



Exploration & Production

GENERAL SPECIFICATION

SAFETY

GS EP SAF 380

Safety Engineering Requirements for an F(P)SO
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Main Instructor for Derogation: ECI (Design of Filed Facilities)

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1. Scope and Applicability

1.1 Introduction

The purpose of this General Specification is to define the Safety Engineering requirements for floating hydrocarbon production and processing facilities as opposed to traditional onshore or offshore “fixed” installations that were the basis for the COMPANY General Specifications for Safety.

Therefore, this General Specification defines COMPANY interpretation of General Specifications in addition to defining specific Safety Engineering requirements for offshore floating production storage and offloading (FPSO) installations. It can be considered as a master Specification giving the rules of applying the other General Specifications for FPSO's. In case of any conflicts between specifications, the FPSO specific requirements given in this General Specification shall take precedence.

For simplicity, the abbreviation FPSO is used throughout this document to refer to a moored monohull floating unit that has oil processing storage capacity and offloading facilities or processing facilities only (FPU), or storage facilities only (FSO).

This specification document was written for use on a typical development with a spread-moored or turret moored FPSO vessel.

1.2 Objectives

The General Specification sets out the COMPANY philosophy and requirements for the safety engineering of FPSO units processing and handling hydrocarbons.

The primary objective of this specification is to protect personnel from hydrocarbon hazards and other operational hazards associated with FPSOs.

For this purpose, this specification has been prepared on the basis of the following requirements:

- To protect personnel on the FPSO during operations by preventing the occurrence of hazards and during their evacuation or escape in case of any hazardous events.
- To minimise damage due to hazards and thus enable the Installation to return to operational status as soon as possible after the event.
- To minimise escalation of any hazard which could lead to widespread installation damage and pollution of the environment?

In order to achieve these objectives this General Specification defines the minimum requirements for both active and passive protection systems for the facilities of a FPSO based development.

- FPSO Interfaces to Subsea Production System (SPS) composed of drill centers with production wells, gas and water injection wells.
- Interface to the Flowlines and their risers to FPSO including Gas lift lines from the FPSO to production riser at seabed.
- FPSO Topsides and the Hull systems, including:
 - FPSO spread moorings or turret mooring arrangements

➤ FPSO Hull tanks

- Oil Export from FPSO via an offshore SPM (Single Point Mooring) oil offloading buoy located about one nautical mile from the FPSO.
- Tandem offloading of oil from the FPSO to offtake tankers. (Back-up case).
- Gas export to shore via a pipeline.

1.3 FPSO Safety Engineering Approach

The risk assessments and safety studies, including those listed in Section 4 of this General Specification, shall be carried out for the hazards identified by hazards identification (HAZID) exercise conducted before the end of the Basic Engineering phase. The results of these assessments and studies shall be used to determine the scope, ratings and the endurance periods of the required safety systems and protection arrangements for the FPSO. If such risk assessments and safety studies are not carried out for the potential FPSO related hazards, then the default criteria for safety systems and protection arrangements, given in this General Specification, shall be used. This approach is illustrated in Figure 1.

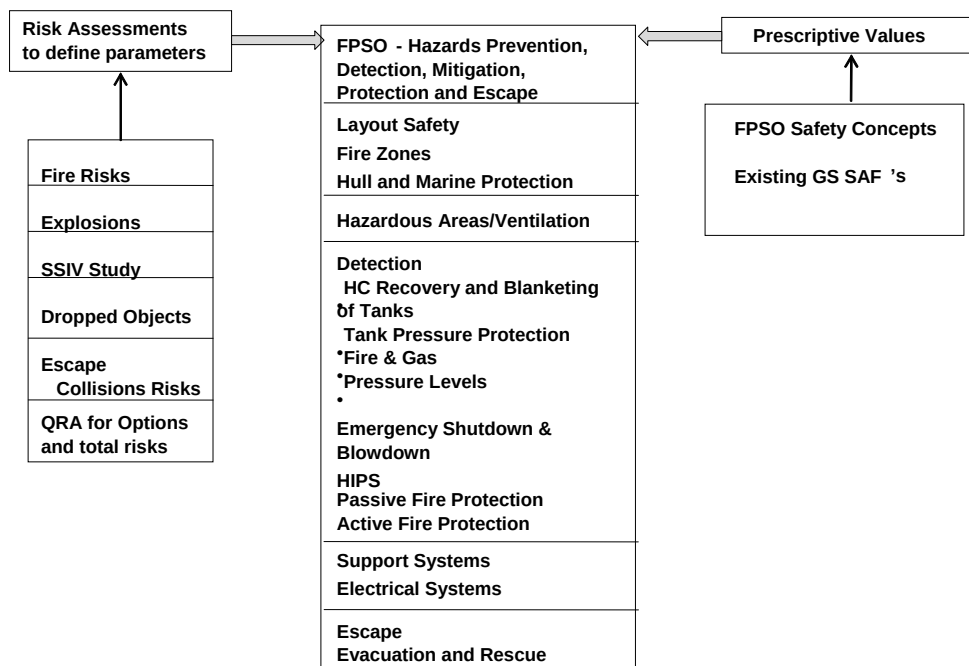


Figure 1 – FPSO Safety Engineering Approach

The default criteria for safety systems and the protection arrangements given in this General Specification can be used for the Pre- Project phase, to develop the Safety Concept for the Project. It is strongly recommended that, the risk assessments and safety studies are carried out before the end of Basic Engineering phase to validate the default values used for the scope, ratings and the endurance periods of the required safety systems and the protection arrangements, for the Project FPSO.



