



Exploration & Production

GENERAL SPECIFICATION

STRUCTURAL

GS EP STR 651

General principles for a F(P)SO Design

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1. Scope

The purpose of this document is to highlight the specificities of floating production facilities as opposed to traditional onshore or offshore “fixed” installations that were the basis to derive the bulk of the codes and standards used in the oil and gas industry and also Company General Specifications.

Therefore, this document describes Company interpretation of General Specifications as applicable to F(P)SOs. It can be considered as a master Specification giving the rules for applying the other GS.

Steel Hull design requirements are described in [GS EP STR 652](#).

Hull fabrication requirements are in [GS EP STR 653](#).

[GS EP STR 102](#) gives requirements for the design of offshore topside structures.

A F(P)SO is a Floating (Production) Storage and Offloading unit. This definition covers a wide variety of floaters used for the production of oil and gas offshore.

This document was written for use on ship-shaped supports. Its use for other support designs (such as SPARs, Semi-submersibles, TLP) needs careful assessment. Even its use for barges such as the Nkossa NKP barge, or a LPG or LNG storage unit needs careful review, particularly with possible requirements of the classification society with regard to the containment system.

Specific aspects of the conversion of a tanker into a F(P)SO are treated in [GS EP STR 655](#).

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.

Choice of reference documents

National regulations are not listed in this document due to their high specificity and variability.

However, where national regulations exist, their provisions and those of the standards and codes to which they refer shall apply to the works done in the State, and supplementing or amending the provisions of this document.

The global design and final operation shall comply with the site Coastal State regulations applicable to F(P)SOs.

The following reference documents are applicable. As most of the documents are not strictly applicable to F(P)SOs, deviations shall be approved by COMPANY.

Recognition of reference documents

Unless otherwise indicated in this document, all the reference documents to be used, as well as their supplements shall be the latest editions.

Standards

Reference	Title
BS 4727PT3: Group 08	Glossary of Electrotechnical, Power, Telecommunication, Electronics, Lighting and Colour Terms - Part 3: Terms Particular to Telecommunications and Electronics - Group 08: Acoustics and Electroacoustics
BS 6841	Measurement and Evaluation of Human Exposure to Whole-Body Mechanical Vibration and Repeated Shock
BS 61260	Electroacoustics - Octave-Band and Fractional-Octave-Band Filters
CAP 437	Offshore helicopter landing areas – Guidance on standards
IEC 34	Equipment noise level
IEC 60079-10	Electrical apparatus for explosive gas atmospheres - Part 10: classification of hazardous areas
IEC 60092-502	Electrical Installations in ships - Part 502: Tankers - Special features
ISO 6954	Mechanical Vibration - Guidelines for the Measurement, Reporting and Evaluation of Vibration with Regard to Habitability on Passenger and Merchant Ships
ISO 13702	Petroleum and natural gas industries. Control and mitigation of fires and explosions on offshore production installations. Requirements and guidelines
ISO 19900	Petroleum and natural gas industries - General Requirements for Offshore Structures
ISO 19901-5	Petroleum and natural gas industries - Specific requirements for offshore structures - Part 5: Weight control during engineering and construction
ISO 19901-7	Petroleum and natural gas industries - Specific requirements for offshore structures - Part 7: Stationkeeping systems for floating offshore structures and mobile offshore units
ISO 19904-1	Petroleum and natural gas industries - Floating offshore structures - Part 1: Monohulls, semisubmersibles and spars
ISO 23251	Petroleum and natural gas Industries - Pressure-Relieving and Depressurising Systems

Professional Documents

Reference	Title
API RP 14C	Recommended Practice for Analysis, Design, Installation & Testing of Basic Surface Safety Systems for Offshore Production Platforms
API RP 14J	Recommended Practice for Design and Hazards Analysis for Off-shore Production Facilities
API RP 520 PT I	Sizing, Selection, and Installation of Pressure-Relieving Devices in Refineries Part I - Sizing and Selection
API RP 520 PT II	Sizing, Selection, and Installation of Pressure-Relieving Devices in Refineries Part II - Installation
IP Code, Part 15	Area Classification Code for Petroleum Installations
ISGOTT	International Safety Guide for Oil Tankers & Terminals
TSCF	Guidance Manual for Tanker Structures 1997
TSCF	Guidelines for the inspection and maintenance of double hull tanker structures 1995

