fire protection system. Having established the need for a water-based system, its design intent can be specified. Guidance on the capabilities and limitations of the different systems available is included in (Sections 4-11).

An assessment of the escalation potential within and beyond each fire area should also form part of the hazard assessment.

The results of this assessment should be used to develop the Performance Criteria for the various elements of the firewater system.

Additional guidance on scenario development and assessment of hazardous event recovery measures is provided in EP 95-0300, EP 95-0350 and EP 95-0351.

The design intent for elements that discharge water or foam should include:

- Element purpose: extinguishing, control etc.
- Fire description: type (jet, pool, etc.); size; duration; intensity; over-pressures from any associated explosion.

From this information, detailed performance requirements and specifications for the individual discharge elements can be prepared (Sections 4-11). Application rates of water or foam solution can then be determined either by experiment or from relevant proven data. In the absence of such information, recognised codes of practice such as NFPA can be used provided it is shown that the application rates applied are relevant to the fire scenario.

3.2.3.2 Firewater demand

The Performance Criteria for the firewater pumps and the firewater main should be based on two scenarios as follows:

- **The design firewater demand;** this is the largest firewater demand for a single fire event and should take into account:
 - any requirements for personnel protection during escape and evacuation;
 - the demand of all firewater systems which are likely to be initiated by the initial fire incident;
 - requirements for manual fire-fighting by personnel with hose lines, monitors etc. (e.g. to provide boundary cooling);
 - any firewater requirements for essential users (e.g. drilling make-safe and generator cooling).
- **The maximum reasonably foreseeable firewater demand;** this should **also** take into account:
 - possible escalation to other fire areas (e.g. due to external flaming or due to failure of a fire barrier as a result of an explosion);
 - release of protection systems covering other areas (e.g. due to an explosion or external flaming being detected by flame detectors in other areas);
 - possible manual initiation of additional water-based protection systems or equipment to protect nearby equipment and facilities.

The firewater system should be capable, at its design conditions and integrity, of meeting the design firewater demand. However, the maximum reasonably foreseeable firewater demand may be met by allowing the firewater pumps to run-out beyond their duty point and making use of all sources of firewater which are likely to be available in the emergency.

The purpose of defining a design firewater demand and maximum foreseeable firewater demand is to provide a basis for sizing, but not excessively over-sizing, the firewater pumps (see Section 4) to enable firewater to be used effectively in fire scenarios involving explosions or escalation. The usual underlying philosophy is that the duty point of firewater pump systems is designed to deal with fire incidents which are not preceded by explosions. Firewater systems are likely to have a useful role following an explosion but such an event should not normally dictate the duty point of the firewater pumps.

The above procedure for determining firewater demands applies to both enclosed and naturally ventilated areas. However, for naturally ventilated areas the fire area should be taken as the largest area likely to be affected by a single fire emergency. That area may be one level of an integrated deck because of the likelihood of fire detectors throughout the same level reacting to the fire.

If the firewater demand for such fire area(s) cannot be satisfied, additional physical separation of the decks and/or adjacent compartments can be employed or additional firewater pumping capacity made available. However, if barriers are provided as a means to achieve segregation or prevent the unnecessary simultaneous operation of firewater system elements in adjacent areas, such barriers should not impede the free natural ventilation of the areas nor result in unacceptable explosion over-pressures.

For existing offshore facilities, it may not be reasonably practical to increase the supply of firewater or provide additional physical separation in order to deal with the maximum foreseeable firewater demand. All cases where there may be limited firewater cover should be identified and the impact of these on the offshore facility's emergency procedures should be considered so that any resultant actions to be taken by Emergency Response personnel can be included in the installation Emergency Response Plan.

If the hazard assessment on an offshore facility indicates that there is no need to provide a water application system, but recommends the provision of hydrants and/or monitors, the possible use of the service water facilities should be investigated. The largest firewater demand in this instance should be based on the numbers of the monitors and hydrants that will be brought into simultaneous operation.

3.2.3.3 Drains

Firewater discharge rates required can be large. Drains should be sized to allow for the flows applied or containment should be such that the water and any other spilled liquids do not spread to other areas. Drains should be designed to prevent fire spread if burning liquids are carried into them by water-based fire systems.

3.2.3.4 Operating environment

The selection of materials for pipework or other firewater system components should take into account the operating environment which is normally highly saline and often has extremes of temperature and humidity. On offshore facilities where temperatures drop below 0 °C and permanently filled firewater system elements are provided, the routing of pipework should be such as to minimise exposure to freezing conditions. Specific measures may be required to eliminate the possible freezing of exposed pipework. The firewater main temperature should be monitored non-intrusively at any exposed locations likely to freeze.

Facilities for injecting additives (chemical or biological) to inhibit corrosion and marine growth within the firewater system should be provided. Any additives may affect foam production and should be checked with the manufacturer. Operation of the flushing system also needs to be considered.

3.2.3.5 Location

The firewater system components should be located so as to minimise the probability of mechanical damage by dropped objects, swung loads, explosion venting, etc.

3.2.3.6 Surge problems

Surge pressures can be induced in a firewater system element by the following causes:

- Starting and stopping the firewater pumps.
- Operation of a firewater system discharge element.
- Closing a firewater system discharge element.
- Failure of a first fire pump to start, resulting in a delay which allows the fire main to drain before a stand-by pump starts.
- Starting the firewater pump against a non-pressurised fire main.

Surge pressures are dependent on:

- Firewater pump characteristics, i.e. run-up time and head generated.
- System design, i.e. length of piping, location of elbows and bends, etc.
- Valve type and location.
- Time of opening and closing of main system valves.

To reduce the effects of surge on the system, a surge study should be conducted upon completion of the firewater main isometric drawings. Corrective measures should be applied to protect the system against surge pressures that are greatly in excess of the system design pressure (see 4.3.2.8).

3.2.3.7 Strainers

To prevent blockage of system elements or components it is normal practice to include strainers in the pump suction line, but it may also be necessary to provide strainers at the inlet to individual system elements.

3.2.3.8 Materials

All water distribution pipework should be designed and constructed from materials suitable for the duty. In addition:

- pipework less than 25 mm nominal diameter should not be used;
- the design velocity should not exceed 10 metres/second;
- pipework should have adequate flanged joints to allow internal inspection.

Materials should be selected that are inherently corrosion-resistant. These may include glass-fibre reinforced epoxy (GRE) and glass-fibre reinforced thermosetting plastic (GRP), as detailed in PTS 31.40.10.19.

