



Exploration & Production

GENERAL SPECIFICATION

STRUCTURAL

GS STR 651

General principles for a F(P)SO Design

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1. Scope

Definition: 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.

For simplicity, we use the abbreviation FPSO throughout this document to refer to a unit that has oil storage capacity and production facilities. The term FSO is used to refer to a unit without an additional deck to support process or utilities equipment above the hull deck. 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 both types of vessels. This document defines the minimum requirements for the design of a F(P)SO.

This document was written for use on ship-shaped supports. Its use for other designs (SPARs, Semi-submersible) 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 into a F(P)SO of a tanker are treated in [GS STR 655](#).

2. Reference documents

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
ISO 19900	General Requirements for Offshore Structures
ISO DIS 13702	Control and mitigation of fires and explosions on open type offshore production platforms
ISO 19901-5	Weight Control during Engineering and Construction
ISO DIS 19901-7	Station-Keeping for floating offshore structures and mobile offshore units
ISO DIS 19904-1	Floating offshore structures – Part 1: monohulls, semi-submersibles and spars
CAP 437	Offshore helicopter landing areas – Guidance on standards
IEC 34	Equipment noise level
IEC 7910	Part 10: Electrical apparatus for Gas atmosphere: for Classification of hazardous areas
IEC 60092-502	Electrical Installations in ships - Part 502: Tankers - Special features
CEI 502	

The document ISO 19904-1 “Floating offshore structures – Part 1: monohulls, semi-submersibles and spars”, DIS, December 2004, being worked constitutes the main reference that will be used when available officially. Its content can be used for guidance as required.

Professional Documents

Reference	Title
ISGOTT	International Safety Guide for Oil Tankers & Terminals Rev 4 1996
Tanker Structure Co-operative Forum	Guidance Manual for Tanker Structures 1997
Tanker Structure Co-operative Forum	Guidelines for the inspection and maintenance of double hull tanker structures 1995
API RP 520	Sizing, Selection and Installation of Pressure-Relieving Devices in Refineries
API RP 521	Guide for Pressure Relieving & De-pressurising Systems
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
IP Code, Part 15	Area Classification Code for Petroleum Installations

Regulations

Reference	Title
IMO MARPOL 73/78	International Convention for the Prevention of Pollution from ships
IMO MEPC 406	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
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
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 NR455	Rules for the Classification of Offshore Units
Bureau Veritas NR 497	Hull structure of Production, Storage and Offloading Surface Units
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 all 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 CIV 101	General earthworks
GS CIV 402	Design and construction of oil field laboratory on production installations
GS CIV 404	Design and construction of offshore living quarters
GS ELE 001	Electrical design criteria
GS ENV 001	Environmental Requirements for Oil and Gas Projects Design
GS LSO 110	Environmental effects considerations for helidecks
GS PVV 000	General Specification catalogue (<i>Pressure vessels, valves</i>)
GS SAF 021	Lay-out
GS SAF 216	Area classification
GS SAF 221	Safety rules for buildings
GS SAF 222	Safety rules for machinery and equipment handling hydrocarbon in enclosed areas
GS SAF 227	Safety Rules for fired heaters
GS SAF 228	Liquid drainage
GS SAF 253	Impacted area, restricted area and fire zones

Reference	Title
GS SAF 260	Control of overpressure hazards by instrumented pressure protection systems
GS SAF 262	Safety rules for hydrocarbon disposal systems
GS SAF 261	Pressure protection and relief, emergency shutdown and depressurisation
GS SAF 263	Safety guidance for flame arrestors
GS SAF 311	Rules for the selection of fire fighting systems
GS SAF 312	Guidelines for selecting and installing fire and gas detection systems
GS SAF 321	Fire pump stations and fire water mains
GS SAF 322	Fixed fire water systems
GS SAF 332	Alternatives to Halon in fire extinguishing systems
GS SAF 334	Foam fire extinguishing systems
GS SAF 337	Passive fire protection
GS SAF 351	Escape evacuation and rescue from fixed installations
GS SAF 371	Emergency control facilities
GS STR 001	Weight monitoring and weighing offshore units
GS STR 002	Permanent lifting or handling devices for offshore installations
GS STR 100	Fixed offshore steel platforms. General
GS STR 102	Design of offshore topside structure
GS STR 103	Design and fabrication of skids and equipment supporting structures
GS STR 201	Materials for offshore steel structures
GS STR 301	Offshore topsides structure fabrication
GS STR 304	Fabrication of welded plate girders
GS STR 631	CALM buoy terminals
GS STR 401	Load-out, transportation and installation of offshore steel structures
GS STR 652	F(P)SO - Steel hull design requirements
GS STR 653	F(P)SO - Hull fabrication requirements
GS STR 655	Requirements for conversion of a tanker to a F(P)SO
GS STR 661	FPSO - Design requirements for mooring and anchoring systems
GS STR 901	Design rules and construction standards for ancillary structures of offshore installations

3. 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 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).

3.1 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 (parcel size, tanker size and frequency, etc.)
- Connections to other installations (risers, mooring-lines, etc.) with their detailed characteristics (size, loads, fluids, etc.)
- Means of Access (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 4.