The reports and recommendations of the risk assessments and safety studies carried out, including those listed in section 4 of this General Specification shall be subject to COMPANY (EP/HSE/ SEI) approval.

The design requirements for protection arrangements and the individual safety systems for the FPSO shall also comply with the applicable General Specifications listed in section 2.0, except in the following cases:

- Some requirements specified in General Specifications listed in section 2.0 are not applicable for a FPSO.
- Revised or additional or reduced requirements specified in this General Specification, based on the experiences of COMPANY and Industry Experience.

In addition the protection arrangements and the safety systems in the Accommodation Block, Hull Deck, Hull tanks and Hull Machinery areas shall also comply with the latest SOLAS requirements. The main SOLAS requirements are identified in this Specification.

2. Reference Documents

The reference documents listed below form an integral part of this General Specification. Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published at the EFFECTIVE DATE of the CONTRACT.

Standards

Reference	Title
IEC 61508	Functional safety of electrical/electronic/programmable electronic safety related systems
IEC 61511	Functional safety : safety instrumented systems for the process industry sector
IEC 60092-502	Electrical Installations in ships – Part 502: Tankers – Special features

Professional Documents

Reference	Title
API RP 14B	Recommended Practice for Design, Installation, Repair and Operations of Sub Surface Safety Valve (SSSV) Systems
API RP 14C	Recommended Practice for Analysis, Design, Installation, and Testing of Basic Surface Safety Systems for Offshore Production Platforms
API RP 14J	Recommended Practice for Design and Hazards Analysis for Offshore Production Facilities - Second Edition
API STD 521	Guide for Pressure Relieving and Depressuring Systems
ISO 10418	Petroleum and natural gas industries – Offshore production installations – Basic surface process safety systems
NFPA 15	Water spray fixed systems for fire protection
NFPA 20	Installation of stationary fire pumps for fire protection

Regulations

Reference	Title
IMO MARPOL	International Convention for the Prevention of Pollution from ships.
IMO SOLAS	International Convention for the Safety of Life at Sea.
IMO COLREG	Convention of the International Regulations for Preventing Collisions at Sea.

Codes

Reference	Title
MODU	Code for the Construction and Equipment of Mobile Offshore Drilling Units.
ISPS	International Ship and Port Facility Security code.
LSA	International Life Saving Appliances Code
ICAO	Annex 14, Volume II Heliports

Other documents

Reference	Title
Not applicable	

Total General Specifications

All engineering work for the safety systems and protection arrangements on the FPSO shall be in accordance with all the relevant latest edition of the COMPANY specifications listed below, unless more specific requirements are given in this General Specification:

Reference	Title
GS EP STR 631	CALM buoy terminals
GS EP STR 651	General Principles for an F(P)SO Design
GS EP STR 652	F(P)SO – Steel hull design requirements
GS EP STR 661	F(P)SO – Design requirements for mooring and anchoring
GS EP STR 901	Design rules and construction standards for ancillary structures of offshore installations
GS EP PLR 100	Installation of submarine pipelines
GS EP SAF 021	Layout
GS EP SAF 041	Technological risk assessment methodology
GS EP SAF 216	Area classification
GS EP SAF 221	Safety rules for buildings
GS EP SAF 222	Safety rules for turbines, Diesel engines, gas engines and process units in sheltered or enclosed areas
GS EP SAF 226	Completed wells safety systems and safety rules
GS EP SAF 227	Safety rules for fired heaters
GS EP SAF 228	Liquid drainage
GS EP SAF 253	Impact area, restricted area and fire zones
GS EP SAF 260	Design of high Integrity protection systems (HIPS)
GS EP SAF 261	Emergency shutdown & emergency depressurisation (ESD & EDP)
GS EP SAF 262	Pressure protection relief and hydrocarbon disposal systems
GS EP SAF 311	Rules for the selection of Fire Fighting Systems
GS EP SAF 312	Guidelines for selecting and installing fire and gas detection systems
GS EP SAF 321	Fire pumps stations and fire water mains
GS EP SAF 322	Fixed fire water systems
GS EP SAF 331	Carbon Dioxide fire extinguishing systems

Reference	Title
GS EP SAF 334	Foam fire extinguishing systems
GS EP SAF 337	Passive Fire Protection: Basis of design
GS EP SAF 351	Escape, Evacuation and Rescue from fixed installations
GS EP SAF 371	Emergency Control Facilities
GS EP ELE 001	Electrical design criteria
GS EP ELE 021	Emergency design Criteria for floating units
GS EP ENV 001	Environmental Requirements for Projects Design and E&P activities
GS EP ENV 500	Noise abatement in production units
GS EP LSO 110	Environmental effects considerations for helidecks
GS EP MED 060	Onsite medical structures

3. Terminology and FPSO definitions

3.1 Terminology

There are three types of statements in this specification, the “shall”, “should” and “may” statements. They are to be understood as follows:

Shall Is to be understood as mandatory. Deviating from a “shall” statement requires derogation approved by the COMPANY

Should Is to be understood as strongly recommended to comply with the requirements of the specification. Alternatives shall provide a similar level of protection and this shall be documented

May Is used where alternatives are equally acceptable.