If materials of construction are not specified, the design Contractor should submit proposals for approval by the relevant approval authority.

Piping classes should be selected from PTS 31.38.01.15.

3.3 OPERATION, CONTROL AND MONITORING

3.3.1 Mode of operation

3.3.1.1 Requirements

All firewater system elements shall be clearly marked with operating instructions easily understood by those required to use them.

All actuation devices or equipment requiring manual initiation or deployment shall be easily accessible and located outside or away from the protected area so that an operator can actuate the systems safely when required.

For manually initiated discharge elements, the time delay before they are actuated and become operational shall not affect their ability to fulfil their intended functions.

For automatically initiated discharge elements, a manual release station which does not rely on the integrity of electrical or pneumatic signals shall also be provided.

Any prior actions required for systems to be effective, such as power or ventilation shut-down, shall be incorporated in the system logic cycle.

3.3.1.2 Guidance

The mode of operation of any firewater system discharge element can be either manual or automatic, triggered by a signal from, for example, a fire detection system.

The means of actuation selected will depend on the time delay acceptable. In general, the faster a discharge element is actuated, the lower the probability of incident escalation. Automatic systems are faster to actuate than manual systems. In addition, the length and size of lines between water source and discharge elements will affect the effective response time.

Automatic systems may be more prone to spurious discharge which, particularly in the case of discharge onto electrical equipment, can cause considerable damage. The FES should therefore address the need for automatic actuation and the consequences in terms of escalation if such automatic actuation or other automatic actions are not provided. In the case of automatic systems, the speed of response should be considered when selecting the most appropriate detection system.

Discharge of water onto live electrical equipment can cause severe equipment damage and provide an electric shock hazard. Energised HV electrical equipment should therefore be isolated prior to any system discharge or designed to prevent water ingress under discharge conditions.

Water-based systems should not be actuated by the detection of gas in the protected area since they may create a potential ignition source by wetting electrical fittings and equipment.

The role of deluge systems in explosion mitigation is discussed in Section (11).

3.3.2 Alarm and annunciation

3.3.2.1 Requirements

The status of all automatic firewater system elements shall be indicated at the Central Control Point. Actuation of an alarm for one system shall not prevent other alarm and annunciation signals.

3.3.2.2 Guidance

All instrumentation associated with the firewater system should interface with the Fire and Gas Panel (FGP). The main objective should be for the discharge of any system and the initiation of actions to be confirmed on the FGP. This should also apply if a system is locally actuated.

Normally, with water-based systems a specific pre-discharge alarm to allow personnel to evacuate an area prior to discharge is not necessary.

As a minimum, the annunciations at the Central Control Point should include the following for discharge systems:

- System Operable;
- System Actuator Fault (e.g. monitoring lines to solenoid valves in actuating systems);
- System actuated;
- System discharged.

3.3.3 Shut-down and reset

3.3.3.1 Requirements

All firewater system elements shall be such that they can be shut down and reset into a fully operable condition as soon as is practicable after the incident.

Automatic shut-down of a system shall not be permitted unless it can be shown that leaving the system running could give rise to a greater risk than shutting it down.

Formal procedures shall be in place for manual response after a system has discharged and for resetting.

System Operable annunciation shall not be possible unless all components are reset.

3.3.3.2 Guidance

Normally only the manual shut-down of an AFP system should be allowed following visual inspection of the incident area to ensure that it is safe to do so.

In some cases automatic shut-down of an AFP system may be allowed if the risk is greater if the system was not shut down (for example, if continued operation of the system could lead to flammable liquids being spread to other areas by the firewater).

The following factors should be considered prior to deciding if automatic shut-down is appropriate:

- Will significant damage to equipment occur if the system is not shut down (e.g. hot machinery, electrical equipment)?
- Will drainage from the area be such that fire spread will occur unless the system is shut down? (e.g. carry-over of hydrocarbon liquid to other areas by firewater due to insufficient containment.)

3.3.4 Emergency response

3.3.4.1 Guidance

A post-discharge emergency response procedure is normally required (as and when it can be conducted safely) to ensure that the system has operated correctly. The formal response procedure should evaluate:

- Safety of personnel;
- Additional shut-down actions required (although shut-down actions in major fires should normally be automatic);
- Back-up fire-fighting equipment required;
- Special equipment required (e.g. gas detection, breathing apparatus);
- Training levels and schedules required including schedules of drills.

Prior to start-up of the offshore facility following a firewater system discharge, electrical equipment that has been within the discharge area should be closely inspected.

Formal training programmes should be in place for all personnel who may be required to operate hydrants or other fire-fighting equipment. The training should include alarm

procedures prior to deploying equipment, identification of types and extents of fires that can be attacked with the equipment, the limitations of the equipment fire-fighting strategy and tactics.

3.4 INSTALLATION, INSPECTION, TESTING, COMMISSIONING AND MAINTENANCE

3.4.1 General requirements

The objectives, functional requirements and frequencies of inspection and maintenance shall be determined according to the specific equipment types chosen.

All firewater system components shall carry certification from a recognised relevant approval authority or the Manufacturer/Supplier shall demonstrate that the components have satisfactory performance.

3.4.2 Inspection requirements

All equipment shall be subject to inspection in accordance with project requirements unless this is waived in writing.

Any rejection made by inspectors will be final. However, such inspection shall in no way release the Manufacturer/Supplier from the guarantees covering materials, apparatus and performance of the equipment supplied.

The Principal and/or his authorised inspection agents shall have access to all parts of the Manufacturer/Supplier's works where the equipment is produced or tested. The Manufacturer/Supplier shall provide the inspector with all reasonable facilities to witness tests and to satisfy himself that the materials are being furnished in accordance with this PTS and other relevant documents, and that the workmanship is satisfactory in every respect.

Records of all quality procedures, inspections and tests shall be retained and made available to the Principal and/or his authorised inspection agents as required.

Quality assurance shall comply with specific project requirements.

3.4.3 Acceptance testing and commissioning requirements

Specifications and checklists for the acceptance testing and commissioning of the firewater system and its components shall be prepared. Pre-commissioning checks shall be carried out using the checklists.

All pipework shall be hydrostatically tested in accordance with the project's piping specification. The test pressure and temperature shall be recorded on charts with the starting and completion times noted and signed by the Principal.

Pipework shall be flushed out with clean water and shown to be clear of foreign matter prior to commissioning. After testing it must be demonstrated that all pipework is free from obstruction and test blanks removed.