3.2 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.

3.3 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 fendering systems (protection against collisions)
- The hull integrated supports of topsides
- The structure integrating the station-keeping system (turret, chain stoppers, etc.)
- The station-keeping system.

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) and the flowlines and risers do not require classification in general unless required by COMPANY.

3.4 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.

3.5 Interface definition

The design 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.

4. Design principles

4.1 General Architecture

4.1.1 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 STR 652**) and in the topsides design.

4.1.1.1 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.

4.1.1.2 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 are 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 STR 652](#) under paragraph “Hydrodynamic characteristics”.

Typically, the displacements and accelerations at the Process Deck location are compiled into tables such as Tables 1 and 2 (see Appendix 2).

4.1.1.3 Impact on equipment

4.1.1.3.1 Impact on process facilities

Concerns 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 midship.
- 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 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 hydrocyclones.

Concerns the slopes for drains and relief gas piping.

4.1.1.3.2 Impact on mechanical equipment

Concerns the suction head variations for the pumps.

Concerns the inertia forces on the bearings and the supports for the rotating machines, the lubrication tank and piping design to avoid sloshing, overflow, etc.

Concerns the general longitudinal equilibrium of shafts and thrusts.

Concerns the equipment handling equipment (trolleys and local hoists) instead of cranes. Two aspects have to be checked: potential sliding of the trolley or hoist on track (brake required) and the pendulum motion of the lifted load (may require lateral restraint).

Concerns the specification of the crane, which is required to provide lifting velocities high enough to avoid excessive balancing/swinging of the loads. Ship cranes specified for harbour conditions are not sufficient in this regard. MODU crane specifications are required. **GS STR 002** to be used. Knuckle boom cranes leading to limited length of cables are recommended for harsh environment.

4.1.1.3.3 Impact on piping

Concerns the distances between modules for piping connecting different modules. These may vary with the hull deflections and/or relative displacements of the modules, in particular at high elevations. Deflection/expansion loops may have to be considered.

Concerns the increased slope and piping diameter for drains, vent and flare systems.

The pipes used for gravity flow shall be designed with sufficient slopes to prevent backflow under certain loading configurations resulting in static tilt (list or trim). Effect of pitch and roll shall also be checked.

4.1.1.4 Effect of motions on structural design

The way to handle the effect of motions is described in **GS STR 102** for the topsides and **GS STR 652** for the hull.

4.1.2 Noise and vibration

The levels for noise and vibrations shall be verified during the design of the accommodation and machinery rooms and during commissioning of the hull and accommodation module. The existing and newly installed equipment/facilities noise levels in the accommodation, machinery areas and working areas of the vessel (due to vessel sources) should not exceed the limits defined in the **IMO A468** (XII). In addition to the above requirements noise levels in living spaces shall comply with the **GS CIV 404**.

Notes:

Noise levels in corridors should not be more than 5 dBA greater than the noise limits specified for adjoining rooms and in all cases shall not exceed 60 dBA.

The noise and vibration level study shall take into account the expected noise level and vibration sources of the topsides and cargo system. The noise and vibration measurements shall be carried out under a realistic combination of the following conditions:

- Essential diesel generators shall run at their rated power
- Central HPU unit shall run to produce the maximum hydraulic flow, at the normal operating pressure
- Mechanical ventilation and air conditioning unit shall be in normal operation
- All doors and windows shall be closed
- Sanitary flushing shall be in operation in adjacent space (if any)
- No intermittent sound from air horn, laundry machine, emergency generator, telephone speaker.

For a conversion, CONTRACTOR shall perform an existing noise and vibration analysis and at the conversion stage for newly installed equipment to confirm that noise and vibration criteria are being met. The procedure for the analysis and the results of the analysis shall be submitted to COMPANY.

For design purposes (new equipment) the following criteria shall be used:

- The noise radiated from topsides will not be more than 85dBA (reference sound pressure $2 \times 10^{-5} \text{ N/m}^2$) 1 m from the face of the accommodation
- The vibration radiated from the topsides in the region of the accommodation will be not be more than the rms accelerations associated with the limits for General Work Areas in the UK HSE Guidance Notes.

If the given criteria are not met at any location CONTRACTOR shall advise the COMPANY and recommend, if any, remedial action to meet the criteria.

Noise levels of equipment shall be according to [IEC 34](#), and shall be checked in worst-case plant operation.

4.2 Layout and Hazardous area classification

The hazardous area classification allows for selection of adequate equipment and definition of operating procedures for the corresponding zones in relation to the risks associated to presence of gas or flammable vapours in the atmosphere.

4.2.1 Area Classification

4.2.1.1 Zone ratings

A zone is a clearly defined area within which an explosive gas-air mixture is present, or may possibly be present, and consequently requires specific precautions being taken with regard to the design of installations, location and specifications of equipment, and operating procedures.

The zone rating shall be made according to:

- Local national rules where the FPSO will operate
- The Project Safety Specifications (including COMPANY rules and specifications).

It shall be consistent over the complete FPSO.