For the purpose of this specification, the following definitions shall apply (the terms defined in this section are often in bold characters in the text of the specification):

Abnormal operating condition	A condition which occurs in a process equipment or unit when an operating parameter range is outside of its normal operating limits. (API).
Availability	Proportion of the total time during which a component, equipment, or system is performing in the desired manner (UKOOA).
Blow-Down (vent gas)	Automatically operated (fail to open) valve used to vent the pressure from a process station on Shutdown (API).
Emergency Depressurisation (EDP)	Control actions undertaken to depressurise equipment or process down to a pre-defined threshold (generally 7 barg or 50% of design pressure) in a given period of time (generally 15 minutes) in response to a hazardous situation (ISO + COMPANY).

Emergency Shutdown (ESD)	Control actions undertaken to shutdown equipment or process in response to a hazardous situation (ISO).
Emergency Shutdown System	System of manual stations and automatic devices which, when activated, initiate installation shutdown (COMPANY).
Emergency Shutdown Valve (ESDV)	High integrity shutdown valve, handling a hazardous fluid or a fluid having an essential function, and located at the limit of a fire zone or within a fire zone to limit hydrocarbon inventory (COMPANY).
Equipment	Any component or group of components specifically identified and itemised on the P&IDs (COMPANY).
Failure	Termination of the ability of a device or equipment item to perform a required function (IEC + API).
Fire & Gas (F&G) System	Safety system which monitors the temperature or the energy flux (fire), the concentration of flammable or toxic gases (gas), and initiates relevant actions (alarm, ESD, EDP, active fire-fighting, electrical isolation etc) at pre-determined levels (COMPANY).
Fire zone	Areas within the installation where equipment is grouped by nature and/or homogeneous level of risk attached to them. The partition into fire zones is such that the consequences of a flammable gas leak, an explosion or a fire corresponding to the worst credible event likely to occur in the concerned fire zone shall not impact other fire zones to an extent where their integrity could be put at risk (COMPANY).
High Integrity Protection System (HIPS)	Instrument-based system of sufficient integrity (involving high reliability redundant and/or diversified instruments) so as to make the probability of exceeding the design parameters lower than a target value (GS EP SAF 260).
Redundancy	Existence of means, in addition to the means that would be sufficient, for a functional unit to perform a required function of data to represent information (IEC).
Reliability	Probability that an item is able to perform a required function under stated conditions for a stated period of time or for a stated demand (UKOOA).
Safety Integrity	Average probability of a safety-instrumented system satisfactorily performing the required safety instrumented functions under all the stated conditions within a stated period of time (IEC).
Safety Integrity Level (SIL)	SIL is a measure of risk reduction provided by a safety-instrumented function based on four levels. Each level represents an order of magnitude of risk reduction. Every safety instrumented function has a SIL assigned to it, the safety instrumented system and equipment themselves do not have a SIL assigned to it (IEC). Safety integrity Level 4 has the highest level of safety integrity and Safety Integrity Level 1 has the lowest (IEC).

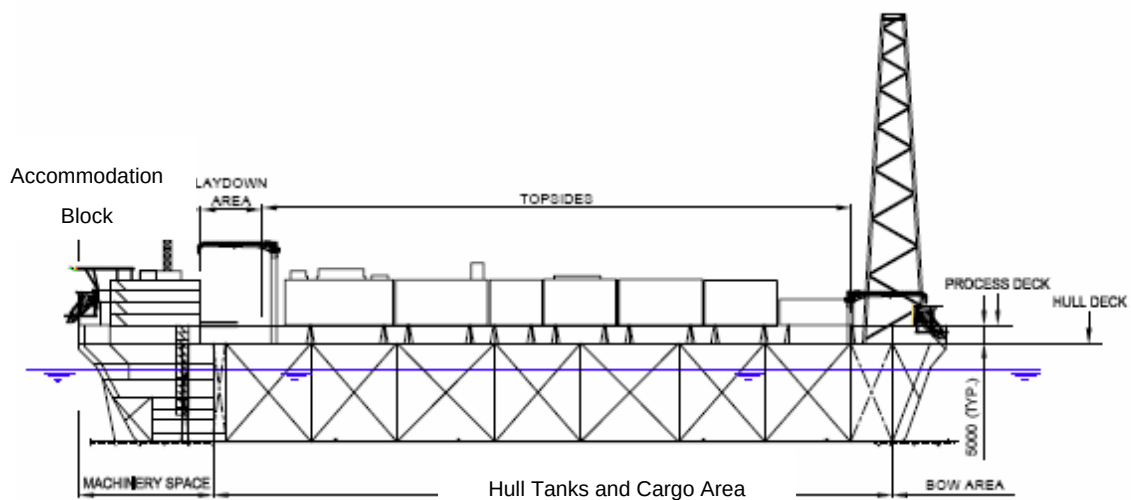
Shutdown (SD)	Control actions undertaken to stop operation of equipment or a process. Shutdown can be automatically triggered or initiated by voluntary action.
Shutdown Valve (SDV)	Automatically operated valve (generally fail to close) used for isolating a process station (API). SDVs are often referred to as Process Shutdown Valves (PSDV). The acronym SDV and PSDV are equivalent but SDV is used in this specification because SDVs may not always be attached to a process system.
SPM or CALM Buoy	Buoy for the oil offshore terminal (OOT).
SSIV	Sub-sea Isolation Valve