Regulations

Reference	Title
IMO MARPOL 73/78	International Convention for the Prevention of Pollution from ships
IMO Res. MEPC 139(53)	Guidelines for Application of MARPOL Annex I requirements to FPSOs and FSUs
IMO SOLAS	International Convention for the Safety of Life at Sea
IMO ICLL	International Convention on Load Lines
IMO COLREG	Convention on the International Regulations for Preventing Collisions at Sea
IMO resolutions A272(VIII) and A330(IX)	Recommendations on safe access to and working in Large Tanks
IMO resolution A343 (IX)	Recommendation on method of measuring noise levels
IMO resolution A468 (XII)	Code of Noise Levels
IMO resolution A686 (17)	Code on Alarms and Indicators
IMO resolution A749 (18)	Code on Intact stability

Codes

Reference	Title
ICAO	Annex 14, Volume II Heliports
IMO 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

Other documents

Reference	Title
OTO 320	UK HSE: Offshore Installations: Guidance on design, construction and certification

Classification Society Rules

Reference	Title
American Bureau of Shipping	Guide for Building and Classing Floating Production Installations
Bureau Veritas NR 445	Rules for the Classification of Offshore Units
Bureau Veritas NR 467	Rules for the Classification of Steel Ships
Det norske Veritas OSS 102	Rules for Classification of Floating Production and Storage Units
Det norske Veritas	Guide to conversion of tankers to oil production and/or storage vessels
Lloyd's Register of Shipping	Rules and Regulations for the Classification of a Floating Offshore Installation at a fixed location
IACS	Shipbuilding and Repair Quality Standard" (N° 47) dated 1996

Note that references to Class Society Ship Rules are implicit through the listed documents and not called independently to clearly keep priority to Offshore Rules.

Total General Specifications

Application of Total specifications is mandatory. The following list focuses on the documents dealing with the main aspects of F(P)SO design, but the complete list of documents applies.

Reference	Title
GS EP CIV 101	General earthworks
GS EP CIV 402	Design and construction of oil field laboratory on production installations
GS EP ELE 021	Electrical design criteria for Floating Units

Reference	Title
GS EP ENV 001	Environmental Requirements for Projects Design and E&P activities
GS EP ENV 500	Noise abatement in production units
GS EP EXP 311	Plant Integrity - Minimum inspection requirements
GS EP LSO 110	Environmental effects considerations for helideck
GS EP LSO 201	Towing Floating Units
GS EP LSO 202	Personnel transfer between ships to ships and offshore structure
GS EP PVV 000	General Specification catalogue
GS EP SAF 021	Lay-out
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 227	Safety Rules for fired heaters
GS EP SAF 228	Liquid drainage
GS EP SAF 253	Impacted area, restricted area and fire zones
GS EP SAF 260	Design of High Integrity Protection Systems (HIPS)
GS EP SAF 261	Emergency Shut-Down and Emergency De-Pressurisation (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 pump stations and fire water mains
GS EP SAF 322	Fixed fire water systems
GS EP SAF 332	Water mist and gaseous fixed fire extinguishing systems
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 STR 001	Weight monitoring and weighing offshore units
GS EP STR 003	Crane for floating offshore structure
GS EP STR 004	Riser/umbilical pulling rig and Mooring Winches
GS EP STR 100	Fixed offshore steel platforms - General

Reference	Title
GS EP STR 102	Design of offshore topside structure
GS EP STR 103	Design and fabrication of skids and equipment supporting structures
GS EP STR 104	Design and fabrication of technical cubicles for offshore oil installations
GS EP STR 201	Materials for offshore steel structures
GS EP STR 301	Fabrication of offshore steel structures
GS EP STR 304	Fabrication of welded plate girders (W.P.G.)
GS EP STR 401	Loadout, seafastening, transportation and installation of offshore structures
GS EP STR 601	Floating units integrity management system requirements
GS EP STR 631	CALM buoy terminals
GS EP STR 652	F(P)SO - Steel hull design requirements
GS EP STR 653	F(P)SO - Hull fabrication requirements
GS EP STR 655	Requirements for conversion of a tanker into a F(P)SO
GS EP STR 661	FPSO - Design requirements for mooring and anchoring systems
GS EP STR 901	Design rules and construction standards for ancillary structures of offshore installations

3. Definitions

- **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)

For simplicity, we use the abbreviation FPSO throughout this document to refer to a unit that has oil storage capacity and production facilities.