Two codes are applicable to the hazardous area classification of FSO/FPSOs:

- IP Model Code of Safe Practice Part 15 ([IP 15](#)): Area Classification for Petroleum Installations. The provisions of this code are supplemented by the COMPANY General Specification [GS SAF 216](#). The IP code applies to the definition of hazardous areas generated by topsides production equipment on FPSO/FSO units. On an FPSO with an integrated production deck, it is applicable to the whole production deck.
- International Standard [IEC 60092-502](#) Electrical Installations in ships - Part 502: Tankers - Special features. This applies to all spaces in the hull of an FPSO/FSO, including the cargo deck (Refer to Appendix 3).

4.2.1.2 Specific features

On an FPSO, the interface between the two codes lies in the space between the production deck(s) and the cargo deck or 'tweendeck. Whatever the separation between the two (grating or plating), the full volume of the 'tweendeck is considered as a semi-enclosed space, in compliance with 4.2.2.5 of [IEC 502](#), and as such a classified zone 1 with a subsequent extension of a 3.5-m zone 2 where appropriate.

If offloading pumps are located in a pump room, the 3-m radius zone 1 imposed by the pump room ventilation outlet should be extended by a 3.5-m zone 2 (instead of 1.5 m as stated in [IEC 502](#)) in order to cope with potentially significant gas releases caused by pump leaks or heavy pressure surges.

A swivel (riser rotating joint) gives rise to a 3-m zone 1 and a further 3.5-m zone 2. These values may have to be increased in specific cases such high volume of gas handling.

Conventional hose-based crude oil tandem-offloading systems generate a 3-m zone 2. However, if a quick disconnect device is installed on the FSO/FPSO, a 3-m zone 1 plus a further 3.5-m zone 2 are required in the vicinity. Consequences of operation of a break-away coupling have also to be addressed.

On an FPSO, a methanol tanker berthed alongside may create a temporary zone 1 and/or zone 2 in the offloading area depending on the location and layout of the methanol tanker, and this should be taken into account in the design.

Hazardous area layout drawings for the entire FPSO shall be part of the early documentation of the engineering, in order to define the type of equipment to be used in the different areas. The hazardous area layout drawings shall take into account the hazardous area generated by topsides, risers, export and import facilities, mooring and sub-sea equipment.

Particular attention shall be paid to equipment which may introduce local aggravation of the rating such as vents, breathers, fuel gas in machine rooms as described above.

4.2.2 Layout

The layout study shall include at least the following in addition to the already identified hazardous areas:

- Potential for simultaneous operations (SIMOPS)
- Fluid transfer between the different units and piperack location
- Power lines transfer between the different units and main cable rack location
- Control and safety lines routing and protection
- Material and equipment handling and storage (with specific attention to chemical products)
- Access to areas reserved for further extension
- Access and gangway landing with mooring points for temporary support vessels (flotel, construction vessel)
- Flare level of radiation
- Noise and vibration transmission towards accommodation
- Escape ways
- Ignition and fuel sources
- Fire-fighting equipment location and pipe routing
- Extent of passive fire protection.

4.2.2.1 Principles

- a) Accommodation spaces shall be located outside of hazardous areas and shall not be located above or below crude oil storage tanks or process areas. Furthermore, there shall be no risers carrying hazardous fluids below the accommodation area.

Accommodation area should not be located downwind the process facilities and no cargo piping shall be located below the accommodations. When this is not achieved (turret installed at the bow for example), ample distance (30 metres or more if the hazards are potentially high) between potential dangerous equipment and accommodation shall be kept.

Requirement for a structural fire/explosion protection for exterior walls of the accommodation units shall be determined according to COMPANY specifications. Blast wall protection may be required under specific cases.

- b) A hierarchy between the different areas shall be established according to the level of risk they generate. The layout shall use this hierarchy to locate "safer" units towards the accommodation.

Attention shall be paid to the conventional marine practice as described in chapter II-2 Part D of SOLAS for Tankers which shall be applied as a minimum.

- c) Process equipment should not be located directly on the hull deck but on a process deck allowing clear separation between the storage-hull and the process facilities. This process deck should be protected from waves (green water effect) either by being raised to a sufficient height or by physical protection.
- d) Laboratory location shall be determined after risk analysis. It shall be considered as a frequent source of incidents which may evolve to accidents if no proper precautions have been taken at design stage and have been completed with adequate procedures. Suitable ventilation, fire protection and access control shall be provided as per **GS CIV 402**.
- e) No engines or naked flame equipment shall be installed in zones 0 or 1.
- f) Control rooms and essential equipment (e.g. electrical generator, back-up batteries, fire pump) shall be located outside zones 0 or 1.
- g) The flare and vents shall be positioned with due regard for prevailing winds and, currents so as to prevent, as far as practicable, gas clouds or oil slicks drifting towards the process installation.

In addition flare shall be positioned to minimise the risk of ignition of a gas-cloud coming from the process installation. If an over water cantilevered solution is considered, it should be at a height sufficient to avoid collision with passing-by vessels including export tanker.