3.2 FPSO Definitions

3.2.1 General

This section defines the terminology used for arrangements, components and areas of the FPSO in this General Specification.

The figure below shows a typical FPSO arrangement to illustrate the definitions and numbering conventions.



- FPSO is a Floating Production, Storage and Offloading Unit
- FPU is a Floating Production Unit. (No Storage facilities).
- FSO is a Floating Storage and Offloading Unit. (No Production facilities)

- The Floating Unit is kept on station by the mooring system, which can be one of the following arrangements:
 - Spread mooring
 - Internal Turret
 - External Turret

For simplicity, the abbreviation FPSO is used in this document to refer to a unit that has oil storage capacity and production facilities.

- The letter O refers mainly to the oil export and covers a variety of possibilities: tandem offloading, export to a remote loading buoy or export through a pipeline.

The use of brackets in F(P)SO means that requirements are valid for any type of vessel.

3.2.2 FPSO Topsides Layout

The FPSO Topsides, comprising several modules normally has the following deck levels:

- Hull deck which is the top of the hull tanks
- Bottom decks of the Process and utilities Modules (Referred to as the Process deck (i.e. the level above the hull deck).
- Mezzanine/deck of the Process and utilities Modules.
- Upper deck of the modules.

The main process systems consisting of separation, compression, flaring and offloading equipment are located on the process deck, at a sufficient height above the hull deck, to provide drainage and separation from the hull deck.

The Electrical/Instrumentation (E&I) buildings can be located if required, above the hull deck and between the process areas and utility areas or in a location inside or adjacent to the Accommodation Block.

3.2.3 FPSO Hull Layout

FPSO hull will contain the oil cargo tanks, process tanks, slop tanks, storage tanks for methanol, Diesel, fresh and potable water and water ballast tanks. Process tanks refer to hull tanks dedicated to process functions such as wash tanks, settling tanks and dewatering tanks. The aft section of the hull will contain the spaces with main machinery rooms.

Hull systems shall be segregated from process or utility systems, for safety, operation and construction purposes. The unavoidable exceptions are the hydrocarbon inerting of the hull cargo, wash, settling and slop tanks. Ballast and bilge pumps and their pipework shall be located inside the hull frame.

The following definitions are used:

- Accommodation Block (AB) includes the Living Quarters (LQ), the Hotel/Catering functions, offices, technical rooms, the helideck and the Central Control Room. Accommodation Block levels are numbered from the level corresponding to the process deck level (A deck) upwards to roof level below the helideck.

- Fore or bow refers to the end of hull where the flare and the oil offloading station are located. When the FPSO is turret moored, the internal or external turret is located at the Fore end. The F(P)SO is generally towed by this end.
- Bow area covers the hull deck area where usually towing equipment as well as tandem offloading equipment is installed.
- Aft or stern refers to the end, where the Accommodation Block is located.
- Cargo Area is the section of the Hull where oil is stored in tanks.
- Machinery space is the section of the hull located under the AB. Machinery space levels shall be numbered downwards from hull deck (N° 0) to keel (N° n).
- Appurtenances: F(P)SO specific elements including their foundations which are protruding from the hull not normally existing on ships such as risers supporting structures, boat-landings, support structures, topsides stools, protectors, flare foundations...).
- Lay-down Area: The Lay down Area is an area situated in front of the AB dedicated for the temporary storage of goods/spares/consumables which are transferred onboard the F(P)SO by one of the pedestal cranes.
- Surfer Landing: The light craft landing structure described in **GS EP STR 901** used to transfer personnel from vessel to vessel.

3.3 Classification Definitions

The FPSO, their station-keeping systems (mooring system, yokes, turrets,), the product transfer systems (tandem offloading) and the SPM (CALM buoys, etc) shall be classed by a recognised Class Society, as specified in **GS EP STR 651**.