When testing an installed system the hydrostatic pressure shall be measured at the lowest point of the system being tested. If this is impracticable the recorded pressure should be adjusted and recorded as such. During hydraulic testing, instruments must be removed to prevent damage from excess pressure.

Block valves shall be tested in accordance with project requirements immediately following the system hydraulic test. A test of the valve seats shall be included.

If test blanks are used these should be of the self-indicating type to indicate clearly their presence and should be numbered and their position recorded on the Permit to Work. A final check should be made to ensure that the blanks have been removed prior to closing out the Permit to Work.

If pipework is pneumatically tested, such a test shall be in accordance with the project specifications and full safety procedures undertaken including the display of warning signs.

Full-flow operational tests, including response times for all firewater system elements and pressure measurements, shall be undertaken. Adjustments shall be made to ensure that the elements can cope with expected surges (pump start-up time/closure of overboard dump valve).

Correct annunciation of the alarms at the Fire and Gas Panel and correct operation of all system trip switches, etc. shall be verified.

After testing it shall be ensured that all valves are in the normal operating position and that drain valves are closed.

3.4.4 Maintenance requirements

Deviations from the Manufacturer/Supplier's maintenance and testing procedures shall only be permitted if they do not affect the Performance Criteria for the system. Any such deviations shall be based on a risk-based analysis of maintenance requirements and agreed by the appropriate authority in the Principal's organisation.

Any special tools necessary to assemble, service or dismantle the equipment shall be supplied by the Manufacturer/Supplier as part of the purchase order.

3.4.5 Guidance

Fire-fighting systems require routine maintenance and testing to ensure that the system and its components are in good operating condition.

The Manufacturer/Supplier should supply all the information necessary to enable the equipment to be maintained in good condition. This should include the recommendations for the operating spares to be held, the frequency with which the equipment is to be examined and the procedures to be used to ensure that the equipment is always available for immediate use.

Further guidance on the maintenance of fire-fighting systems is given in NFPA 25 and in the specific NFPA codes relevant to individual firewater system elements.

An example of a checklist for commissioning and routine testing is given in (Appendix 2).

3.5 DRAWINGS AND DOCUMENTATION

3.5.1 Requirements

Drawings, test reports, certificates, quality plan, spare parts data, manuals and all other necessary documentation shall conform to the project requirements.

All appropriate drawings shall contain an arrow indicating the direction of North (a plant North arrow) and a Key drawing showing the location of the area in question.

As-built drawings shall be based on a survey of the completed work.

Hydraulic calculations shall be carried out for all firewater system pipework and discharge systems using a validated and recognised computer program.

Hydraulic calculations shall be based on composite pipework isometric drawings. Isometric drawings shall give all installed pipe lengths, fittings and diameters, and service take-off details. Each pipework intersection point shall be identified as a node point on the isometric drawing. The node number shall be cross-referenced to the hydraulic calculation data file and a summary sheet of hydraulic calculations shall be provided.

A unique data-set shall be submitted for each calculated system. Each data-set should comprise the following:

- one print of the input data-set;
- one print of the input check;
- one print of the pipe table;
- one print of the overall hydraulic isometric;
- one hydraulic calculation print-out including details of any constraints such as flow velocities, minimum and maximum pressures and unacceptable pipe diameters.

When a system is revised during the course of a project, hydraulic calculations shall be re-run and the revised data shall be added to the input data, together with an explanatory text.

Previous data shall not be amended or edited. Revised data shall be issued separately.

All drawings and calculations shall be retained on file for the life of the offshore facility.

3.5.2 Guidance

At least the following design and as-built drawings and documentation should be prepared for each element:

- plans, elevation/sectional drawings and flow sheets, including layout of pipework and showing location of isolating valves, deluge or sprinkler valves, nozzles, maintenance access and pump withdrawal requirements, etc.;
- P&IDs and PEFS, including instrument valve tag numbers and unique equipment numbers;
- PES Cause & Effects;
- instrument data sheets and loop diagrams;
- electrical schematics;
- Programmable Logic Controller (PLC) logic diagrams;
- electrical certification schedule;
- schematics/isometrics showing dimensions, node points, etc.;
- performance test requirements/results;
- hydraulic calculations;
- pressure surge calculations;
- schedule of equipment and symbols used.

Dimensions critical to correct installation should also be shown.

Some of the documents and drawings listed above may be required to support a Safety Case submission.

The primary objective of the as-built drawings is to establish the pipe diameters used and any variations in numbers of pipe fittings, and that pipe lengths are within 5% of the original design. Significant variations may influence the system hydraulic performance and may require a re-run of the hydraulic calculations.

The Statutory Authorities may require drawings and calculations to be submitted as part of the re-certification of an offshore facility following any modifications.

Relevant NFPA publications refer to accepted flow formulae. If programs using alternative formulae are used they should be checked to ensure that they are relevant and that the results include sufficient safety margins to allow for changes in pipe characteristics with time and for tolerances within pipework and fittings.

The hydraulic calculations should be supervised by a person experienced in the use of the chosen program and under the direction of an engineer familiar with firewater system element design.

The following should be taken into account when using a computer program to perform the hydraulic calculations:

- flows and discharge pressures from all relevant discharge points should be calculated and shown on the print-out. (Any system discharge valve, e.g. deluge valve should be treated as a pipework node);
- pressure losses through any restriction orifices or strainers should be calculated and shown on the print-out;
- equivalent lengths of valves and strainers should be scaled in accordance with NFPA 15 or based on Manufacturers' validated data;
- changes to system flow and pressure by the operation of a secondary source of supply;
- the need, dependent on the calculated availability of components of the firewater main and on the FES, to carry out the hydraulic calculations with one or more of the sections of the main isolated;
- system calculations should be compared with (or superimposed on) the available firewater supply curve to ensure that the firewater supply is adequate and at the required supply pressure. This comparison should be made at the system control valve at the firewater pump discharge nozzle taking into account the pipework in between and, if the sea is used as the water source, relative to the Lowest Astronomical Tide.

A full hydraulic calculation print-out should be provided at the following stages as a minimum:

- initial system design;
- prior to issue of fabrication tender documents;
- as-built.

4. FIREWATER PUMPS

The firewater pump system comprises one or more pumps drawing water from a supply source (normally the sea in the case of offshore facilities) and supplying it, under pressure, to the distribution system which feeds the various discharge elements, application systems and equipment.

This section shall be read in conjunction with (Section 3).

Firewater pumps shall be in accordance with PTS 37.29.01.30.

4.1 GOALS

The overall goal of a firewater pump system is to provide a reliable and secure supply of firewater to the firewater main system at the required pressures and flows for all the firewater dependent equipment or systems on an offshore facility.