- h) Whatever the flare type, no major or safety equipment shall be located in the area affected by heat radiation under maximum design rate (including blowdown) as determined by conventional methods.
- i) The offloading and mooring points shall be positioned so as to minimise the risks of collision with the export tanker or of rupture of offloading hoses, this being checked under various environmental conditions in line with the position of the FPSO.
- j) The installation shall be protected by isolation at its limits against incoming or backflowing fluids detrimental to safety or harmful to the environment. This includes the export lines to tankers.
- k) HVAC air intakes shall be located outside hazardous areas according to **GS SAF 216** (at least 2 metres from edge of hazardous areas) and positioned with respect to prevailing winds.
- l) Location of risers shall be determined with consideration to the risks of damage due to events such as collision by external vessels (including export tanker), dropped objects, pool fire and explosion.

If the risers are supported on the external of the hull, they should preferably be located on one single side opposite to the supply boat main unloading area. Should this be not possible, a structural protection of the risers top shall be envisaged and the subsea part should not pass under the unloading area to decrease probability of damage by dropped objects.

If they are supported within a turret, specific attention shall be paid to potential damage during mooring line handling.

- m) Sea inlets or outlets (sea-chest and internal I-tubes) shall be avoided. Vertical risers (caissons) fitted with their strainer running along the side plating is the preferred option. These risers shall be protected against collision and designed for an easy maintenance.
- n) Mooring systems is to be located outside of hazardous areas unless special precaution to avoid risk of ignition during normal operation and eventual emergency release is provided.
- o) Two sides of the process area shall be kept sufficiently clear to allow the deployment and operation of external intervention means.
- p) Inspection, Maintenance and repair of hull, topsides and other systems (risers, mooring, etc.) requirements shall be addressed in the inspection plan and consequences addressed in the layout design (access, handling, etc.).
- q) General arrangement and the associated risk analysis shall be submitted to the COMPANY Representative for approval.
- r) Cargo tanks are equipped with Pressure Vacuum valves that are essential to the safety of their structure. Their locations shall be studied carefully as they have significant impact on the escape ways and the hazardous areas.

4.2.2.2 Access under topsides

Layout study shall not deal only with the horizontal distribution of equipment and area allocation. Vertical access shall also be treated through different elevations. Particular attention shall be paid to the access to areas under the topsides or packages supported by the main deck. Sufficient height (typical minimum of 3 metres) and access shall be provided for:

- Deck piping inspection and maintenance, including replacement of valves, PV breaker and similar equipment
- Handling of equipment and materials necessary for tank inspection
- Handling and removal of Cargo Pumps
- Operation, inspection and maintenance of equipment installed on the hull main deck such as fire-pumps, risers ESDV, drainage tanks, flare drums
- Inspection of hull structure and topsides supports
- Inspection and maintenance of painting and passive fire-protection in the area.

4.2.2.3 Access for personnel

- a) Docking facilities for light seacraft shall be positioned with regard to wind and sea conditions as well as operating conditions, so as to ensure a good availability.
- b) Escape means shall comprise fixed access to sea:
There shall be at least two, located in such a way that both cannot be simultaneously impracticable for the same causes (the above mentioned docking facilities shall be considered as an escape means).
- c) Access by basket lifting can also be envisaged if adequate procedures and equipment are provided. Crane lifting velocities and landing areas free of obstacles are requested for this operation.
- d) Helideck location shall permit an access facing the prevailing winds and should avoid flying over the installation or other facilities (such as export tanker) as much as possible during landing and takeoff. (See **GS LSO 100**)

4.2.3 Material Handling

a) A Material Handling plan shall be provided. It shall include:

- A description of the work and supply boats which will have access to the FPSO
- A description of the loads and volumes to be lifted from the supply boats with indication of the frequency of these lifts (day to day, frequent, exceptional)
- Identification of lifting requirements for maintenance (location, loads) of the installation
- Description of the lifting means and routes to be used
- Description of dismantling, storage and lay-down areas with loads capacities, height clearance and surface requirements
- Description of horizontal transfer of equipment to storage areas, workshops or other areas (means, routes) taking due considerations of the steady heel and trim due to ballast operations and of the roll and pitch at wave-frequency.

b) A supply boat access zone shall clearly be defined and marked. It shall be free of mooring devices and risers. Its length shall allow side approach of a supply boat. Fenders shall be provided to allow safe operations and hull protection against damage. Hull reinforcement shall be studied at design stage.

c) No cargo tank shall be directly adjacent to the supply boat access zone.

The sizing of the tanks shall be such that accidental flooding of one of the tanks adjacent to the supply boat access zone should not require drastic and urgent correction of the ballast/cargo distribution.

d) At least two cranes shall be provided for supply boats unloading.

The one with the largest capacity shall be designed to allow lifting of spare parts and equipment as required by the material handling plan, it may be used in lieu of the second for day to day operations.