For the FPSO, the scope of Classification shall include the following components which shall comply with the latest requirements of the applicable SOLAS Regulations:

- The hull
- The Accommodation Block
- The utilities systems of the hull
- The safety and life saving systems
- The cargo oil handling systems
- Tandem oil offloading system (hawsers, hoses and ancillary equipment)
- The methanol loading and storage system
- The lifting appliances (Cranes and other devices)
- The hull integrated supports of topsides
- The structure integrating the station-keeping system (turret, chain stoppers, etc)
- Hull onboard towing equipment

The oil offloading transfer systems (SPM or CALM Buoy or other types and their moorings) shall be classed separately from the FPSO.

The process systems (topsides), the export lines and the flow lines and risers do not require classification by the Class Society.

4. Overall assessments of FPSO hazards

4.1 Technological Risk Analysis

The Technological Risk Assessment methodology in accordance with COMPANY **GS EP SAF 041** shall be implemented for the FPSO development. The method includes two parallel approaches, namely scenario based risk assessment and quantitative risk assessment (QRA). An overview of the risk assessment process is shown in figure 2. Both these approaches shall be used for FPSO based developments.

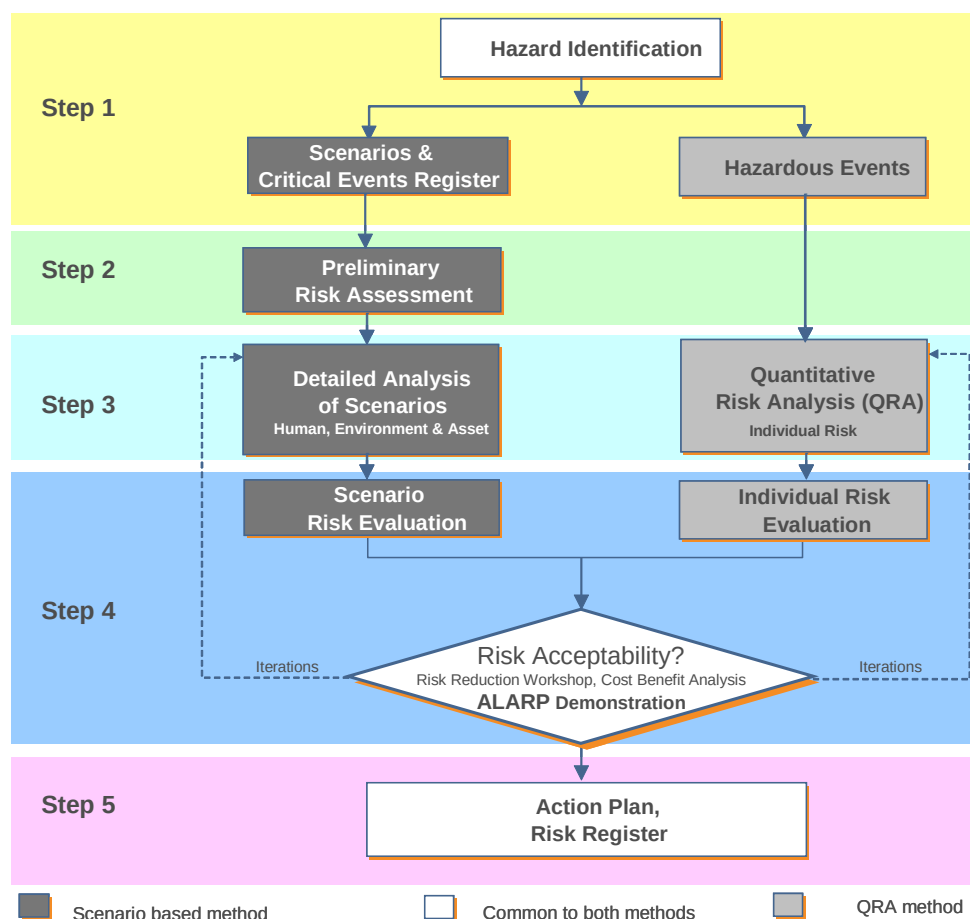


Figure 2 - Scheme of Technological Risk Assessment

This Technological Risks Assessment shall cover all the systems, components and activities required for the Development, including the following:

- The FPSO Topsides, Hull and the mooring system
- Subsea production systems, flowlines, pipelines and the risers

- Oil Export systems
- Gas Export systems
- Simultaneous Production, Drilling and Construction Operations (SIMOPS)

The main internal and external hazards to above systems and components shall be identified by a HAZID. The initial HAZID shall be done in the Pre-Project stage and this HAZID shall be used as the input to the Technological Risk Assessment.

This HAZID shall also identify the specific safety evaluations and the scope of the Consequence Analysis and safety studies to be carried out as part of the Quantitative Risk Analysis (QRA) are summarised in Section 4.4.

4.2 Hazards Evaluation

The hazards to be evaluated by both the scenario based risk assessment and the QRA, shall include those listed in this section.