Specific goals are:

- Goal 1: To supply firewater with the required integrity and reliability to all users.
- Goal 2: To provide a secure source of supply of firewater from an area not likely to be subject to hydrocarbon or biological contamination.
- Goal 3: To provide an adequate supply of firewater that is immediately available on demand.
- Goal 4: To ensure that the supply of firewater to the largest firewater demand does not compromise the ability to supply any other equipment required to operate at the same time.
- Goal 5: To ensure that the firewater pump unit will not be adversely affected by the environment.
- Goal 6: To provide facilities at the normally manned Control Point to monitor the fire pump unit's status and initiate pump start.
- Goal 7: To ensure maintenance and testing of the fire pump units can be carried out without significant impairment to the firewater supply capability/capacity.
- Goal 8: To ensure that the pump system is capable of continuous unattended operation, once started, for a period determined in the FES.

4.2 DESIGN

4.2.1 Requirements

The drivers for firewater pump units shall have adequate integrity to allow the firewater pump(s) to fulfil their role.

Electrically driven firewater pump units shall have power available at all times, even under emergency conditions.

The firewater pump system shall be designed to avoid common modes of failure.

The operational and Manufacturer's testing requirements shall at least comply with NFPA 20.

The materials of construction shall comply with PTS 31.38.01.10 and be suitable for operation in a safe and efficient manner in an exposed marine environment. These materials shall be capable of withstanding the environmental conditions and should not deteriorate at a rate which will impair the efficiency of the unit within its specified working life. Materials shall also be appropriate for the type of water that will flow through the system. If dissimilar materials are proposed which could lead to potential electrolytic corrosion, then proposals shall be given for galvanic protection.

The performance characteristics of the firewater pump unit shall ensure that adequate firewater capacity is available and can be maintained to supply all demands that may occur simultaneously as required in (3.2.2).

The firewater pump shall be sized to provide either 100% of the calculated design firewater demand for the largest identified fire area or an appropriate fraction determined by any sparing philosophy adopted. Whatever philosophy is adopted, the firewater pump shall be sized such that the calculated design firewater demand (or fraction thereof) shall be met by the pump(s) operating at their duty points.

The firewater pump discharge head characteristics for each pump unit shall be sufficient to meet all firewater system pressure demands plus pressure losses within the firewater main distribution system.

4.2.2 Guidance

4.2.2.1 Location of water inlet

The water inlet should be located so that it is not affected by hydrocarbon spillage, sewage and other contaminants and does not impede diving operations.

The inlet location should be adequately protected against damage. Firewater pump caissons should be sited inside the jacket structure, wherever practical, to prevent collision damage to the pump caisson and permit the caisson to be supported from the jacket.

4.2.2.2 Firewater pump arrangements

The normally preferred firewater pump type is the line-shaft vertical-lift pump directly driven by a diesel engine, in order to remain independent of the offshore facility's power generation services, especially during emergency conditions. If this cannot be achieved alternative firewater pump types include:

- diesel-hydraulically driven submersible pump;
- diesel-electrically driven line shaft pump;
- diesel-electrically driven submersible pump.

The number of pumps to be installed on an installation will be influenced by the 100% design firewater demand, the maximum reasonably foreseeable firewater demand (see 3.2.3.2) and the capacity and reliability of each pump.

The following firewater pump arrangements/combinations represent different solutions for large normally manned installations:

- 3 x 100% firewater pump units;
- 3 x 100% dual duty firewater/service water pump units;
- 2 x 100% firewater pump units + 1 x 100% dual duty firewater/service pump unit;
- 4 x 50% firewater pump units;
- 3 x 50% firewater pump units + 1 x 50% dual duty firewater/service water pump unit;
- 1 x 100% + 2 x 50% firewater pump units + 1 x 100% or 2 x 50% dual duty firewater/service water pump units.

If sea-water pumps are used either as back-up firewater pumps or for dual purpose, they should be designed to the fire pump standards and should incorporate a high-integrity feature to automatically change over to firewater duty on demand. The sizing of any such sea-water pump should include the demand for all essential service water that must be supported when the transfer to firewater duty takes place.

The combinations listed above each have a spare unit as insurance against start failure and a second spare unit to ensure availability of sufficient pump capacity at all times, even when a unit is taken out for maintenance or repair. Any of the combinations stated above will ensure no facility production restriction upon loss of one unit. However, facility production restrictions may become inevitable if the back-up service water pump units do not meet the required firewater pump design standard, or the integrity of the change-over facility to firewater duty cannot be assured or if that facility cannot supply the full demand.

Alternative pump configurations, such as those listed below, may also be acceptable particularly where firewater is provided mainly to minimise the economic losses arising from a fire. However, such arrangements may lead to facility production restrictions on loss of one of the units in the combination.

- 2 x 100% fire pump units;
- 3 x 50% fire pump units;
- 2 x 50% dual duty firewater/service water pump units + 100% fire pump unit;
- 2 x 100% dual duty firewater/service water pump units.

Final selection will depend on various parameters which include:

- pump size
- pump cost
- weight
- space
- platform arrangement
- operating costs
- availability of back-up systems
- manned or unmanned
- level of risk
- range of actuation
- consequences of fire pump failure on production operations

A firewater pumping contingency matrix should be prepared for the chosen combination at the early stages of the conceptual design to identify the economic impact of the pump unit outage on production operations and so establish an optimum maintenance strategy and help ensure minimum disruption to production operations. The matrix should identify the safety envelope within which production can proceed and highlight specific production and operational restrictions. See (Appendix 3) for typical firewater pumping contingency matrix.

The maximum foreseeable firewater demand (see 3.2.3.2) should be supplied by utilising the run-out of the pump curve or by operation of the second, or further firewater pump units. The numbers of pumps may have to be reviewed to ensure sufficient pump capacity at any given time.

4.2.2.3 Location of firewater pump units

To maximise availability and survivability of the firewater pump units, the drivers and power sources should be located in dedicated enclosures and the pumps located in areas where they are unlikely to be disabled by a fire or explosion and/or a collision incident. This can be achieved by locating the drivers, power sources and pump units at the non-hazardous end of the platform.

For indirect undriven firewater pump units, where the drivers and power sources are located at different points on the platform, detailed attention should be given to the rating and protection of the electric or hydraulic lines between the pump and the power source, including the switchgear, so that they meet the survivability requirements.

