

DEP SPECIFICATION

FIRE PROTECTION SYSTEMS FOR OFFSHORE FACILITIES

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DESIGN AND ENGINEERING PRACTICE

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1. INTRODUCTION

1.1 SCOPE

This DEP specifies requirements and gives recommendations on the design, installation, and commissioning of fire protection systems on all types of offshore facilities. This DEP provides tools for definition of scope of Fire Safety improvement projects to existing assets.

The requirements of the Fire and Explosion Strategy (FES) developed during the process of evaluation and risk management within the Hazards and Effects Management Process (HEMP) are included in this DEP.

The DEP is based on the requirements of ISO 13702, which should additionally be consulted for local requirements in areas of application.

The FES drives the decision to use a particular type of fire protection system, 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 DEP contains mandatory requirements to mitigate process safety risks in accordance with Design Engineering Manual (DEM) 1 – Application of Technical Standards.

This is a revision of the DEP with the same number dated February 2015; see (1.5) regarding the changes.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

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This DEP is intended for use in facilities related to offshore exploration and production facilities. This DEP may also be applied in other similar facilities.

When DEPs are applied, a Management of Change (MOC) process shall 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 could be more stringent than in this DEP, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable with regards to the safety, environmental, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this DEP which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned, the objective being to obtain agreement to follow this DEP 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 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 it. 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 capitalised term **SHALL [PS]** indicates a process safety requirement.

The word **should** indicates a recommendation.

The word **may** indicates a permitted option.



1.3.2 Specific definitions

Term	Definition
Active Fire Protection	Equipment, systems and methods that can 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	Elements of the overall firewater system that discharge water into a fire-affected area (e.g., deluge systems, sprinkler systems).
Emergency Response Personnel	Personnel who have a designated response role in an emergency.
Emergency Response Personnel	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	Strategy that uses an assessment of the hazards of fires and explosions to determine the measures required to manage such hazardous events.
Hazard Consequence Modelling (HCM)	Use of mathematical models to estimate the effect of explosions, fires and dispersion.
Jet Fire	Ignited release of pressurised, flammable fluid.
Passive Fire Protection	Coating, cladding arrangement or free-standing system, which in the event of a fire provides thermal protection to restrict the rate at which heat is transmitted to the object or area being protected.
Performance Standard	A statement, expressed in qualitative or quantitative terms, of the performance required of a system or item of equipment, which is used as the basis for managing risk of the Severity 5 or high risk Hazards and Events
Pool Fire (Spill fire)	Combustion of flammable liquid spilled and retained on a surface.
Toxic	Refer to DEP 01.00.01.30-Gen for classification of toxicity

1.3.3 Abbreviations

Term	Definition
AFFF	Aqueous Film Forming Foam
AFP	Active Fire Protection
BLEVE	Boiling Liquid Expanding Vapour Explosion
BOP	Blow Out Preventer
CAA	Civil Aviation Authority
CAF	Compressed Air Foam
CCTV	Closed Circuit Television
DN	Diameter Nominal
EER	Evacuation, Escape and Rescue
EDP	Emergency Depressurisation
EIV	Emergency Isolation Valve
ESD	Emergency Shutdown
ESSA	Emergency Systems Survivability Analyses
FEED	Front End Engineering and Design
FES	Fire and Explosion Strategy
FIT	First Intervention Team
FHA	Fire Hazard Assessment
FGS	Fire and Gas System
FLNG	Floating Liquified Natural Gas
FPSO	Floating Production Storage and Offloading
HCM	Hazard Consequence Modelling
HEMP	Hazards and Effects Management Process
HLO	Helicopter Landing Officer
HP/LP	High Pressure / Low Pressure
HSE	Health, Safety & Environment
HVAC	Heating, Ventilation and Air Conditioning

Term	Definition
IEC	International Electrotechnical Commission
OIM	Offshore Installation Manager
LAT	Lowest Astronomical Tide
MOPO	Manual of Permitted Operations
NDE	Non-Destructive Examination
NEC	National Electric Code
NFPA	National Fire Protection Association
NPS	Nominal Pipe Size
NUI	Normally Unmanned Installation
OPITO	Offshore Petroleum Industry Training Organization
PEFS	Process Engineering Flow Scheme
PFP	Passive Fire Protection
POB	Personnel on Board
P&ID	Process and Instrumentation Diagram
QRA	Quantitative Risk Assessment
ROV	Remote Operable Valve
SCSSSV	Surface Controlled Sub Surface Safety Valve
SSIV	Sub Sea Isolation Valve
TR	Temporary Refuge

1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section or clause number is shown in brackets (). Other documents referenced by this DEP are listed in (15).

1.5 SUMMARY OF MAIN CHANGES

This DEP is a full revision of the DEP of the same number dated February 2015. The following are the main, non-editorial changes.

Section/Clause	Change
All	Restructured and clarified requirements, enforced use of shall/should/may for normative statements.

1.6 COMMENTS ON THIS DEP

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DEP Standard Form (other users)	Use DEP Standard Form 00.00.05.80-Gen. to record feedback and email the form to the Administrator at standards@shell.com .

Feedback that has been registered in the DEP Feedback System by using one of the above options will be reviewed by the DEP Custodian for potential improvements to the DEP.

1.7 DUAL UNITS

This DEP contains both the International System (SI) units, as well as the corresponding US Customary (USC) units, which are given following the SI units in brackets. When agreed by the Principal, the indicated USC values/units may be used.

1.8 NON NORMATIVE TEXT (COMMENTARY)

Text shown in italic style in this DEP indicates text that is non-normative and is provided as explanation or background information only.

Non-normative text is normally indented slightly to the right of the relevant DEP clause.