4.2.1 Hydrocarbon Hazards

- Accidental gas leaks on the FPSO from Process Systems, the riser terminations and the risers.
- Releases due to dropped objects onto hydrocarbon containing equipment, risers or pipelines
- Collisions of vessels with the FPSO and/or the risers causing structural damage to the FPSO hull and /or the risers, resulting in a release of hydrocarbons.
- Jet fires and pool fires due to ignited hydrocarbon releases on or near the FPSO
- Ignited gas releases from FPSO flares
- FPSO flare flame out causing potential gas hazard
- Fire in hull tanks
- Fire in the hull or topsides machinery areas
- Explosions due to delayed ignition of gas releases on or near the FPSO
- Explosions in hull tanks

4.2.2 Marine and Operational Hazards

The impact of the following scenarios which could impact the FPSO hull integrity shall be evaluated to determine the necessary protection requirements.

- Extreme site environmental and sea conditions that could cause excessive excursions of the FPSO, resulting in possible damage to risers and flowlines.
- Hydrocarbon release in case of a failure or fracture of a flowline routed under the FPSO.
- Maloperation of the cargo and ballast transfer systems would lead to stressing of the hull which could result in fractures or break-up of the hull.
- Marine collision risks to the FPSO hull that can arise from the vessels visiting the installation and the adjoining fields.

- Failure of the cargo offloading system (through the buoy or in tandem) to shuttle tankers.

4.3 Scenario Based Risk Assessment

A Preliminary Risk Assessment (PRA) shall be performed during the pre-project phase of the Development in line with the requirements of **GS EP SAF 041**. The PRA may be carried out using semi-quantitative analysis to estimate the frequency and damage severity of accident scenarios identified by a HAZID. The resultant values are to be plotted on the COMPANY "Screening Matrix" to select scenarios to be evaluated in more detail in the Detailed Risk Assessments and ALARP demonstration to be carried out in the following Project Phases.

4.4 Consequence Analysis and Safety Studies

The detailed evaluations including those as specified in this section shall be carried out before the end of the Basic Engineering Phase. The findings from these studies shall be utilised for the Scenario Based Risk Assessment and the Quantitative Risk Assessment. In addition, the recommendations from these evaluations shall be reviewed and the identified risk reduction measures and protective arrangements shall be incorporated into the design.

4.4.1 Dropped Object Study

The Dropped Objects Study shall be carried out to identify the frequency and impact of dropped objects for the following:

- FPSO topsides due to crane and other mechanical handling operations.
- Riser bay, risers and pipelines in the vicinity of the FPSO due to crane operations.
- Subsea wells and manifolds due to drilling and well intervention activities.
- Installation or handling risers while FPSO is in operation.
- Mechanical handling of cargo pumps located in the hull tanks.

Study recommendations shall be used to identify protection for subsea wellheads, manifolds, flowlines, risers and the deck areas of the FPSO.

4.4.2 Risers Risk Reduction Study

An evaluation, based on Consequence Analysis, Quantitative Risk Assessment (QRA) and Cost Benefit Analysis as specified in **GS EP PLR 100** section 16, shall be carried out to determine the risk reduction and protection measures required to protect the FPSO from hydrocarbon releases from the hydrocarbon pipelines connected to the FPSO. This evaluation shall determine if it is necessary to install Subsea Isolation Valves (SSIV's) on these hydrocarbon pipelines. This is to ensure the safety of personnel and ensure the integrity of the FPSO against potential hydrocarbon fire threats due to the failure of the risers.

This evaluation shall also evaluate the benefits of installing automatic operated valves on the manifolds of the flowlines as a risk reduction measure to protect against a potential failure of the flexible risers, for the incoming flows from the wells.

4.4.3 Fire Risk Analysis

Potential jet fire and pool fire scenarios due to potential ignited hydrocarbon releases on the FPSO or from the risers to the FPSO shall be evaluated. Fire Risk Analysis results shall be

used to formulate protection and mitigation measures against jet and pool fires for the FPSO areas and critical components as specified in Section 7.0.

4.4.4 Explosion Modelling and Overpressure Resistance

Explosion modelling based on 3D Computational Fluids Dynamics (CFD) shall be carried out to determine explosion overpressures on the FPSO due to ignited gas clouds of varying gas mixtures and sizes. Based on previous evaluations for FPSO's, it is expected that at least the following four explosion scenarios must be considered with detailed layouts in the CFD modelling:

- Case 1: An explosion in the gas compression module
- Case 2: An explosion in the riser manifold area
- Case 3: An explosion in the region around the main separators
- Case 4: An explosion in spaces between the hull deck and the process deck.

The explosion overpressure loadings for the structural design using the results of the 3D explosion modelling and exceedance curves shall be determined for all areas of the FPSO, including the primary structural members and Safety Critical Elements. The following classification shall be used to define the Safety Criticality:

Level 1 = items whose failure due to gas explosion would lead to major fire escalation or major impairment of EER possibilities.

Level 2 = items whose failure due to gas explosion would contribute to significant fire escalation locally but not of such magnitude as to be outside the fire design scenarios.

Level 3 = items whose failure in an explosion event would contribute to minor effects.

Two level of explosion resistance with the pressure pulse profile shall be determined as follows:

- Ductile Level Blast resistance based on the likelihood of failure in an explosion of any of the above structural elements would be less than 1E-04/year.
- Strength Level Blast resistance which is about 1/3rd the Ductile Level Blast resistance

4.4.5 Evacuation, Escape and Rescue Analysis

An Evacuation, Escape and Rescue Analysis for the FPSO shall be carried out to ensure that the required adequate escape routes and rescue facilities are incorporated in the design and layout of the FPSO.