Where possible each of the firewater pump units should be installed in a separate location on the offshore facility so that it is extremely unlikely that a single fire or explosion will put all the units out of action simultaneously.

4.2.2.4 Firewater pump unit enclosures

Normally the firewater pump unit should have an enclosure housing the pump's prime mover and all associated services. For direct-drive firewater pump units, the pump should also normally be in the same enclosure. Such enclosures should be made to withstand the effects of weather and, as far as is reasonably practicable, those of fire and/or explosion that may occur or impinge within the area in which the enclosure is located. The enclosure should also have mechanical strength and fire rating adequate to withstand the calculated loading that may be experienced during the fire.

Each enclosure should contain only one prime mover and should be at a separate, non-hazardous location on the offshore facility and as far as possible from any other enclosures. In exceptional circumstances involving low levels of risk and high availability, enclosures may contain more than one prime mover.

Due consideration should also be given to the protection of the pump unit against dropped objects.

Each firewater pump prime mover should be provided with its own fixed fire protection system where necessary. The type of fire protection system required for the different types of firewater pump prime mover should be identified as part of the FES. (Due account should be taken of the effect of extinguishant release on the unit).

The possibility should be minimised of explosion and damage to the firewater pump units if hydrocarbon gases migrate to the pump enclosure. The preferred method is to ensure that the pumps, prime movers, associated electrical services and any hot surfaces are unlikely to be ignition sources.

The ventilation air inlet should be provided with gas detectors if it is shown that a gas cloud could reach the inlet during an event. If gas is detected inside the ventilation air inlet, all non-Zone 1 rated electrical equipment should be isolated and the fire pump electric starter should be inhibited. If the pump has started and is operating, all non-emergency electrical equipment should be isolated. (The pump unit should be capable of continuous stand-alone operation. Overspeed protection should be fitted as detailed in EEMUA 107. Vibration protection, if fitted, should not be allowed to trip the pump under emergency conditions.)

The enclosure's fire and gas detection should be connected to the installation's Fire and Gas Panel for annunciation, alarm and actions. (Refer to Figure 3 for details.)

Fire and gas detection in any other areas of the offshore facility should not affect the status of a firewater pump nor should they inhibit the pump start facility.

Every attempt should be made to minimise the noise envelope generated by any firewater pump unit when running, under all load conditions, so that personnel in the firewater pump enclosures are not subjected to levels of noise that exceed the limits for exposure as defined in local regulations or the PETRONAS Safety Committee Publication "Noise Guide", whichever is the more stringent. Outside the firewater pump enclosures the noise levels should also be as low as reasonably practicable.

Adequate drains should be fitted to permit general good housekeeping in the enclosure.

Firewater pump unit enclosures should be ventilated during non-operational conditions and the HVAC "normal running" systems should supply air to the enclosure to maintain a maximum temperature of 35 °C and a minimum positive pressure of 50 Pa. Extract ventilation should be via louvered pressure relief outlets to atmosphere.

If a diesel engine package provides engine air for cooling and combustion and is separate from the normal HVAC system, then the fire/gas damper logic should be fully integrated with that of the enclosure system. These separate systems should generally form part of the

Emergency Supply and/or firewater pump package(s) and should be powered from the engine(s). However, the HVAC design may be required to include, in addition to the package supply, engine cooling air inlets with fire/gas dampers interlocked with the engine operation.

Penetrations of the enclosure should not jeopardise its integrity and should use certified type penetrations.

4.2.2.5 Firewater demand (see also 3.2.3.2)

Firewater pump curves of units which comply with NFPA 20 have flat run-out characteristics so it is possible to utilise the water available beyond the duty point to deal with any large firewater demands, including those following explosions. Furthermore, the integrity of firewater pump units should be such that it is reasonable to assume that all units are likely to be available when there is a demand for firewater.

The duty point of firewater pumps for new installations may therefore need to be adjusted from that determined for the design firewater demand to ensure that sufficient water is available to deal with this case.

The calculation or estimation of the design firewater demand, including the adequate contingency figures for the largest fire area, should be in accordance with the requirements of the FES.

4.2.2.6 Firewater pump sizing

Sizing of the firewater pump units should ensure that they are capable of supplying the required flow and pressure effectively during credible simultaneous demands. This should also ensure that excess demands do not damage the pumping equipment or draw down the system's pressure to such an extent that it becomes ineffective.

4.2.2.7 Pump materials

- a) Pump materials shall be as specified below.

Alternative materials may be used subject to approval by the Principal. Any alternatives shall be based upon high alloy duplex stainless steels which have proven satisfactory service in similar offshore applications. Evidence of satisfactory service shall be provided by the Manufacturer/Supplier.

Casing and impeller Aluminium Bronze
BS 1400-AB2C
(ASTM B148 Alloy 958)

Shaft BS 3076 NA18
(Monel K500 type)

Rising main and caisson Aluminium Bronze
mating flange BS 1400-AB2C
(ASTM B148 Alloy 958)
or Ni-resist
BS 3468: S-NiCr20-2

Strainer and anti-fouling BS 3076 NA18
system mountings (Monel K400 type)

Fasteners BS 3076 NA18
(Monel K500 type)

NOTE: Ni-resist cast iron shall have a minimum elongation property not less than 10% -12% and a corrosion allowance of 3.0 mm.

Detailed material specifications including the wear-ring harness shall be provided by the Manufacturer/Supplier in the proposal, and subjected to review and approval by the Principal.

- b) Materials, casting factors and the quality of any welding shall be equal to that required by ASME VIII, Div. 1. The Manufacturer's data report forms specified in the code are not required.
- c) Minor parts not identified (nuts, gaskets, washers, keys and so forth) shall have corrosion resistance equal to that of specified parts in the same environment.
- d) Castings shall be sound and free of shrink holes, blow holes, cracks, scale, blisters and other similar injurious defects. The surfaces of castings shall be cleaned by sandblasting, shot-blasting, pickling or any other standard method. All mould parting fins and remains of gates and risers shall be chipped, filed or ground flush.
- e) The use of chaplets in castings shall be kept to a minimum. The chaplets shall be clean and corrosion free (plating permitted) and of a composition compatible with the casting.
- f) The repair of leaks and defects in pressure casing castings by peening or burning-in, or by the use of plastic or cement compounds is prohibited. Repair by welding or plugging shall be undertaken only when permitted by the material specification and then only in accordance with the procedures detailed below.