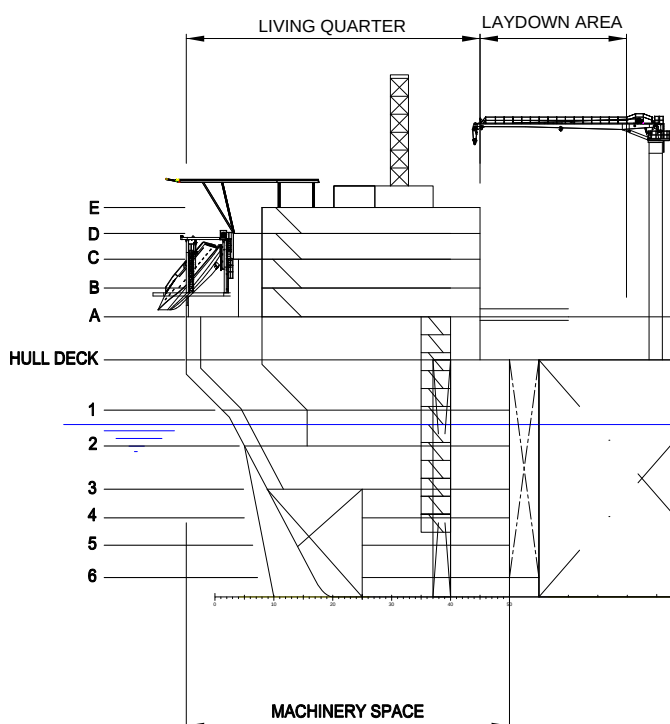
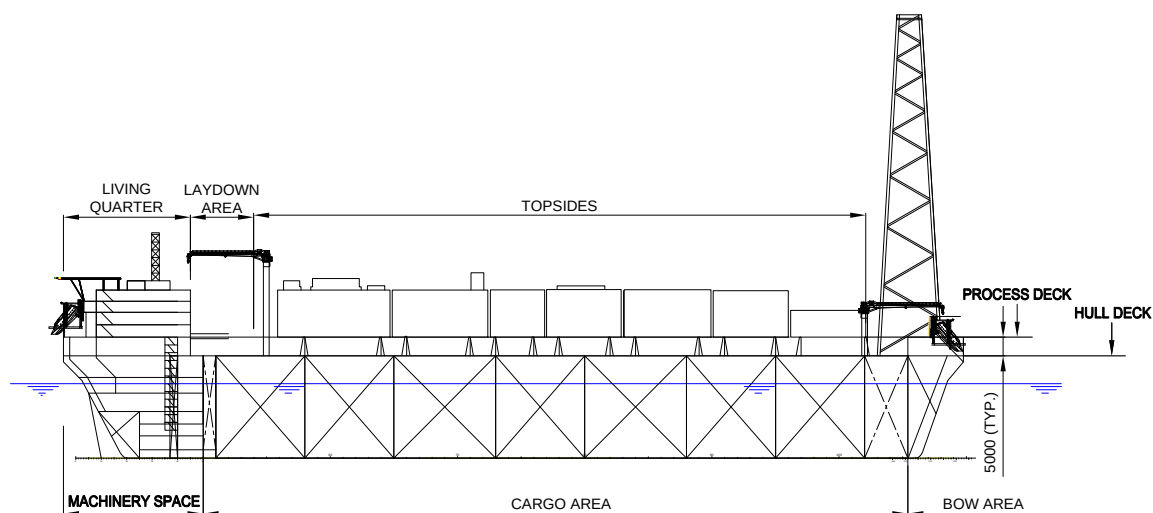
- The letter O refers mainly to the oil export and covers a variety of possibilities: tandem offloading, export to a remote loading buoy or export through a pipeline.