The second is designed for day to day operations such as catering, chemical product or fuel lines handling.

e) A buffer storage area shall be provided close to the supply boat access zone and accessible by both cranes.

f) Handling by cranes of materials or equipment is not permitted above the main process equipment. Handling by cranes above cargo piping is not permitted unless adequate protection means against dropped object are provided. Handling by cranes is not permitted over riser areas under normal operation.

g) For maintenance lifting, preference should be given to the use of removable hoist devices on fixed beams in order to decrease lifting height and sensitivity to roll and pitch motions or permanent heel or trim. Specific attention shall be paid to equipment with difficult access such as flare tips.

h) Horizontal transfer of equipment shall provide temporary fixing devices to prevent unexpected motions due to roll and pitch or permanent heel or trim.

4.2.4 Escape routes

An escape route plan shall be established taking into account vessel motions or potential heel. This shall apply to each deck and major equipment location.

- There shall be two separate escape routes from the bow to the stern, one on each side of the vessel
- These routes shall be out of reach of waves under normal configurations such as fully loaded storage
- They shall be clearly identified
- They shall allow the use of a stretcher and permanent medical assistance
- They shall be free from obstacles, unobstructed and as such different from the storage, handling areas.

Provision shall be made for helicopter evacuation of harmed personnel (access to helideck).

The GS SAF specifications deal mainly with fixed platforms, SOLAS shall be used to cover specific aspects such as how to deal with potential heel and efficiency of evacuation means.

In addition, the GS SAF specifications have to be used with the following amendments.

4.2.4.1 GS SAF 221 § “Number of means of egress”

It is recommended that one of the escape routes from living quarter areas above the lowest open deck be installed outside the quarters in order to allow escape from any fire inside them. Consequently, except when specific constraints apply (e.g. distances to be covered, arrangements, etc.), a single escape route may suffice inside the living quarters.

4.2.4.2 GS SAF 351 § “Number and size of escape routes” and GS SAF 221 § “Protection of the means of egress”

A continuous stair with fire rating shall connect the bottom of the machinery space to the lowest open deck. The second escape route should, whenever possible, be a second stair. If this is not technically possible, an escape trunk (as defined in SOLAS reg. 45-I-2) is admissible provided its size is compatible with the number of people to evacuate.

All spaces in the cargo area such as cargo tanks, ballast tanks, cofferdams, double hull and other void spaces shall be provided with at least two exits, to be positioned as far apart as possible and with due consideration of the topsides risks. The second exit may be a temporary one, installed for the needs of inspection of the space.

Stretcher route shall be studied and documented from tank bottom to tank exit.

4.2.4.3 GS SAF 351 § “Protection of escape routes”

One main escape route shall be situated along each side of the hull deck.

4.2.4.4 GS SAF 351 § “Location of muster areas”

As fire on sea is one of the major hazards on FSO/FPSO vessels (mainly when they are spread-moored or with turret at bow and without permanent current taking away any oil slick from the cargo area), the main muster area shall be:

- Located as close as possible to the living quarters
- Enclosed to afford protection against smoke and flames
- With access points from the living quarters protected against smoke and flames.

4.2.4.5 GS SAF 351 § “Totally Enclosed Motor Propelled Survival Crafts”

As stated in the GS, a free-fall launching system is the recommended solution. The use of any other launching system shall be duly substantiated.

The POB referred in the GS for the sizing of the lifeboats is equal to the number of available beds plus maximum potential number of visitors. The base number of lifeboats is to be determined according to the SAF and SOLAS for Tankers.

In addition, if topsides layout is such that, under certain accident scenarios, some people may not be able to reach the main muster area, additional life-boats shall be installed at the opposite end of the F(P)SO with embarkation posts protected from the effects of the relevant accident scenarios. The capacity of the additional lifeboats shall be a function of the number of people, their location over the topsides area and the location of the hazardous process modules.

Lifeboats shall be installed in areas protected from any explosion effects.

Location of lifeboats shall be determined on the basis of environmental conditions such as current and swell directions.

Evacuation routes from muster area, embarkation posts and lifeboats shall be protected against fire radiation and smoke from cargo area (one cargo fire may render both starboard and port side lifeboats unreachable if not sufficiently protected).

If lifeboats are installed at a single location close to the main muster area, a smoke- and flame-tight tunnel protected against explosion effects is required to allow access from muster area to lifeboats whatever the accident scenario. In this case the launching system shall accept to be operated satisfactorily under list or trim due to normal operation or due to the accident.

4.2.4.6 GS SAF 351 § “Jumping to sea”

If the height of the hull deck exceeds 10 meters above the sea level, a fast evacuation system shall be designed to prevent falls at sea (e.g. escape socks). Whenever possible, it should allow direct access to the deck of rescue vessels.

4.2.5 Critical rooms

Location of critical rooms such as muster, crisis and control rooms must allow for all main hazards:

- Fires and explosion stemming from process (including piping to/from turret and offloading facilities)
- Fires stemming from cargo and slop tanks
- Fires at sea
- Fires stemming from machinery rooms (including pump room)
- Structural damage due to collision (off take tanker, supply vessels).

The safest location is generally in the living quarters. Consequently:

- Critical rooms have to be installed in the least hazardous part of the living quarters or in a specifically protected area.
- For converted F(P)SOs, a risk analysis must be performed to assess the use of the existing cargo control room and adjacent rooms which generally have a direct view over the deck.