2. FIRE AND EXPLOSION STRATEGY AND FIRE HAZARD ASSESSMENT

2.1 GENERAL

1. The Fire and Explosion Strategy (FES) shall be developed as part of HEMP.

A Fire and Explosion Strategy (FES) is the result of the process that uses information from the fire and explosion evaluation to determine the measures required to manage these hazardous events and the role of these measures.

An effective management system that addresses Health, Safety and Environmental (HSE) issues that are relevant to offshore oil and gas activities is a fundamental industry requirement. A key element of the HSE MS is a process of evaluation and risk management, called Hazards and Effects Management Process (HEMP).

2. The FES shall identify the credible hazardous scenarios related to fire/explosion, the measures to prevent fire/explosions scenarios and to consider the consequences along with the performance criteria for each of the measures.
3. FES performance objectives for a facility or installation shall be identified in a 'philosophy' or 'strategy' document.

The strategy sets the objectives and performance criteria for control and recovery preparedness measures, from corporate goals down to operational criticality, including systems availability and required reliability.

The FES is also used in the operate phase of facility's life cycle when a new FES is being developed.

4. The Fire Hazard Assessment (FHA), as specified in (2.3), shall be used in the Define phase to develop an FES.

The "Fire Hazard Assessment" for offshore oil and gas facilities replaces the old Fire Protection Analysis, known as "FIREPRAN" for Exploration and production facilities mentioned in the EP HSE Manual Volume 3, EP 95-0350.

The FHA is a structured method to identify potential fire and explosion hazardous events and to develop the appropriate fire prevention controls and recovery preparedness measures related to fire protection and fire fighting in the design phase of the facility. It can assist in building up an FES for streamlining during design progress, provided an FES objective statement is available as reference.

FHA may be used as a tool to scope fire safety improvement projects on existing assets. It should focus on existing HSE Case and the FES of the facility, to identify potential fire and explosion hazardous events and deficiencies in existing barriers, controls and recovery measures. The focus in operate phase is on the recovery capability of a facility in terms of fixed systems, fire response and emergency preparedness.

2.2 PERFORMANCE CRITERIA

1. Performance criteria shall 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).
2. They provide the basis for monitoring the actual status of the measures throughout the life of the offshore facility.
3. Templates for the development of facility-specific performance criteria for firewater-systems are provided in (Appendix A) as examples.

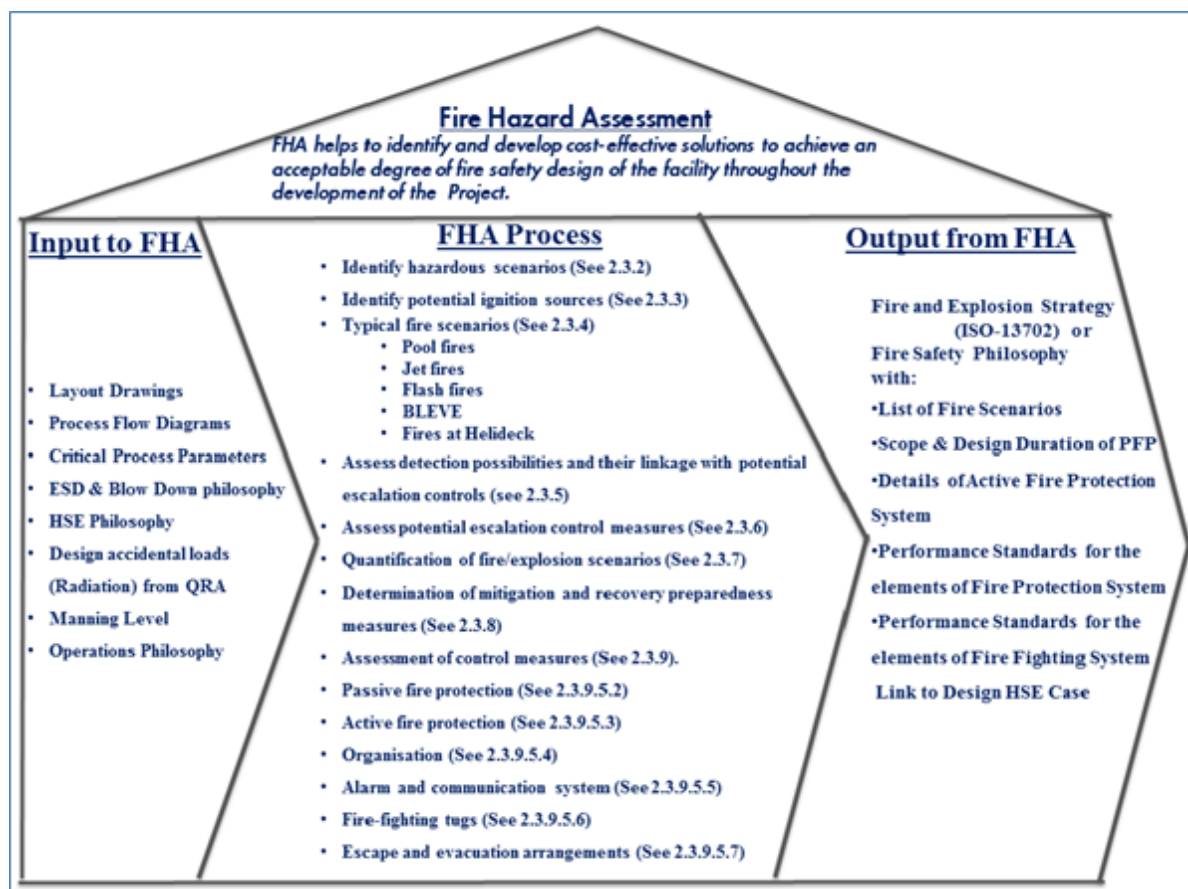
2.3 FIRE HAZARD ASSESSMENT (FHA) FOR OFFSHORE FACILITIES

2.3.1 General

The FHA covers all aspects of fire safety at an offshore oil and gas facility and helps to identify and develop cost-effective solutions to achieve an acceptable degree of fire safety design of the facility throughout the development of the project.