Repair by welding

Weldable grades of castings may be repaired by welding, subject to the following criteria:

- Approval by the Principal shall be obtained before any major weld repair is carried out.
- All repairs shall meet the inspection requirements and acceptance standards for the original material.
- For steel castings, the repair welding procedure and the repair welder's qualifications shall both be in accordance with ASTM A 488. Repair procedures are subject to approval by the Principal.
- The total quantity of weld metal deposited shall be less than 10% of the mass of the casting.
- After weld repair, castings shall be suitably heat-treated if this is specified in the relevant material specification.
- Details of all weld repairs, and of the heat treatment where applicable, shall be recorded.

The definition of a major weld repair is to be taken as either a removal of more than 50% of the wall thickness, or a length of more than 150 mm in one or more directions, or a total surface area of all repairs exceeding 20% of the total casting surface area.

Repair by plugging

Ni-resist cast iron may be repaired by plugging within the limits specified in ASTM A278, ASTM A536 or ASTM A395 respectively. The drilled holes for plugs shall be carefully examined by dye penetrant to ensure removal of all defective material.

All necessary repairs not covered by ASTM shall be subject to approval by the Principal. Details of all repairs shall be recorded and reported to the Principal who shall be informed of the need for plugging before any repair is carried out.

Fully enclosed cored voids in castings, including voids closed by plugging, are prohibited.

4.3 OPERATION, CONTROL AND MONITORING

4.3.1 Requirements

A pump start feature shall be provided local to any firewater panel and at the HLO's position if helicopter services are provided.

A pump stop feature shall be local only. Except during testing, any alarms from pump monitoring systems shall not automatically stop the fire pump.

The facilities required to shut down a firewater pump shall not require any external power.

A duty/standby selector switch shall be provided for the firewater pump system when more than one pump is provided in addition to any selection logic from the fire and gas detection system.

Pump control panels shall be provided for each firewater pump unit and the control of each firewater pump unit shall be via its own individual controller.

The control panel shall monitor and annunciate the normal and malfunction status of the firewater pump unit during stationary and operational states.

The control panel shall generate key signals and repeat annunciation at the Fire and Gas Panel at the Control Point and shall accept start-only control signals from remote locations.

Any instrument critical to the safety of the installation shall be in accordance with PTS 32.80.10.10.

The control requirements shall at least comply with NFPA 20.

4.3.2 Guidance

The following should be provided in the firewater pump system:

4.3.2.1 Utilities: Fuel, cooling water and cooling systems (if fitted) to enable continuous operation for a prolonged period.

Firewater pump units, once started, should have the capacity for continuous stand-alone operation, for the duration of the fire event or a period to achieve safety, or a time consistent with the endurance time of the TR.

Whatever approach is adopted for setting the minimum duration for the operation of the firewater pump units, each diesel-driven firewater pump unit should be designed to incorporate the following:

- Be totally self-contained including all fuel storage, control and starting equipment, to enable stand-alone operation for the duration of the incident, or for a period determined by the results of evaluations.
- Incorporate a water/water jacket cooling system fed by take-off from the firewater pump discharge line. The cooling system should be independent of the diesel engine enclosure ventilation system.
- If gas may reach a firewater pump enclosure a rig-saver device should be fitted to each diesel engine driver for the firewater pumps to prevent the engines overspeeding due to intake of gaseous hydrocarbons.

4.3.2.2 Starting facilities: Manual and automatic starting facilities capable of multiple start attempts.

Each firewater pump should normally be provided with starting facilities and arranged for automatic start under normal operation. The automatic start should be initiated in response to loss of standing pressure in the firewater main, or confirmed fire detection in any area where firewater is required on the offshore facility.

Remote manual start should be provided at key positions such as the Control Point or helideck and, where deemed necessary, via manual break glass stations throughout process areas.

If firewater pumps are located on separate bridge-linked platforms it may be impracticable to start the firewater pumps sequentially, and the start sequencing of the firewater pumps and the location of pressure switches should be carefully considered to ensure reliable start-up. These functions should be checked in detail during the commissioning phase of the project and fully detailed in the Installation Operating and Maintenance Procedures.

For diesel-driven firewater pumps, there are three methods of providing starting facilities as follows:

- Battery start: Unless specified otherwise, each set of batteries should be rated for 12 starts. Dual sets of batteries are mandatory and an automatic start sequence should be arranged such that there are 6 starts, at minimum engine cranking speed, interspersed with 6 rest periods each of 8 seconds duration.
- Pneumatic start: Unless specified otherwise, engine starting should be from compressed air supplied to an air-driven starting motor. The air receiver should be sized to provide 12 starts without recharging.
- Hydraulic start: The accumulator capacity should be sufficient for a minimum of 6 starts. If the hydraulic system is a back-up to the main engine system, accumulator capacity should be sufficient for a minimum of 3 starts.

If pneumatic or hydraulic methods are used, a feature for black start should be incorporated. The speed of response in the event of gas cloud ignition should be considered.

To enable the diesel firewater pump driver to start automatically in response to fire signals from the Fire and Gas Panel, the diesel engine should be provided with primary and secondary starting systems to maximise the probability of starting on demand. If dual battery banks are fitted these may be regarded as the primary and secondary automatic start facilities with as back-up a manually initiated hydraulic or pneumatic start.

For electrically driven firewater pumps, power availability at all times can be achieved by the provision of dedicated power sources such as a diesel-driven alternator. If electric firewater pumps are driven by the main generators these should be dual-fuelled or a standby diesel generator should be available. In any case, automatic change-over to diesel fuel or to a standby generator should be ensured.

- 4.3.2.3 Duty/Standby selection: Selection switch located in the Control Point and locally at the firewater pump panel.
- 4.3.2.4 Pump shut-down: There should be no automatic shut-down of firewater pump units. A pump should only be shut down from its local dedicated controller.
- 4.3.2.5 Pump Control Panels are required to monitor the performance of the pump units during duty and standby conditions and annunciate back to the Control Point for operator information or action.
- 4.3.2.6 Pump tie-ins: Separate pump tie-ins to a separate section of the firewater ring main are required to prevent common mode failure of supply and to enable off-line management of the pump.

A dedicated overboard dump line and a firewater pump test line should be incorporated as part of each pump tie-in. The open/closed status of the valves in the overboard dump line should be indicated at the Control Point. The overboard dump line and test line may be combined, provided full functions of both duties are achieved.

- 4.3.2.7 Pressure relief valves: To protect the pump discharge lines from over-pressure if the pump shut-in head exceeds system design pressure.

Relief valves in the firewater pump discharge lines are only required to protect the piping system from over-pressure if the pump shut-in discharge head exceeds the system design pressure. Relief valves should be sized to allow for conditions such as engine overspeeding. Relief valves should discharge overboard and should be accessible for inspection and maintenance.