If ever the critical rooms are not located in the living quarters (e.g. process control room on topsides), they must be:

- Designed in accordance with **GS SAF 221**
- Located in the least hazardous area of the vessel (in particular, not above cargo tanks, and protected from process equipment).

4.3 Drains, Vents and Environment protection

Reference shall be made to COMPANY GS ENV 001 for additional information on the subject.

Attention is drawn on the applicability of IMO MARPOL 73/78 Convention and in particular MEPC Circular No 406 "Guidelines for Application of MARPOL Annex I requirements for FPSOs and FSUs".

4.3.1 Liquid effluents

There are several types of effluents on a FPSO:

- Produced waters
- Oily waters close drain
- Drainage water, washing water, fire water
- Sewage waters
- Ballast waters
- Rain waters.

Appendix 6 of Annex I to MARPOL is reproduced hereafter.

It clearly defines the boundaries between discharges submitted to MARPOL and others.

The effluents can be disposed in three ways:

- Discharge to the natural environment
- Treatment in adapted installations
- Export to another installation by mean of a supply vessel for further treatment.

Appendix 6

Offshore platform discharges



- Oily waters coming through closed drains formed by the liquid drained from all equipment and vessels containing hydrocarbons.

These fluids are not covered by MARPOL. In the absence of specific local regulations it is a requirement of the COMPANY that produced waters be treated in a way acceptable for the environment. As such, a residual oil content of 30 mg/l without dilution is a typical value to be met under normal circumstances.

Drainage systems, comprising open and closed drains, are installed on all FPSO/FSO vessels as on all units on- and offshore.

The closed drains are used for draining off equipment and lines for maintenance operations and under routine operation (exceptionally and to be minimised).

Open drains which are classified in three categories (see **GS SAF 228**) are used for recovering leakage, drippage, washing, rain and fire deluge waters.

4.3.2.1 Design Basic Principles

There must never be any connection between the open and closed drain systems and everything practically possible must be done to prevent hydrocarbons from a classified area arriving in a non-classified area.

4.3.2.2 Closed Drains

Design of these must comply with the provisions of the General Specification in reference, and special care must be taken to ascertain that lines are sufficiently inclined under all configurations of the floating storage vessel. A continuous slope down to the closed drains receiving vessel is required.

In the case of an FPSO, the possibility of installing several closed drain drums at strategically positioned locations may be envisaged to avoid an excessively high topsides deck and improve segregation before pumping in slop tanks.

The arrangement of connecting pipework between the closed drain drums and the slop tanks shall be such as the slop tanks cannot be overpressured even in the case of leaking valves.

4.3.2.3 Open drains

Refer to **GS SAF 228** for the classification of open drains in three categories OD1, OD2 and OD3.

OD1 (permanently oil contaminated open drains) and OD2 (accidentally oil contaminated open drains) open drainage is collected in separate circuits arriving in an inerted tank which is at a very slight over pressure compared to atmospheric pressure, usually a slop tank. Upstream of the slop tank, there must be no communication between the open and closed drainage systems. A valve must be placed on the port and on the starboard open drain networks, at main deck level, to allow "oil contaminated" waste liquids to be pumped and gravity drained to one or the other of the slop tanks on the deck.

The networks are segregated on the basis of both geographical source (hazardous and non-hazardous areas) and frequency of risk of contamination by Hydrocarbons.

For F(P)SO units, there is not any real disposal tube, though the slop tanks may be considered in this instance as sump tanks. The different waters in these tanks must be pumped out and treated for compliance with discharge standards (15 ppm), before being evacuated to sea, if possible via a discharge tube.

As the sump tanks (slop tanks) are inerted or swept under slight over pressure/atmospheric pressure, a liquid seal must be installed on each open drain inlet to the sump tanks. The liquid seals must be instrumented (level glasses and low level alarm, as a minimum) and readily accessible for level checks and water top-ups. Permanent water connections must be installed for topping up with water. The height of the production deck (topsides) must be defined considering the necessary height of the liquid seals and a continuous slope of the open drains down to the slop tanks, under all configurations of the floating storage vessel. The slope must be sufficient under all configurations of the floating storage vessel to prevent liquid slugs left in the pipes from moving and siphoning the seals by piston effect. It must be defined after first determining the range of movements of the ship in operation.

If the extent of the slopes entails an excessively high deck height, the possibility of installing one or more intermediate vessels with recovery pumps starting and stopping automatically on high and low levels has to be studied.

The edges of the drip pans must be high enough to prevent overflow (at least 100 mm plus the effects of the vessel movements and possible height of the generated waves). The drip pans must slope continually down to the "gullies" and "tundishes". The diagrams shown in Appendix 5 of spec. **GS SAF 228** are applicable provided the requisite diameters and heights are altered to allow for movements of the support vessel.

For "high capacity gullies", the specification quoted above refers to an "overboard for fire water disposal". The principle of direct discharge to sea remains acceptable provided the deck is partitioned and removable plugs are provided, with the possibility of directing the liquids manually either to OD2 (contaminated waters collected via drip pans or fixed piping which are normally isolated), or directly for discharge to sea ("clean" waters). The relevant equipment must be installed such as to limit the impacts of the support vessel movements.