This analysis shall also evaluate the protection requirements for the escape routes and muster stations against the potential hazards to them

4.4.6 Ship Collision Study

Studies will be conducted to examine the ship collision risk for the FPSO from vessels visiting the installation and from passing vessels. The study shall determine the frequencies and consequences of potential collision risks.

The results of the Ship Collision Risk Assessment shall be used by implementing the following:

- Procedures for the approach of supply boats and oil export tankers to the FPSO.

- Protective fenders to be installed around vulnerable equipment, typically such as risers, moorings and the offloading lines.

4.5 Quantitative Risk Assessment (QRA)

A QRA Study shall be carried out to determine the risk levels associated with all FPSO operations and hydrocarbon handling facilities. The risk levels shall be calculated using the results of the evaluations listed in Section 4.4 and shall also include the risks due to the transfer of personnel to and from the FPSO.

The QRA shall be undertaken in accordance with **GS EP SAF 041** principles to confirm that individual risk levels are tolerable and to identify and define further risk reduction measures that are required to reduce the FPSO risks to ALARP.

In line with COMPANY Policy the maximum individual risk per annum (IRPA) due the FPSO operations must be below 1.0 E-03 and the COMPANY aim is to achieve an IRPA close to 1.0 E-04.

5. Interfaces with Subsea Production System

This section identifies the potential interactive hazards for the FPSO due to hydrocarbon systems connected to it and defines the protection requirements.

5.1 Management of Interactive Hazards

Particular attention shall be paid to the safety requirements to be included in the design to manage hazards due to simultaneous operations (SIMOPS). These operations include specific well operations (drilling, work over, pulling, wire line, stimulation, other servicing etc), maintenance work or construction activities adjacent to live wells and manifolds.

The following safety engineering measures shall be implemented during the Project Development phases of the COMPANY FPSO Projects:

- Protection against impact of dropped objects on the Sub-sea Production Systems, including potential dropped objects during simultaneous well operations and hydrocarbon production
- Restricted areas between moored Drilling Rigs (and their anchors) and the FPSO (and its moorings) shall be identified for all SIMOPS scenarios in the field.
- Each well intervention scope of work shall be subject to a specific HAZID study whereby adequate emergency shutdown arrangements to mitigate the risk shall be addressed. The well being worked over shall be under the control of the ESD system of the well intervention vessel for the duration of the well intervention work.
- An evaluation of all overpressure scenarios in the flowlines from the wells to the FPSO to identify any additional over pressure protection measures required for these lines.
- Implementation of a minimum safe distance separation between the anchor lines and mooring lines and the subsea production equipment.

5.2 Protection Measures for the Subsea Production Facilities

The COMPANY specification **GS EP SAF 226** defines the safety requirements applicable to well integrity, surface equipment (including flow-lines and injection lines) and active safety devices.

Safety requirements given in this specification shall be incorporated in the design of the well Xmas tree completion and the flowlines.

In accordance with the hazard management for production installations (as per [API RP 14J](#)), the safety measures contribute to the containment of hydrocarbon by meeting the following objectives:

- Providing the subsea wellheads with adequate protection and barriers.
- Providing flowlines and injection lines with adequate isolation and safety devices.
- Provisions to prevent leaks from the wells.

A subsea preservation system comprising of methanol injection to subsea wellheads and jumpers and dead oil or diesel displacement of live production fluids in the production flowlines shall be provided, in case of a production shutdown where a re-start cannot be achieved before hydrate formulation conditions are expected to develop in the subsea production system.

5.3 Emergency Shutdown (ESD) of the Subsea Facilities

The FPSO Emergency Shutdown (ESD) System shall be interfaced with the subsea ESD system which is defined by the following shutdown levels:

- Individual well stop (WS) – shutdown level SD 3
- Shutdown of individual production well (W.SD)
- Shutdown of individual subsea production loop (SPL.SD)
- Shutdown of all subsea production (Subsea ESD)

The following minimum subsea ESD levels are initiated as a result of the following FPSO ESD conditions:

- ESD 0 on FPSO initiates shutdown of all subsea production (Subsea ESD) and close the surface controlled down hole safety valve (SCDHSV) in the production well
- ESD 1 on FPSO initiates shutdown of all subsea production (Subsea ESD)

Individual well shutdown shall be carried out by closure of the well valves as defined in [GS EP SAF 226](#).

6. Interfaces to Umbilicals, Flowlines and Risers (UFR)

6.1 Interactive Hazards from Flowlines and Risers

Accidental loadings on the UFR components that could occur as a result of the marine hazards shall be evaluated and taken into consideration in the design of the protection requirements for the risers and pipeline end terminations.

Fire and explosion scenarios are defined as an ignited hydrocarbon release from any subsea hydrocarbon pipelines causing a fire on the sea surface, or from a hydrocarbon riser causing a fire on or above sea surface, including escalation from a riser to other risers.