- 4.3.2.8 Main surge control: To protect downstream pipework and components from damage caused by the hydraulic shock associated with start-up or shut-down.

If the fire main surge analysis identifies potential problems, surge control measures should be considered for incorporation into the firewater pump tie-in design. A typical surge control measure is as follows:

- installation of a start-up dump valve and overboard piping tie-in in the firewater pump discharge line upstream of the non-return valve. This valve should be designed to divert all or part of the initial start-up firewater discharge overboard. A flow control system is preferred whereby, on firewater pump start-up, all flow is diverted overboard and after a period of time the dump valve closes. A manual override feature should be provided for the valve. Surge alleviation using a fast acting anti-surge roll seal type valve may be considered as an alternative protection device. The flow control valve should be fail-closed, of high-integrity design (see PTS 32.80.10.10.) and be suitably rated for performance in the conditions expected in an emergency. Also a cooldown mode should be provided to stop overheating of diesel engine after running loaded;
- the above system should be backed-up by a vacuum breaker/air release valve located in the firewater pump discharge piping upstream of the non-return valve and sized for the anticipated airflow requirements without damage. This valve will have the dual function of preventing a vacuum being pulled by riser draining and limiting water velocity in the riser by controlling the rate of air discharge under fire pump start conditions.

Other options, such as a back pressure control valve, have been used.

Consideration should also be given to the possible effects of water hammer on pump shutdown. Diesel engines should incorporate an idle/cooldown cycle before stopping as a means of preventing this effect.

4.4 FIREWATER PUMP TESTING

4.4.1 Requirements

Each firewater pump shall have facilities for testing the control sequences and performance characteristics. These shall be arranged so that testing of a pump unit shall neither inhibit the automatic start of other units nor the ability to deliver firewater if required to do so.

4.4.2 Guidance

The primary purpose of testing the fire pumps is to ensure the reliability and availability of the system and to confirm periodically that the performance characteristics of the system have not significantly deteriorated.

The fire pump should perform at the minimum rated and peak loads as indicated on the Manufacturer's certified shop test characteristic curve, within the accuracy limits of the test equipment.

A firewater pump test line should be located in an area adjacent to each firewater pump enclosure so that each firewater pump can be tested without affecting the integrity and performance of the firewater main or other firewater pumps. The test line should be adequately sized and incorporate suitable devices to measure the rate of flow, net pump pressures, volts/amperes for electric driven pumps and speed, across the full firewater pump curve. The tests should also include response time.

For test tolerances refer to NFPA 20.

5. FIREWATER MAIN

The firewater main system is the pipework system and associated valving that distributes water from the pumps to the various application systems and equipment.

This section shall be read in conjunction with (Section 3).

5.1 GOALS

The overall goal of the firewater main is to provide a reliable and secure system to distribute firewater to all firewater-dependent protection systems, on demand, at the required pressures and flows.

Specific goals are:

- Goal 1: To ensure that firewater is distributed to all end users at the required pressure and flow during reasonably foreseeable fire emergencies.
- Goal 2: To maintain the operability and integrity of the firewater main system during maintenance and/or loss of a section of the main system without impairment to the efficiency of the distribution to the end users.
- Goal 3: To ensure that the firewater main system is of sufficient integrity that it will survive under fire emergency conditions and any explosion which may precede a fire.

5.2 DESIGN

5.2.1 Requirements

The firewater main shall supply both the fixed firewater systems and manual fire-fighting equipment, i.e. hydrants and hose reels, etc.

Adequate piping capacity shall be provided so that firewater is transported and distributed effectively.

The survivability of the firewater ring main shall be maximised by avoiding areas of high risk, choosing resilient materials and by making use of any form of protective shielding afforded by structural members.

The piping materials shall be capable of operation in a safe and efficient manner when in an exposed marine environment. Refer to 3.2.3.8 for guidance on materials.

The layout of the firewater main shall consider the requirements for access for maintenance of equipment, valves and instrumentation.

If a platform incorporates a drilling package, the package firewater main shall be compatible with the installation's firewater main.

5.2.2 Guidance

5.2.2.1 Layout

The firewater main should generally be designed as a ring or loop so that a firewater-dependent system is supplied with fire-fighting water from two directions.

On multi-platform complexes the firewater main should be run as a separate loop around each individual platform. A single interconnecting line, or lines, may be adequate between adjacent platform firewater mains depending on pump locations. A block valve should be

incorporated at each end of each interconnecting firewater main. Provision should be made for connections to allow temporary firewater hoses to run over bridges to provide reduced firewater distribution if the primary firewater bridge link is out of service (e.g. for maintenance).

The routing of firewater mains through the following areas should be avoided wherever practicable:

- Wellhead
- Process plant
- Gas compression
- In the path of explosion venting
- Areas containing electrical equipment.

In addition the firewater main layout should:

- Be designed to allow for the maximum possible amount of onshore fabrication and testing of large-diameter pipework;
- Minimise the number of interconnections and tie-ins that are required during offshore installation activities.

When deciding whether to route firewater main risers inside or outside the accommodation, the need to protect external mains should be weighed against the difficulties of inspecting internal mains and the consequences of leaks in internal mains.

To ensure a reliable supply to all firewater-dependent systems and to minimise common-mode failures, each connection to the firewater main should supply only one system.

However, up to three twin-outlet hydrants or hose-reels in a single area may be supplied from a single branch connection to the firewater main, provided that there are other hydrants or hose-reels which could be used to fight a fire in the same area and that these are supplied by a separate connection to a different section of the firewater main. Up to five hydrants or hose-reels may be supplied from a single connection to the firewater main, if they are in different areas.

Two independent connections from different sections of the firewater main should feed separate sub-main loops for each of the following services. If the sub-mains are within low-risk areas and there are no maintenance concerns, then a single connection is acceptable.

- The helideck firewater hydrant/foam system
- The living quarters sprinkler systems
- The living quarters hose-reel system
- The drilling module firewater supply system.

5.2.2.2 Response time

The firewater distribution system, including the firewater pumps, should normally be capable of supplying effective firewater upon demand within 30 seconds as required by NFPA 15. Longer response times may be acceptable but should be justified by the FES and the relevant Performance Criteria.

5.2.2.3 Standing pressure

To make firewater available immediately upon demand, the firewater main should normally be filled and pressurised. The means and the standard of pressurisation should be determined by the system/platform requirements.