1. The level of control measures for fire prevention, mitigation and recovery should consider the criticality and importance of the facility/installation in the context of:
 - a. the overall investment strategy for the company/country;
 - b. interdependencies with other facilities;
 - c. local and international requirements, and;
 - d. the Business HSE risk criteria identified in the FES.
2. The hazards assessment process should review:
 - a. the value of the asset;
 - b. the impact of loss of the facility in terms of loss of life, environmental damage, time/cost, and;
 - c. the impact of long term non-availability of the facility on the customer, stakeholders and national government if a major incident occurs.

Figure 1 Linkage of FHA with deliverables from HEMP process and FES/Fire Protection Philosophy



2.3.2 Identify hazardous scenarios

1. The scenarios to be considered should be restricted to equipment failures that are likely to occur and which involve the leakage of flammable and toxic material, of which the frequency of occurrence and the severity of the consequences have been taken into consideration.

Examples of scenarios that meet these criteria include, but are not limited to, the following:

- *small leaks (e.g., from process equipment and piping, sampling systems, sight glasses) For calculation purposes an equivalent hole size of 6 mm (0.25 in) diameter should be assumed;*
- *leaks from failure of an instrument fitting, typically 10 mm or 15 mm (0.4 in or 0.6 in) in diameter;*
- *small leaks from flange joints. Representative hole sizes are 1 mm (0.04 in) diameter for ring type joints, 2.5 mm (0.1 in) diameter for spiral wound gaskets and 7 mm (0.28 in) diameter for sheet gaskets;*
- *full bore ruptures of process lines up to size DN 20 (NPS 3/4);*
- *pump and compressor seal failures. These failures can be represented by assuming equivalent hole sizes of 9 mm (0.35 in) diameter;*
- *for storage areas, releases into curb areas (e.g., HP/LP separators, suction tank of export pumps);*
- *helicopter re-fuelling, landing and take-off operation;*
- *subsea import/export line leakage and full bore rupture near offshore facility;*
- *small leak and snapping of the loading arm during ship-to-ship transfer (limited to hydrocarbon inventory in the loading arm);*
- *rupture of wellhead tubing and casing blowouts.*

2.3.3 Identify potential ignition sources

1. Ignition sources shall be identified that may be present in the area and can cause the potential ignition of the released flammable material.
2. Ignition sources should be identified beyond the immediate proximity of the potential release event at potential migration paths due to prevailing winds and static electricity sources.

Examples of common ignition sources at an offshore oil and gas facility are; hot exhaust from the turbines and electric power generators, thermal radiation from flare of the permanent facility/drilling rig, spark from non-certified electrical equipment, electric switch gears and natural causes (e.g., lightning).

2.3.4 Typical fire scenarios

2.3.4.1 General

1. The scenarios to be considered shall include those that may occur at fixed offshore hydrocarbon production and processing facilities, FLNG and FPSO, such as:
 - a. process areas with large inventories of hydrocarbons (HP/ LP separators, buffer vessel for pump/compressor suction);
 - b. export pumps and compressors;
 - c. piping/instrumentation, and;
 - d. Storage tanks on FPSO/FLNG.
2. Fire scenarios shall include the following typical scenarios:
 - a. vent fires;
 - b. jet fires, pool fires and combined jet/pool fires in process areas;
 - c. flash fires (e.g., involving LPGs);
 - d. Boiling Liquid Expanding Vapour Explosion (BLEVE) for pressurised vessels;
 - e. fires at Helideck during re-fuelling, landing and take-off of helicopter.

2.3.4.2 Pool fires

Liquid pools can be formed by all hydrocarbon products containing pentane and heavier components but also by butanes/butanes at ambient temperatures below 0 °C (32 °F). Propane and lighter refrigerated/cryogenic liquefied gases (e.g., LNG) may also form liquid pools in the event of accidental leakage while they are handled at temperatures at or near their atmospheric boiling points. This may be the case during a prolonged leakage, if the rate of leakage exceeds the rate of vapourisation.

Running pool fires are burning pools of liquid that are unrestrained by any wall or bund and are hence able to move depending on the surface gradient. Pool fires not contained by bund/curbs are liable to cause severe deck plate buckling and possible weld shear. Such damage would depend on a number of factors, including the size of the open deck surfaces and if the plates are fully welded to cross members.

Buckling can be caused by thermal expansion, which is not relieved at its edges due to very rigid peripheral structural members to which the walls and decks are attached. The burning fuel may flow through a split in the deck with the potential for vertical fire spread and associated escalation and deck buckling in an unpredictable manner.

1. While assessing the pool fire scenarios around a potential source of leak at the offshore oil and gas facility, grated flooring should be considered, as the actual pool formation may occur at the plated decks below the affected equipment/vessel.
2. Refer to section 2 of DEP 80.47.10.30-Gen. for additional guidance on assessing pool fires.

2.3.4.3 Jet fires

Vapour leakage will naturally disperse as a jet. Pressurised liquefied gases that will not form liquid pools upon accidental leakage will disperse as a vapourising liquid aerosol jet.

Ignition of a liquid or a vapour jet results in a jet fire that may cause impinging flames with high radiation intensities. The length and width of unobstructed jet flames vary as a function of the pressure upstream of the leak, the size and geometry of the hole and the wind speed. Levels of radiant heat may be in the order of 250 kW/m² (80,000 Btu/h·ft²) – 450 kW/m² (140,000 Btu/h·ft²).

Radiation heat level from high pressure jet fires such as those involving LNG, could be above 1 MW/m² (3,414,425 Btu/ft²).