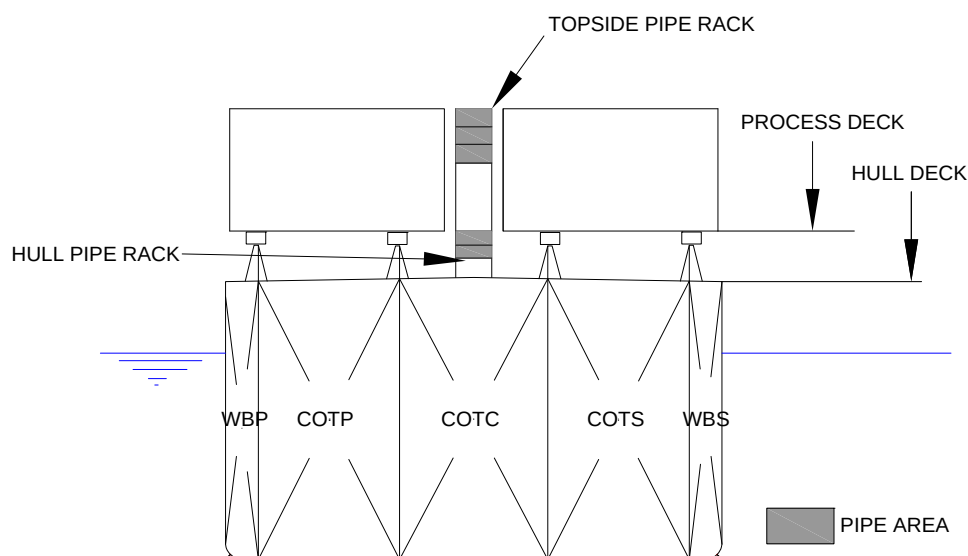
The use of brackets in F(P)SO means that requirements is valid for any type of vessel.

- **LPG**: Liquefied Petroleum Gas
- **LNG** Liquefied Natural Gas
- **Hull**: includes hull structure, marine systems, living quarters and any other equipment located inside the hull
- **Topsides**: corresponds to the facilities located above hull used for process, utilities and other related functions. FSOs do not have topsides
- **Turret**: corresponds to the structural, mooring and riser support parts of a turret.

- **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, mooring support structures, topsides stools, protectors, flare foundations...).
- **Fore** or **bow** refers to the end of hull where flare and possibly turret are located. The F(P)SO is generally towed by this end. Note that for interpretation of ship rules during towing, the end from where the FPS(O) is towed shall be treated as a bow; Moreover, for interpretation of ship rules on site, the end facing the prevailing waves shall be treated as a bow as well.
- **Bow Area** covers the hull deck area where usually towing equipment as well as tandem offloading equipment are installed.
- **Aft** or **stern** refers to the bow opposite end, where living quarter is generally located.
- **Hull deck:** refers to the uppermost continuous deck of the hull. The term of main deck, sometimes used for process deck shall not be used
- **Process deck** is the Topside lower deck
- **Process tank:** refers to hull compartment dedicated to process function such as wash tanks, settling tanks.
- **LQ: Living Quarter** includes the Hotel / Catering functions, the helideck and usually the Central Control Room. LQ level are numbered from the level corresponding to the process deck level (A deck) upwards to roof level below the helideck.
- **Lay-down Area:** The Laydown Area is an area situated in front of the LQ 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.
- **Cargo Area** is the section of the Hull where oil is stored.
- **Machinery space** is the section of the hull located under the LQ. Machinery space levels shall be numbered downwards from hull deck (No 0) to keel (No n)

The following sketches show a typical FPSO arrangement to illustrate the above definitions and numbering conventions.





4. General considerations

A F(P)SO shall be treated as a single facility with different functions. An integrated approach is required for its design, in particular for the evaluation of operational and safety aspects.

All systems such as:

- Instrument, Control and Safety System
- Safety and escape
- Fire protection and fire-fighting
- Piping
- Electrical
- Mechanical handling
- Marine operations
- Etc.

must be considered globally for the whole facility.

Similarly HAZID, assessment of accident consequences such as explosions shall be conducted for the overall facility. Particular attention shall be paid to risers, loading system (bunkering, methanol) and offloading systems.

Consideration shall also be given as far as required to facilities which may interfere with the FPSO operation and safety such as the sub-sea layout, the export tanker and any other vessel in the near vicinity (wellhead platforms or drilling rigs for example).

The F(P)SO design shall be studied for all phases that may be contemplated by the unit, from construction to decommissioning. At early phase of the project, utility balance and design principles shall be defined to determine when and how critical utility systems (water, air...) are available. Such principles shall be part of the project particular specifications.