Any pool fire, jet fire or flash fire from a flammable liquid or gas release could cause the impairment of the risers main safety functions with probable loss of production and fatalities or injury to personnel. These fires can also impact on the hull of the FPSO and escalate to the wing tank.



6.2 Management of Hazards

6.2.1 Assessment of risk reduction Measures for the Gas Export Pipeline

The requirements for automatically isolating the FPSO gas export riser and other hydrocarbon risers from their respective pipelines, in case of a gas release below the riser ESD valve, must be evaluated. This is in order to minimize the duration of any potential hydrocarbon release (and the duration of a jet and /or pool fire if the release is ignited) in the vicinity of the FPSO.

For this purpose, an evaluation shall be carried out to determine the need to provide Subsea Isolation Valves (SSIV's) on the hydrocarbon pipelines connected to the FPSO. This evaluation shall be based on the following two methodologies:

- Consequence Analysis of the potential failure scenarios, Quantitative Risk Assessment (QRA) and a Cost Benefit Analysis (CBA) of the alternative protection measures, as per the Methodology given in **GS EP PLR 100** Section 16.
- Technological Risk Assessment Methodology as per **GS EP SAF 041**.

If these evaluations are not performed, automatic subsea isolation valves shall be located on the hydrocarbon flowlines and pipelines connected to the FPSO.

6.2.2 Failure of Risers due to loss of FPSO station keeping

FPSO mooring lines failure and/or extremely adverse weather could cause the excursion of the FPSO from the station and could cause excessive tension in the risers with potential failure, resulting in the hydrocarbon release. Monitoring facilities shall be provided to detect these hazards.

A Clashing Analysis shall be carried out to determine the minimum separation distances required between the subsea facilities, flowlines, risers and the FPSO mooring lines. This Analysis shall take into consideration the potential extreme FPSO excursion conditions.

6.3 Prevention of hazardous occurrence

There are potential hydrocarbon jet fire and explosion threats from riser releases to the FPSO, including the Accommodation Block. As such the following protection measures shall be confirmed by risk assessments and the safety studies:

- Risers and their structural supports shall be provided with passive fire protection against collapse of the structure or any other failure: it gives higher availability and lower maintenance requirements than for other protection means (including I tube used to route the risers).
- Possible segregation and sequencing of risers according to risk potential or mechanical protection to prevent escalation.
- The routing of flowlines or pipelines under the FPSO shall only be permitted if it is demonstrated by a Risk Assessment that a hydrocarbon release from these flowlines or pipelines will not impact the station keeping of the FPSO.

6.4 Emergency Shutdown of the risers and pipelines

Two ESD valves shall be provided on each hydrocarbon riser including the gas lift risers connected to the FPSO. The inboard ESD valves can also be used as a process shutdown

valve (SDV) provided it is fitted with two solenoids to accept separate signals from the FPSO ESD system and the process control system.

Automatic closure of these two ESD valves located on each of the hydrocarbon risers shall be initiated when an Emergency Shutdown Level 1 is generated on the FPSO. In addition, automatic closure of the two ESD valves located on each of the hydrocarbon risers shall be initiated by a low (PSLL) signal generated by the pressure monitoring system of the particular hydrocarbon riser.

In the case of Subsea Isolation Valves (SSIV's) being installed on the hydrocarbon pipelines connected to the FPSO's, the following arrangements shall be provided for the operation of these SSIV's :

- An automatic shutdown of the SSIV's, if an ESD0 Shutdown is initiated on the FPSO
- Push button in the FPSO CCR to initiate the opening and the closure of SSIV
- Confirmed fire and gas detection in the riser porch (or riser balcony) alarm annunciation shall be provided in the CCR, to warn the Operator, on the need to close the SSIV for the affected pipeline /riser
- Pressure switches on the inboard side to the SSIV skid or on the riser tower shall be installed to generate a PSLL signal with 2oo3 voting arrangement, which shall initiate an automatic shutdown of the SSIV.

7. FPSO Overall Requirements

7.1 Management of Hazards

This section defines the minimum requirements for the overall FPSO safety related systems and protection arrangements which are common for the Topsides, Hull and Mooring systems of the FPSO. The formulation of these requirements is based on the following hazards management strategy:

- Prevention of hazards and their escalation by layout and passive protection
- Detection of the hazards initiating conditions by fire and gas detection
- Mitigation of the consequences of the hazards by emergency shutdown arrangements
- Protection of personnel and the FPSO from the effects of the hazards, including providing passive and active protection against potential hydrocarbon jet fires (ignited gas release), explosions and/or pool fires (ignited liquid release)
- Protection shall be provided against the non hydrocarbon fires that could occur on the FPSO, including fires inside the hull spaces, the topsides areas, in the E/I buildings and in the Accommodation Block
- Provision of Escape, Evacuation and Emergency Response arrangements

7.2 FPSO General Arrangement

7.2.1 Layout Philosophy

The FPSO general arrangement shall comply with the requirements of this General Specification by establishing a hierarchy between different areas according to the hazards they