2.3.4.4 Flash fires

A flash fire can occur when the combustion of a flammable liquid and vapour results in a flame passing through the mixture at less than sonic velocity. Damaging overpressures are usually negligible, but severe injuries can result to personnel if caught up in the flame. A flash fire may travel back to the source of any release and cause a jet fire if the release is pressurised.

2.3.4.5 Vapour cloud explosions

Vapour Cloud Explosions can result in damaging overpressures, especially when flammable vapour/air mixtures are ignited in a congested area. Blasts could lead to death or injury to personnel as well as damage or demolition of control room, accommodation blocks and process equipment.

2.3.4.6 BLEVE

A BLEVE (Boiling Liquid Expanding Vapour Explosion) is usually a consequence of prolonged heating of a pressurised vessel (normally LPG-like product) by an external fire. The vessel may heat up rapidly and fail, spreading burning fuel as it ruptures. The initiating fire may be a pool or jet fire.

2.3.4.7 Fires in storage tanks

Storage tanks containing flammable hydrocarbon can have fires in the vent, which have the potential for internal explosion. This can, in turn, lead to full surface fires in the storage tanks.

2.3.4.8 Fires at Helideck

A helicopter crash incident at the helipad during landing and take-off can result in spillage of aviation fuel. The wreckage and subsequent fire and smoke at the helideck could render some of the emergency response equipment unusable or preclude the use of some passenger escape routes.

A potential for aviation fuel fires also exists at the helideck due to loss of containment or spillage during helicopter re-fuelling operations.

2.3.4.9 Fires in the low combustible oil in galley/kitchen

Heating of cooking oil in the offshore galley/kitchen may lead to fires unless proper safety devices are installed and a safe system of work is followed.

Normally, cooking oil has a flash point in the region of 310 °C (590 °F) to 360 °C (680 °F). Deep fat fryers, if not fitted with fire safety lids or a second thermostat to provide a thermal cut-out, can overflow leading to a fire, and the generation of thick and potentially lethal smoke. Ordinary cooking pots/pans filled with cooking oil at high temperature can also lead to serious fires with a moment's inattention.

If water is used to extinguish galley fires, it will turn to steam and explode, leading to escalation of the incident.

2.3.5 Assess detection possibilities and their linkage with potential escalation controls

1. The FHA shall assess how the fire or product leakage is detected using:
 - a. fire/gas detectors;
 - b. CCTV;
 - c. process instrumentation;
 - d. personnel patrolling the plant.

The FHA assessment allows an estimate to be made of the time elapsed between the onset of the leakage/fire and the moment operating personnel become aware of the abnormal situation.
2. The FHA shall determine the detection target and detector coverage factors of the detection system.
3. The FHA shall define the fire and gas detector positioning methodology.
 - a. The positioning methodology shall be subject to approval by the Principal before the start of FEED phase.
4. The design engineer shall review the cause and effect chart to verify the FGS:
 - a. is capable of detecting all the credible fire/leak scenarios;
 - b. provides alarms to allow personnel to evacuate;
 - c. initiates executive actions for the required level of shutdown;
 - d. activates fixed extinguishing system;
 - e. depowers any potential ignition sources.
5. For unmanned offshore facilities, the design engineer shall ensure that the FGS status information is available locally, via audiovisual alarm system at the facility for the occasions when it is manned or visited.
6. The FGS for unmanned facilities shall be capable of being monitored, including the acknowledgement and resetting of the alarms, from a remote location.
 - a. This remote location may be the control room of a nearby platform or from the shore facility.
7. The FHA shall confirm that the confirmed fires and flammable gas alarm in the wellhead area.
 - a. Automatically leads to collective closure of all wells -surface controlled sub-surface safety valve (SCSSSV);
 - b. Automatically depressurises the installation;
 - c. Closes all import and export riser ESD valves leading to full facility platform shutdown.
8. The FHA shall confirm that the flammable/toxic gas and smoke detectors are provided in HVAC systems of accommodation blocks, TR and control room in order to alert and allow escape/muster of the personnel on board.
9. The facility to activate audio/visual alarms throughout the installation shall be provided at manual alarm call points, in addition to direct activation from the FGS.

2.3.6 Assess potential escalation control measures

- *Assess the possible operational measures to isolate and/or reduce the fuel feeding the fire (manual valves, ROVs or EIVs, EDP/blow down and ESD systems, rapid dumping system, SSIVs, etc.).*
- *Ensure that the operational measures can be deployed during the emergency and ensure that the power supply system (Electrical/Pneumatic/Hydraulic) to these facilities is not affected by fire. Assess the ESD/Blow down operation time of the section involved and threatened sections.*
- *Review the time to failure of threatened sections and the potential for escalation if the time to failure is less than the time to blow down fully.*
- *Assess if the fire/explosion event could impair the well-kill facilities (including the ability to open the SCSSV after ESD), the escape routes and means of evacuation.*

2.3.7 Quantification of fire/explosion scenarios

1. Once the fire scenarios, i.e., pool fires, jet fires, flash fires, vapour cloud explosions (deflagrations or detonations) and BLEVEs have been identified, the consequences of the subsequent hazardous events should be evaluated using HCM.

The effects of such fire scenarios in terms of flame impingement, heat radiation, overpressure levels to which adjacent equipment may be exposed and flammable/toxic gas migration to an ignition source/occupied area or dispersion can be established with acceptable accuracy.

2.3.8 Determination of required mitigation and recovery preparedness measures

The results obtained from the calculations performed identifies the equipment most likely to fail, causing further escalation of the fire emergency or impairing the means of escape, evacuation and muster areas.

This analysis provides the basis for the selection of fire protection measures (e.g., water spray systems, fixed fire-water monitors, mobile monitors, manual water application by emergency responders, passive fire protection).