If the firewater main is charged with sea water and maintained at a standing pressure by means of a pressurising line from the service water system, this pressurising line should be tied into the firewater main with isolation valves provided between the tie-ins.

If the service water system is unable to meet the standing pressure requirements, or is not considered suitable for the service, electric-motor-driven jockey pumps should be installed to provide pressurisation.

The capacity of the pressurising line and the pressure available should be such that a drop in pressure caused by the operation of one fire hydrant will not cause the main firewater pump to start. A demand in excess of one hydrant capacity should initiate the automatic firewater pump start sequence.

On Normally Unmanned Installations (NUI) the firewater main may be normally dry providing a rapid response is still possible when firewater is required for hydrants and fixed firewater systems.

5.2.2.4 Sizing

Sizing of the firewater main system should be based on:

- The maximum reasonably foreseeable firewater demand for a single fire event (see 3.2.3.2).

The firewater main should be designed to supply the required volume of firewater with any one section of it inoperative. In the case of a sub-loop or cross-over, it should be assumed that the firewater is only available at one connection to the firewater main so the sub-loop or cross-over should be sized to transfer 100% of the required loop firewater demand.

- Tolerable pressure drop within the system (maximum allowable water velocity for the selected piping material).

The maximum allowable water velocity for such piping is usually based on material erosion considerations for continuous flow duty. Higher velocities may be permitted in view of the exceptional usage of firewater and so smaller pipe sizes may be used. Other considerations such as pressure drop affecting firewater pump head and pipe rating may prevent the use of the maximum allowable velocity.

- The required outlet pressure especially at the most hydraulically remote location.

In the event of a fire in any one area, the pressure and flows available from the firewater pump configuration to hydrants, monitors, deluge and hand hose lines local to the incident should be sufficient to control the fire. A minimum of 7 bar (ga) for monitors and 3.5 bar (ga) for hydrants should be available for equipment in areas not protected by deluge. Flowing pressure requirements for hose lines and deluge systems should be determined by their designed pressure requirements.

The pressure switch is to be set or located high enough such that the firewater pump will start at the duty point of the jockey pump, to avoid unnecessary starting of the firewater pump.

- The hydraulic performance of the system.

The hydraulic performance of the firewater main should be analysed to establish that an hydraulically balanced system has been designed.

The calculated system demand at each tie-in point to the firewater main should be used to analyse the firewater distribution system characteristics.

The hydraulic analysis of the firewater main performance characteristics should be performed in conjunction with the hydraulic analysis of deluge firewater systems and other systems/equipment served by the firewater main.

5.2.2.5 Protection from freezing

One of the methods available to protect the firewater main system from freezing is to provide an overboard firewater dump feature at the opposite end of the firewater main from the sea water pressurisation inlet. The overboard dump should be sized to establish a small flow in the ring main and controlled in such a way that the firewater pump will not kick-in during its operation. It should be arranged for automatic actuation and isolation.

5.2.2.6 Interface with drilling package

Interfaces between the installation firewater and drilling derrick firewater mains may require the use of suitable flexible, fire-resistant and abrasion-resistant hoses.

5.2.2.7 External supply

To provide a source of firewater to the installation firewater main during major maintenance, construction and commissioning work, especially when the fixed firewater pump systems are not available or have reduced capacity, the need for at least one auxiliary tie-in point should be considered. This will allow connection of an alternative firewater supply from a flotel or multi-functional service vessel. Such tie-in point(s) should be full-bore, flanged and blanked.

The tie-in points should be located at a point easily accessible to the external supply units; for example located near the bridge landing point for a flotel.

5.2.2.8 Connection with service water system

If sea water pumps are used either as back-up fire pumps or for dual purpose, a full-bore connection sized for the maximum water demand should be provided between the firewater main and the service water system. This cross-connection should be isolated by a closed block valve which should be automatically actuated on demand and controlled from the Control Point. Its position should also be indicated at the Control Point.

The cross-connection between the service water and the firewater mains should incorporate a non-return valve to prevent the flow of water from the firewater main to the service water main on occasions when the isolation block valve is open. It should be arranged to ensure that contamination of the firewater main from the sea water system is not possible.

5.2.3 Maintenance and monitoring

5.2.3.1 Isolation and valving

Isolation (or sectioning) valves should sub-divide the firewater main into sections to allow for any maintenance work to be undertaken. Position indication and remote actuation may not be necessary if there is a system of work control which provides information on the position of key isolation valves at the Central Control Point. Access for maintenance and inspection should be provided from deck level, if practicable, or alternatively from permanently installed platforms. Extended stems for operation of valves in firewater mains running below a main deck level may be provided where required. Chain-operated valves may be used for valves which only serve a maintenance function.

A second reason for isolation valves is to retain a supply to firewater systems and essential users following damage to a section of the main in an explosion or fire. System performance

outside the damaged section should not be seriously impaired. Remote position indication and actuation should be provided for those valves which perform such a safety-critical function. Chain-operated valves should not be used for this purpose.

Use of large numbers of sectioning valves should be avoided in order to minimise maintenance requirements.

Each branch connection to the firewater main should be provided with isolation valves located in an accessible position as close as possible to the firewater main itself. This requirement may be relaxed for branches where an operating valve to a firewater system is installed within approximately 5 m of the firewater main.

5.2.3.2 Corrosion protection

The firewater main system should be designed to minimise external corrosion and inherent internal corrosion/blockage, preferably by using materials that are inherently resistant to external and internal corrosion.

If a metal firewater piping system is used the following points are generally applicable:

- Each section of the firewater main, between sectioning valves, should be bonded to the installation earth system via sacrificial links;
- Dissimilar metal interfaces which will cause galvanic corrosion should be avoided. In cases where dissimilar metal interfaces are unavoidable and one side of the interface is a relatively small component (e.g. sprinkler head), this component should be made of the more noble material. For existing systems with dissimilar metal interfaces between large components, disposable spool pieces of the less noble material shall be incorporated into the system. The spool pieces should be regularly inspected by ultrasonic wall thickness checks and replaced when necessary.

5.2.3.3 Monitoring devices

A minimum of two pressure transmitters should be fitted to monitor the firewater main standing pressure. On bridge-linked installations at least one pressure transmitter should be located on the firewater main on each separate section of the installation. A pressure transmitter should interface directly into the firewater pump panel to start the pump. All transmitters should be monitored at the Control Point.

For pressurised systems, an automatic firewater pump start sequence should be initiated when a pressure drop of typically 1 to 2 bar (ga) from the firewater main standing pressure is detected.