4.1 Common design data

Part of the FPSO such as the hull or a process-package may be designed and constructed under a separate contract.

However the design shall satisfy at least Common design data specific to the site and the application.

The Common design data shall include detailed information on:

- Environmental data
- Fluid information (viscosity, temperature, etc.)
- Layout of the field-facilities (including subsea)
- Health, safety and environment protection plan
- Operating philosophy
- Typical requirements for export (nominal cargo (or parcel) size, tanker size (displacement) and frequency, etc.)
- Connections to other installations (risers, mooring-lines, etc.) with their detailed characteristics (size, loads, fluids, etc.)
- Means of Access (including type and size of supply-boat, helicopter, crew-boats)
- Emergency evacuation
- Contractual and technical interfaces (scope and battery limits)
- Main global analysis results such as motions values, level of accelerations, hull deflections
- Module or pancake deck supporting arrangement (layout and loads)
- Temporary phases in particular type of work performed and manning during tow from yard to site and start-up phases on site
- Inspection, maintenance and repair strategy
- Plan for future extension or works including decommissioning and dismantlement.

It will be based on the design principles developed in section 5.

4.2 Safety and Environment

A unique Health and Safety management system shall be established and provided.

A safety concept should be prepared and updated at all stages of the project.

It shall be based on an integrated description of the facilities dealing with all functions and resources as well as on an integrated risk analysis.

This risk analysis shall be performed and consequences integrated in the design during conceptual studies. Due consideration shall be taken to accidental scenarios, including hull damage extent and their consequences on availability (time and means required to perform repair in particular in remote areas or deep seas) and operability. They shall be confirmed during the basic design studies and early in the detailed engineering phase as required.

As needed, specific documents may be required for temporary phases.

4.3 Classification

The F(P)SOs, their station-keeping systems (mooring system, yokes, turrets, ...), the product transfer systems (side by side or tandem offloading) and the SPM (CALM buoys, etc.) shall be classed by a recognized Class Society.

For the F(P)SO, the scope of Classification shall include the following components:

- The hull and living quarters
- The utilities systems of the hull
- The safety and life saving systems
- The cargo handling systems and in particular the 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.)
- The station-keeping system.
- Hull onboard towing equipment.

The hull shall be built under the survey of the Classification Society such that the following class notations (or equivalent if Classification Society is not Bureau Veritas) are assigned when the FPSO is completed:

I ✕ HULL ✕ MACH

Offshore Service Barge – Production - Oil Storage –

Unrestricted navigation "SITE Notation"

✕ POSA ALM LSA HEL IG COW AUTO STI COMF HEALTH-NOISE1 HEALTH-VIB1

VeriSTAR HULL

The "Unrestricted Navigation" notation is required for voyage.

The detail of STI (specific thickness increment) notation shall be based on [GS EP STR 652](#) requirements for corrosion allowance.

For benign environment, tropical or sheltered area notation may be considered upon COMPANY and CLASS approval.

The FPSO shall be designed and built to comply with the latest editions of the Regulations and Guidance (at effective date of Contract) unless otherwise required by COMPANY.

The certification for the transit voyages should be limited to the minimum required by flag state. However it shall be assumed that the tow voyages will be performed with personnel on board.

The transfer systems (SPM or other types and their moorings) shall be classed separately from the F(P)SO, but if possible by the same Classification Society.

The process systems (topsides), the export lines and the flowlines and risers do not require classification in general unless required by COMPANY.

4.4 Flagging

Depending on Countries, Project Particular Specification may require a flagging policy on site.

In case of wet tow, FPSO shall be flagged as required in **GS EP LSO 201**.

4.5 Security

F(P)SOs, and the associated SPM (CALM buoys, etc.) if any, shall be considered as Port Facilities in application of the **ISPS** Code.

4.6 Interface definition

The design and the follow-up of construction of a FPSO shall include:

- Identification of interfaces (nature, type, performance and verification of this one) between different areas or functions
- Physical description (location, nature, loads, displacements, deflections)
- Split of responsibilities in the management and documentation of these.