1. Steel equipment and structure may need cooling when exposed to heat radiation levels between 8 kW/m² (2,500 Btu/h·ft²) and 32 kW/m² (10,150 Btu/h·ft²).
2. Above 32 kW/m² (10,150 Btu/h·ft²), cooling should be provided to prevent failure of unprotected steel.
3. Unprotected steel will quickly exceed the critical structural steel temperature (just above 400 °C [752 °F]), which could result in the equipment losing its mechanical integrity and causing escalation of the fire emergency. (Normally, fixed systems would be required.)
4. Refer to Section 4 of DEP 80.47.10.30-Gen. for typical water application rates using the fixed firewater system for providing the exposure protection in case of fires.

2.3.9 Assessment of control measures

2.3.9.1 General

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

1. Threat control measures shall be assessed and measured to mitigate the consequences of hazardous events and to determine recovery preparedness measures for improvement.

Threat control measures are an integral part of the design, engineering and construction of plants.

The following are additional measures that may be taken to decrease the probability that explosion and fire incidents could occur:

- *threat control measures to prevent hydrocarbon leakage;*
- *mitigation control measures to minimise leakage quantities and;*
- *measures to minimise the probability of ignition if a leakage should occur;*
- *recovery preparedness measures to minimise the consequence of fire/leak.*

2.3.9.2 Threat control measures to prevent hydrocarbon leakage

1. Assess the threat control measures, as a minimum, considering the following check points:
 - a. Refer to DEP 31.38.01.11-Gen. Piping general requirements for requirements pertaining to the piping arrangement. Attention should be paid to the fail-safe position of instrumentation and final control elements;
 - b. in the fire hazardous service, conventional level gauges (glass gauges) are vulnerable for leak and therefore should not be used;
 - c. magnetic level gauges should not be used in the systems handling butane or lighter hydrocarbons, hydrocarbons which forms flammable/toxic vapours heavier than air, and in the hydrocarbon services with pressure higher than 70 bar (ga) [1000 psig] and temperature more than 200 °C (400 °F);
 - d. the shaft sealing systems for rotating equipment shall be designed with the aim of reducing the probability of product leakage if seal components fail;
 - e. risers and conductors should be designed and positioned or protected to minimize the likelihood of damage, including damage due to ship impact and dropped objects;
 - f. redundant process and equipment monitoring alarms are highly effective in protection against malfunctioning process instrumentation and runaway of process conditions. Early detection of extreme temperatures, pressures, and levels, can prevent serious incidents;
 - g. atmospheric tank level alarms, in particular, independent high-high level alarms with corrected action, may be considered to be risk reduction measures for tank overfill where an effective barrier is demonstrated.

2.3.9.3 Mitigation measures to minimise hydrocarbon leakage quantities

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

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

1. Assess the mitigation measures, as a minimum, considering the following check points:
 - a. to restrict or reduce the quantity of flammable product feeding the fire, isolating valves that are accessible and operable during a fire incident should be incorporated to segregate sections of the plant;
 - b. if the manual isolation valve will not be accessible during a fire emergency, installation of a Remote Operable Emergency Isolation Valve (ROV or EIV) should be considered;
 - c. the availability of sub/surface safety valve (SSV) for the wells, ESD valves for full platform shutdown, EDP system for automatic depressurisation of the installation, and closure of all import and export risers should be considered in case of fire/explosion;
 - d. the reliability of isolating valves, valve actuators, instrument air supply, control system signal cabling, hydraulics actuators and piping, should be considered under fire or explosion conditions;
 - e. the failure mode and survival time of isolating valves, valve actuators, instrument air supply, control system signal cabling, hydraulics actuators and piping should be considered if exposed to damaging heat radiation or engulfed in fire;
 - f. risers and wells shall be provided with Surface controlled Sub-surface Safety Valve (SCSSSV);
 - i. SCSSSV's shall remain operable during fire/explosion scenarios on the top side of offshore oil and gas facility.
 - g. the positioning of ROVs or EIVs, taking into account isolatable inventories shall be determined during the FEED and Execute design phases;
 - h. safety Critical isolating valves shall be specified fire safe if installed in locations where it is likely that the valve will be engulfed in flames during a fire emergency;
 - i. for plants with a significant inventory of light hydrocarbons or toxic material an ESD system should be considered which can shut down a total plant or individual plant sections;
 - i. the individual plant sections should be selected on the basis of the location of the equipment, the layout of the plant section, and the quantity of hydrocarbons contained per section.
 - j. topsides riser ESD valves should be located as low down the riser as practicable, so as to minimize the likelihood of damage to the pipeline below the ESD valve and subsequent release of non-isolatable pipeline inventories;
 - k. where operation, maintenance and inspection requirements dictate that the riser ESDV is to be located on the platform, then protection should be provided to the valve in order to withstand the effects of fire/explosion;
 - l. small bore connections shall not be permitted below the riser isolation valve;

- m. the requirement to supplement the Riser ESDV by a Surface controlled sub-surface safety valve (SCSSSV) should be considered to limit the duration of leaks associated with failure of a riser;
- n. for design requirements criteria to establish protection against overpressure and sectionalizing processing streams, refer to the following:
 - i. DEP 80.45.10.11-Gen. Overpressure and underpressure – Prevention and protection;
 - ii. DEP 80.45.10.12-Gen. Layout of offshore facilities.

2.3.9.4 Measures to minimise the probability of ignition of hydrocarbon leakage

1. Assess the measures to minimise the probability of ignition of hydrocarbon leakage, as a minimum, considering the following:

Electrical area classification will be dictated by local regulations/Codes (e.g., IEC in Europe or NEC in the US). Applicable standards such as IP 15 and API 505 will be applied. Areas classed as Zone 0 by IP Code Part 15 should be avoided and steps taken to achieve the lowest hazardous area classification.