Attention is drawn to the possible important tilt variations during the tow, installation and commissioning phases that can impact the efficiency of the open drains system (i.e. trim by the stern is often required during the export lines connection preventing rain water drainage on deck).

4.3.2.4 Slop tanks

Slop tanks are used for collecting and storing oily waters resulting from:

- Free water removal from tanks
- Tank washing
- Process open drains (OD1 and OD2) (oil and residue).

4.3.2.4.1 Slop tanks design Parameters

Usual tanker slop operations

Characteristics of the crude oil (wax, viscosity, etc.), as these influence tank washing frequency and the volume of water to be handled.

Crude oil process system and operation procedures, as these may require collection of oily waters, non-commercial oils, various oily residues, etc.

Other requirements such as needs for temporary storage of flushing fluids from process equipment and flow lines must also be expressed early on as they may have significant impact on total slop volume.

4.3.2.4.2 Calculation methods

Slop tank capacity for tanks operations must be at least in accordance with MARPOL.

In principle, for tankers converted to FSOs, the slop tank volume and layout should be kept unchanged. For conversion to an FPSO, it is important to reassess the volume of processed oily waters, as this may influence slop tank capacity.

For an FPSO, when fluids from process residues or flushing are planned to be collected, the slop tank capacity should be increased accordingly.

However, on a converted vessel, it is possible to provide for process/flushing volumes exceeding the available slop tank capacity to be stored in a cargo tank in emergency. In this case, the total cargo volume must be increased to beyond the strict minimum value.

4.3.2.4.3 Recommendations for design

Two equally sized hull slop tanks must be provided.

They must be arranged to allow two-stage decantation.

Normal operation should be based on one clean and one dirty tank, with water decanting from one to the other. A decantation piping and valve system must be installed, connecting the two slop tanks (through a cross-over and gravity controlled flow). The water decantation line must be operated by two remotely operated hydraulic valves so as to provide flow from the bottom of the dirty slop tank to one third of the height of the clean slop tank.

Clean waters must undergo further treatment by two (redundancy) oil/water separators yielding a 15-ppm maximum hydrocarbon content.

A clean water discharge pump and dedicated clean water line for the clean slop tank must be provided to transfer clean water overboard via the Oil Discharge and Monitoring Equipment (ODME).

The slop tanks (sump tanks) must be arranged to receive fluids from various drainage systems. Upstream of the slop tanks, no communication is permitted between open and closed drain systems. There must be a deck surface valve port and starboard to allow both pumping and gravity draining of deck oil spills to either slop tank via a drop line and seal.

Slop tank must be designed according cargo tank design rules to limit effect of sloshing and free surface.

Slop tanks must be fitted with a biocide treatment facility.

Slops tanks are generally to be heated. In that case, design shall take into account the possible rupture of one heating coil and the release of hot water or steam which will cause high pressure and/or high degassing of the effluent in the tank (high rate relief devices).

Slop tanks must be inerted or swept at a lower pressure than for the other cargo tanks (20 mbar inert gas) to avoid the necessity of installing too high a hydraulic liquid seal in the open drains system to prevent any gas return in the drip pans. However structural design pressure of the slop tanks will be the same as the one of other tanks.

Special attention should be paid to corrosion protection system in the slop tanks due to the corrosive environment (presence of heated sea water).

In the case of a conversion, due attention must be paid to the possible trim of the F(P)SO, compared to the trim of the tanker when verifying the slop tank pump characteristics.

4.3.3 Sewage water

4.3.3.1 Purpose

Sewage waters are waters from accommodations and other quarters including kitchen, laundry and sanitary. The provisions of Annex 4 of MARPOL shall apply.

4.3.3.2 Principles

Sewage of accommodation unit requires a treatment plant.

It is accepted that sewage is treated in a simplified way in other locations with no frequent manning such as control rooms in the process area where permanent manning is not required. However should this simplified solution be retained it would have to comply with the intent of the regulations and satisfy to health criteria.

Sewage piping shall not be connected to drain production systems provided for dangerous liquids.

4.3.4 Ballast water

These include water from:

- Clean ballast which is the ballast contained in a tank cleaned since oil was last carried
- Segregated ballast.

Annex I of MARPOL shall apply.

As far as oil-discharge is concerned, Reg 9 § 4 shall apply (namely oil content of 15 ppm without dilution). Reg 21 has also to be considered.

The following requirements shall apply:

- Ballast water shall not be put in cargo tanks under normal circumstances
- Segregated ballast tanks shall be provided.

4.3.5 Rain waters/Deck washing water

The facilities shall be designed to avoid to a maximum extent rain water pollution, under these conditions, non contaminated waters either gathered in drains or not may be disposed directly into the environment.

4.3.5.1 Principles

Keeping the rain waters clean is an objective both of initial design, construction and operational procedure.

The design of the facilities shall minimise the possibilities of contaminating large areas during operations and maintenance by limiting the extent of sensible zones and collecting contaminated liquids in drains. Where this does not introduce major hindrance to material handling, natural ventilation or safety, the use of roofs over sensible pieces of equipment can prevent pollution of rain waters.