5. Design principles

5.1 General Architecture

5.1.1 Impact of response to environment

- F(P)SOs move under the actions of the environment. This results in accelerations and inertia loading which influence the structural design and modify the behaviour of equipment.
- Similarly, the floater is submitted to static inclinations (trim and heel) due mainly to ballasting/cargo configurations but also to the mean action of environment (wind in particular). These effects are different and affect the accuracy of certain measurements, in particular liquid/gas levels in tanks and vessels. Permanent trim by the flare is recommended for the safety of the venting/draining system of the production plant. This is to avoid any liquid back-flow in those systems under FPSO motions.
- Extreme inclination by flooding of compartments is to be assessed in the stability analysis (refer to **GS EP STR 652**) and in the topsides design.

5.1.1.1 Effect of motions on process

Motions and angular displacements have significant effect on performance: Primarily refer to equipment with liquid/liquid interface such as:

- Three-phase separators
- Oil treatment units
- Water treatment units
- Trayed contact towers
- Process controls such as level indicators/controllers, etc.

Motions have less effect on Performance: Primarily refer to equipment with gas/liquid interface such as:

- Two-phase separators
- Cyclonic separation systems
- Gas scrubbers
- Surge tanks
- Packed contact towers
- Heaters.

Motions have minimal effect on performance: primarily refer to equipment with single-phase or mixed two-phase fluids such as:

- Heat exchangers
- Pumps/Prime Movers
- Compressors
- Coolers
- Manifolds.

5.1.1.2 Motions characterisation

The equipment design will include different conditions:

- Normal operation under given motion level (including production process systems continuing to operate).
- Reduced operation under higher motion conditions due to greater environmental sea states associated with short-term storms/squalls. (Maintenance of system pressure tightness and structural integrity of process deck, process equipment skids, pipe hangers/supports, electrical and instrumentation cable hanger assemblies with the process systems full of product). This may be the case in the North Sea when part of the installations is shut down due to poor efficiency of equipment under high storm conditions.
- Specific operations for certain locations or vessels, which not fully admit the environmental conditions. This may be the "Design Storm" used in the design of a permanently moored FPSO, or the environmental sea limitations for an FPSO that will disconnect for departure. (Maintenance of system pressure tightness and structural

integrity of process deck, process equipment skids, pipe hangers/supports, electrical and instrumentation cable hanger assemblies with the product flushed out of the process systems). This is the case in particular when typhoons, hurricanes or icebergs are forecast.

- Survival conditions, since the possibility of minimum damage may be accepted on process deck, process equipment skids, pipe runs and supports, electrical and instrumentation cable hanger assemblies with the product flushed from the process systems when the FPSO is subjected to elevated sea states associated with longer transit storms or after accident has happened (flooded compartment, etc.). This may include potential storms encountered during initial transit to the site or possible exposure on escape routes from the location.

While the latter three cases above are significant, the effectiveness of the FPSO design is contingent above all on operational characteristics. The FPSO motion characteristics shall therefore be investigated: under fully loaded (say 100%), ballast (say 30%) condition, or other conditions likely to be critical due to hydrodynamic characteristics.

The way to determine the motions is described in [GS EP STR 652](#).

5.1.1.3 Impact on equipment

5.1.1.3.1 Impact on process facilities

Motions affect the efficiency of the three-phase Separators and interface controls with specific design for internals (baffle, packing), appropriate technology and position of level controllers (e.g. differential pressure sensors), vessel position on the deck and vessel dimensions.

- To decrease sensitivity to motions, it is recommended that separators be installed so that internal risk of liquid surface perturbation is minimised, most of the time this is longitudinally parallel to the main hull axis and in the midship area.
- Loading operations require a quasi-static trim and heel. To allow minimum perturbation of process-control, the number and location of sensors must be considered at design, as must the averaging over time period.
- Sloshing induced by accelerations shall be controlled via the internals design.

Concerns the other vessels, with a preference for vertical ones equipped with specific internals (tranquillisers, vortex breakers).

Concerns the efficiency of wash tanks with large free surface.

Concerns the gas treatment contact towers with packing instead of trays, liquid distributors and adapted takes off for level controllers.

Concerns the oil treatment units with a greater steam space and appropriate location on the deck.

Concerns water de-oiling with a preference for hydro cyclones.

Concerns the slopes for drains and relief gas piping.

5.1.1.3.2 Impact on mechanical equipment

Concerns the suction head variations for the pumps.