- a. installation of electrical equipment in the hazardous area should be avoided;
- b. the overall area layout in combination with the surface drainage arrangement should be designed such that large pools of fuel will not collect under, or in the vicinity of equipment containing flammable liquids or vapours;
- c. In case of loss of containment the spill will thus be confined to a small area. In case of ignition of the spill the probability of escalation will then be low;
- d. the equipment layout should avoid installation of fire/blast walls and plated decks;
- e. fire/blast walls and plated decks interfere with natural ventilation since confinement increases the level of damage if accumulated vapours ignite;
- f. the module design should be as open as possible using grated floors to promote natural ventilation;
- g. essential equipment which could be a potential ignition source, should be located away from the vent openings;
- h. if enclosures for equipment are used, then attention shall be given to the ventilation of these enclosures;
- i. this can be achieved by providing required ventilation and minimizing the number of leak sources within the enclosure (flanges, for example, might preferably be located outside of the enclosures.);
- j. refer to DEP 80.00.10.12-Gen. Layout of offshore facilities for plant layout and safety-related aspects of plant orientation and spacing;
- k. diesel engines in non-hazardous areas powering essential safety systems, (e.g., firewater pumps and emergency power generators) should be designed to continue to operate in the presence of flammable gas.

2.3.9.5 Recovery preparedness measures to minimise the consequence of fire/leak

2.3.9.5.1 General

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

Offshore facilities do not have the freedom of layout available; and, it is not always feasible to achieve controls related to fire prevention. As a result, a small fire/leak event has the potential for escalation. Additional recovery preparedness measures, i.e., passive fire protection, active fire protection and firefighting system may be necessary to prevent escalation of a fire incident.

2.3.9.5.2 Passive fire protection (PFP)

1. Passive fire protection performs its function without relying on activation. The prime function of passive fire protection via fireproofing is to retard the rate of temperature increase of a given substrate.
2. While considering PFP, the implications of corrosion under PFP and the effectiveness of inspection techniques during the installation service life shall be considered.
3. Selection of fireproofing (PFP) shall take into account fire type (e.g., pool/jet), fire size, and likely duration.
4. Based on the pool/jet fire scenario, the type of passive fire protection system provided should not restrict maintainability and operability of equipment.
5. Decision to provide fire/blast walls to prevent the escalation of fire/explosion to other areas shall be made as per the requirements of FES and design HSE case.
6. For the assessment of fireproofing criteria, see section 3, of DEP 80.47.10.30-Gen.

2.3.9.5.3 Active fire protection

Active fire protection systems offshore mainly comprise water spray systems, area deluge systems and firewater monitors for exposure protection. Water mist may be used for specific equipment with enclosures replacing total flooding CO₂ system under specific circumstances. For control and extinguishment of flammable liquid pool fires, foam systems may be considered.

Active fire protection systems may be activated automatically by the FGS or manually from control room once the information is received from the scene of the fire that protection is required. Their function is to protect against escalation of the fire emergency and avoid the need for manual intervention in the fire area.

1. Based on the fire scenario and potential escalation possibilities, the FHA shall define the degree of active fire protection system on performance basis, specifying fire extinguishing agent quantities and application rates.
2. The evaluation criteria to assess the mitigation capabilities of the fire protection shall include the following:
 - a. survivability, where the system is exposed to fire or explosion events involving the protected hazards;
 - b. integrity and availability of the fire water pumps and fire mains to meet the worst case demand;
 - c. Integrity and maintainability of the physically installed systems;
 - d. interlocks and warning notices to protect personnel where gaseous agents that are not human compatible are employed, e.g., carbon dioxide.
3. The performance of the fire protection systems should be reviewed against the criteria in the FES.

2.3.9.5.4 Organisation

Most of the active fire protection systems at an offshore facility are designed to actuate automatically based on the confirm fire/leak signal from fire and gas detection system or manually from control room.

Despite the auto and remote actuation of recovery preparedness measures, some manual firefighting efforts can be necessary to mitigate the release/fire incident, to support operation action, to enable rescue of injured personnel and to enable escape and evacuation.

1. All the POB, the offshore facility, should be trained in basic firefighting operation as per the local and international (OPITO) requirement.
2. The POB should be aware of the incident command system, operation of all the firefighting system and other emergency response procedures as per the Fire and Explosion Strategy of the facility.

2.3.9.5.5 Alarm and communication system

The speed and effectiveness of the various actions related to mitigation and recovery from the incident depend on the availability of a reliable alarm and communications system. Alarm systems and communication are the vital element in the overall fire and incident management system in terms of protecting personnel by initiating escape and evacuation procedures.

1. FGS related alarms shall be assessed, along with the following other alarm and communication systems:
 - a. telephone, radios and PA system alarm systems, to call out duty personnel;
 - b. FIT, nearby offshore facility.
2. The function and purpose and availability of alarm and communication system should be reviewed during the FHA to verify that it is effective in all the identified hazard scenarios, as per the cause and effect matrix.
3. Refer to DEP 32.30.20.11-Gen. for designing the fire and gas detection system and alarm systems.

2.3.9.5.6 Fire-fighting tugs

1. When required for the facility the firefighting tugs and OSVs shall be capable of providing exposure protection using long range high discharge capacity firewater monitors from a safe distance, as per the HCM, in the event of an accident.
2. Firefighting tug class (FIFI-1, FIFI-2 and FIFI-3) are notations granted to vessels built and equipped in compliance with the relevant class requirements. The class defines the tugs' firefighting capability, stability to keep position when the firefighting monitors are in operation and ability for self-protection.

2.3.9.5.7 Escape and evacuation arrangements

1. Refer to DEP 37.17.10.11-Gen. Design of offshore temporary refuges for the requirement of escape routes, means of evacuation, and muster and Temporary Refuge.
2. The following factors shall be reviewed against the requirements of the fire and explosion strategy:
 - a. number of escape routes from various parts of the facility or installation;
 - b. location and routes to the temporary refuge (or designated safe area);
 - c. protection from smoke and heat;
 - d. marking and elimination of dead ends in the escape routes;
 - e. critical widths (e.g., can a stretcher be carried) and headroom;
 - f. ventilation, smoke barriers and emergency lighting;
 - g. duration of availability of key routes during a major fire and/or explosion incident.
3. Manned areas like control rooms, accommodation areas separated by fire/blast walls from process areas and temporary refuge should be reviewed for the effect of heat radiation, smoke, flammable and toxic gases on personnel and for the potential impairment of emergency escape and evacuation facilities.
4. Where smoke ingress is identified as a major potential issue, mitigation measures shall be provided depending upon the fire and gas event.
5. The escape/evacuation, muster areas and temporary refuge (if present) shall be marked clearly, not encroached by temporary storage of supplies and has a floor surface that gives good grip even in wet weather.

Any impairment of escape and evacuation routes exposes personnel to an increased risk from fire and explosion hazardous events. Integration of a logical alarm system with good training and well thought out escape and evacuation routes can be highly effective in reducing risks to personnel operating the plant and also to those responding to emergency situations.
6. The results of any practice major emergency evacuation drills shall be reviewed.

2.3.9.5.8 Pre-incident planning

Well-developed pre-incident plans using the information provided in the "Fire Hazard Assessment" and FES are effective recovery measures.

1. Pre-incident planning involves preparation of operational and firefighting details to allow credible fire and release incidents to be controlled in the most efficient and effective manner.

Pre-incident plan mainly includes planning, coordinating and taking process operational and operational firefighting actions to control the emergency for each potential major fire scenario.
2. For Offshore facilities, pre-incident plans should include interface with the adjacent facility/shore base control room, availability of Marine security forces (Coast Guard, etc.) for possible evacuation in the event of failure of primary means of evacuation or TR impairment due to fire/explosion scenario.

2.3.10 Compare risk reduction measures with objectives and set criteria in the fire and explosion strategy

1. All the controls related to fire prevention and mitigation and recovery preparedness measures related to fire protection and firefighting identified in the "Fire Hazard Assessment" shall be reviewed against the Fire and Explosion Strategy to ensure that all affected people can safely and easily escape and evacuate the site of the incident and reach a safe refuge quickly.
2. Many of the offshore facilities which are of less criticality (unmanned remote facility), exhibit the potential for fire and explosion events without a serious risk of escalation. This may be due to the location, layout or physical barriers of the facility. The replacement cost of the facility may be less than the installation cost of the recovery preparedness measures related to fire protection system.
3. Where the replacement cost of the facility may be less than the installation cost of the recovery preparedness measures then the Fire Hazard Assessment" should consider not providing any recovery preparedness measures related to fire protection/fighting for preventing escalation.
4. The FHA should consider the option of isolate and blow down its supply of flammable hydrocarbons (emergency shutdown) upon fire detection and allow it to burn until the residual hydrocarbon inventory present is exhausted.
5. The approach of not providing any means of preventing escalation from fire/explosion shall be reviewed and documented in the fire and explosion strategy/philosophy document.

3. FIREWATER SYSTEMS

3.2 SYSTEM OVERVIEW

3.2.1 General

1. 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 in the category of Active Fire Protection (AFP). They are usually operated only after the initial hazardous event (e.g., hydrocarbon liquid release) and ignition have occurred.
2. Risk reduction measures should be combined, e.g., ESD & EDP system to consider the fuel inventories, ventilation, 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 system drainage and use of PFP along with the firewater system to increase the overall emergency response capabilities of the facility.
3. The intent of firewater systems is to mitigate the consequences of the event by extinguishing or limiting the spread of fire and as such shall be regarded as a recovery measure within the FES.
4. The firewater system should only be put in place after it is shown that control measures cannot reduce risk to a tolerable level and that risk is as low as reasonably practicable (ALARP).

3.2.2 Elements of firewater systems

1. (Figure 1) and (Figure 2) in (Section 14) show the different elements that make up a firewater system. Design guidance on specific elements is included in (4) through (11):
 - a. The main element of the firewater system are:
 - i. firewater supply source;
 - ii. firewater pumps including their prime movers and control system;
 - iii. firewater mains including isolation valves;
 - iv. hydrants;
 - v. firewater Monitors;
 - vi. deluge system;
 - vii. fixed firewater spray systems and;
 - viii. associated foam system.
2. Systems that may be required to operate simultaneously shall be identified when developing the FES.
3. Common elements in firewater system (supply source, pumps and firewater main) and other systems (e.g., deluge system) may have different availability requirements (see 3.2.3).

3.2.3 Overall system requirements

1. The justification for provision of a firewater system shall be based upon a formal Fire hazard assessment (FHA) and documented in the FES.
2. The Performance Standard for each individual firewater system element shall be defined.
3. Application rates of water and/or foam solution SHALL [PS] meet the Performance Standard of the relevant firewater system.
4. Each fire water system element SHALL [PS] meet its individual Performance Standard, including when operating simultaneously with the other fire water system elements.
5. Equipment specifications including materials of construction shall take into account the operating environment of the firewater system and its design life.
6. Firewater element design shall consider drainage requirements from any discharge area to ensure that the drains are capable to carry the firewater runoff from the protected area.
7. Firewater shall not be discharged into areas containing water-reactive materials.

3.2.4 Overall system guidance

3.2.4.1 Design intent

1. The need for water-based active fire protection systems should be justified in the FES, which is developed as part of "Fire Hazard Assessment".

3.2.4.2 Firewater demand

1. The Performance Criteria for the firewater pumps and the firewater main shall be based on two scenarios as follows:
 - a. the design firewater demand, being the largest firewater demand for a single fire event, taking into account:
 - i. any requirements for personnel protection during escape and evacuation;
 - ii. the demand of all firewater systems that are likely to be initiated by the initial fire incident;
 - iii. requirements for manual firefighting by personnel with hose lines, monitors etc. (e.g., to provide boundary cooling);
 - iv. any firewater requirements for essential users (e.g., drilling make-safe and generator cooling).
 - b. the maximum reasonably foreseeable firewater demand should also take into account:
 - i. 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);
 - ii. release of protection systems covering other areas (e.g., due to an explosion or external flaming being detected by flame detectors in other areas);
 - iii. possible manual initiation of additional water-based protection systems or equipment to protect nearby equipment and facilities.
2. The firewater system should be capable, at its design conditions and integrity, of meeting the design firewater demand.
3. The maximum reasonably foreseeable firewater demand may be met by allowing the firewater pumps to run-out up to 150% of their duty point and by using all sources of firewater that are likely to be available in the emergency.

3.2.4.3 Drains

1. Firewater discharge drains should be sized to allow for the designed discharge rates or containment should be such that the firewater and any other spilled liquids do not spread to other areas.
2. Drains should be designed to prevent the fire from spreading if burning liquids are carried into the drains by water-based fire systems.

3.2.4.4 Operating environment

1. On offshore facilities where temperatures drop below 0 °C (32 °F) and that have permanently filled firewater system elements, the routing of pipe work should consider its exposure to freezing conditions.
2. Specific measures may be required to eliminate the possible freezing of exposed pipe work.
3. The firewater main temperature should be monitored non-intrusively at any exposed locations likely to freeze.
4. Facilities for injecting additives (chemical or biological) to inhibit corrosion and marine growth within the firewater system should be provided.

3.2.4.5 Location

1. The location of the firewater system components should consider the probability of mechanical damage by:
 - a. dropped objects;
 - b. swung loads;
 - c. explosion venting, etc.

3.2.4.6 Surge problems

1. To reduce the effects of surge on the firewater system, a surge study should be conducted upon completion of the firewater main isometric drawings.
2. Corrective measures shall be applied to protect the system against surge pressures that are in excess of the system design pressure (see 4.4.2.8).

3.2.4.7 Strainers

1. To prevent blockage of system elements or components, the pump suction line should have strainers.
2. It may also be necessary to provide strainers at the inlet to individual system elements.

3.2.4.8 Materials

1. All water distribution pipe work should be designed and constructed from materials suitable for the duty.
2. In addition:
 - a. pipe work less than 25 mm (1 in) nominal diameter should not be used;
 - b. the design velocity should not exceed 10 m/s (33 ft/s).
3. Materials should be selected that are inherently corrosion resistant and these may include non-metallic piping of composite materials as per applicable piping class.
4. Refer to DEP 39.01.10.11-Gen. for requirements pertaining to material selection.
5. If materials of construction are not specified, alternative proposals should be submitted for approval by the Principal.
6. Refer to DEP 31.38.01.15-Gen. for requirements pertaining to piping classes.

3.3 OPERATION, CONTROL AND MONITORING

3.3.1 Mode of operation

1. All firewater system elements should be clearly marked with operating instructions.
2. The mode of operation of any firewater system discharge element can be manually or automatically initiated by a signal from, for example, a fire detection system.
3. Refer to DEP 32.30.20.11-Gen. Fire, gas and smoke detection systems for design of detection systems for automatic initiation of elements.
4. 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.
5. 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.
6. For automatically initiated discharge elements, a manual release station that does not rely on the integrity of electrical or pneumatic signals shall also be provided.
7. Any prior actions required for systems to be effective, such as power or ventilation shut-down, shall be incorporated in the system logic.
8. Refer to DEP 32.30.20.11-Gen. Fire, gas and smoke detection systems for requirements pertaining to mode of operation.
9. 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.

3.3.2 Alarm and annunciation

1. The status of all automatic firewater system elements shall be indicated at the FGS.
2. Refer to DEP 32.30.20.11-Gen. Fire, gas and smoke detection systems for requirements pertaining to alarm and annunciation.

3.3.3 Shut-down and reset

1. All firewater system elements shall be able to be shut down and reset into a fully operable condition as soon as is practicable after an incident.
2. Automatic shut-down of a system shall not be permitted unless it can be shown that leaving the system running can give rise to a greater risk than shutting it down.
3. Formal procedures should be in place for manual response after a system has discharged and for resetting.

3.4 INSTALLATION, INSPECTION, TESTING, COMMISSIONING AND MAINTENANCE

3.4.1 General requirements

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

3.4.2 Inspection requirements

1. Contractor shall develop and handover maintenance routines for the operation phase.
2. Records of all quality procedures, inspections and tests shall be retained in accordance with the project requirements.

3.4.3 Acceptance testing and commissioning requirements

1. Refer to DEP 74.00.10.10-Gen. Shop and Field Testing of Piping Systems for requirements pertaining to acceptance testing and commissioning.
2. Full-flow operational tests, including response times for all firewater system elements and pressure measurements, shall be undertaken.
3. Adjustments shall be made to the operational test to ensure that the elements can cope with expected surges (e.g., pump start-up time/closure of overboard dump valve).

3.4.4 Maintenance requirements

1. Contractor shall develop and handover maintenance routines for the operation phase.
2. 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. Further guidance on the maintenance of firefighting 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 B).

3.5 DRAWINGS AND DOCUMENTATION

1. Hydraulic calculations shall be carried out for all firewater system pipe work and discharge systems using a validated and recognised computer program.
2. A unique data-set shall be submitted for each calculated system.
3. Each data-set should be comprised of the following:
 - a. one print of the input data-set;
 - b. one print of the input check;
 - c. one print of the pipe table;
 - d. one print of the overall hydraulic isometric;
 - e. one hydraulic calculation print-out including details of any constraints such as flow velocities, minimum and maximum pressures and unacceptable pipe diameters.
4. When a system is revised during the course of a project, hydraulic calculations shall be re-run.