4.3.6 Environment protection

4.3.6.1 Emission of gases

4.3.6.1.1 Purpose

Emission of gases that can have an impact on the environment shall be identified and controlled as far as reasonably practical. This concerns in particular gases from flare, venting of the tanks, power generation/turbine emissions, etc.

4.3.6.1.2 Principles

The global reduction of gas emission should be introduced as an objective when designing gas-consumers such as inert gas system and gas driven generators such as power generation unit. However this shall not decrease the installation level of safety or availability.

Annex VI of MARPOL shall apply.

The quality of burnt gases shall be a criterion of selection for flare tips.

4.3.6.2 Garbage

The facilities require temporary products and materials for production.

All products materials used for the maintenance or production of the facilities will be collected and treated to avoid impact on environment.

The provisions of Annex V of **MARPOL 73/78** including 94/95 amendments shall apply with the qualification "outside special areas".

This does not concern the hydrocarbon process systems. However garbage coming from the process systems shall be treated in a similar way where this is possible.

4.3.6.2.1 Principles

An estimate of the different types and likely quantities of garbage generated by the different areas (including the process area) of the FPSO shall be made.

Segregation of garbage coming from hazardous areas shall be assumed.

Plans for garbage handling shall be made, considering the following possibilities:

- Temporary storage and transfer to shore (partial treatment such as compacting may be envisaged)
- Local treatment and elimination by incineration
- Direct overboard (with or without treatment).

This latest possibility shall not be used under normal conditions but for very specific products such as grey waters.

Storage and handling requirements should be deduced from this estimate and used when designing the layout.

4.3.6.3 Oil spill prevention and response

4.3.6.3.1 Purpose

The management of the incidents and accidents will be handled through the area pollution contingency plan.

The FPSO will be the prime support for a first intervention and will be equipped with limited contingency equipment.

4.3.6.3.2 Oil spill prevention

An inventory of the potential source of oil release under normal and exceptional circumstances has to be made.

This should in particular address:

- Leakage of sub-sea facilities from Christmas trees to risers tops
- Leakage at sub-sea wells risers top
- Leakage at the export loading line
- Leakage at the filling station from supply boat
- Leakage from the process area due to equipment or piping mis-operation or damage.

This inventory should be used to determine the pro-active measures such as mechanical protection means of risers, control of valves and pumps on export lines, oil containment on the main deck, etc.

This inventory shall be conducted having in mind the associated safety aspects and in particular the ignition risks.

4.3.6.3.3 Oil spill response

Storage area for dispersants and oil spill containment boom shall be provided on board. Lifting equipment on board shall allow their transfer to and from an external mean which will perform the deployment and restorage.

4.4 Oil storage

4.4.1 Purpose

The FPSO has a storage capacity to store the produced fluids between the offloading operations to export tankers.

4.4.2 Principle

The overall storage capacity should be based on the following information:

- Expected oil-plateau production rate (and not plant processing capacity which may be higher)
- Oil characteristics (maximum density, minimum and maximum temperature, content and corrosiveness, etc.)
- Size of the export parcel as required by the COMPANY (depends of the trade assumptions and in particular whether the export is done by shuttle tankers or by tanker of opportunity)

- Expected filling of the tanks (not more than 98%)
- Expected oil thermal expansion between tank storage temperature and oil export reference temperature (15°C)
- Oil remaining in the tanks and which cannot be pumped at the nominal rate
- Requirement to handle separately different fluids (separate capacities to be specified)
- Requirement for settling tanks.

The storage capacity is divided in tanks, the definition of which shall take into account:

- Production requirements (number of different fluids, requirement to store off-spec products in separate tanks, quality of the fluid and minimum temperature to be kept)
- Required time to empty or fill
- Stability requirements in normal and abnormal conditions
- Ballasting philosophy
- In addition due attention should be paid to the tank inspection and maintenance.

The storage tanks shall accommodate equipment for:

- Crude Oil Washing according to SOLAS for Tankers
- Maintaining a permanent inert gas mattress above the stored oil

The Inert Gas system shall be designed to allow for simultaneous oil production, oil storage, oil offloading, tank venting, tank gas freeing and purging for Inspection and maintenance activities

The cargo system definition should consider the following:

- Consequences of tank overfilling
- Requirement to allow simultaneously load oil from the process and discharge to the export tanker
- After processing, the stabilised oil is sent to the cargo tanks through specific drop lines
- A by-pass should allow the shipment of production without passing through the storage
- Each dropline fitting with a fail safe closed shutdown valve close to the tank penetration
- Requirement to empty any tank any sequence during offloading
- Requirement to transfer oil from one tank to any other
- Requirement for always filling simultaneously several tanks
- Requirement for production flow control on each tank being filled
- Requirement to work in or inspect any emptied tank (refer to [GS STR 652](#)).

The cargo pumps capacity and number shall be determined according to the following:

- Expected loading duration (typically 24 hours)
- Sparing philosophy.

In case of submerged pumps, attention should be paid to the arrangement of the bottom structure in way of the pump suction to improve the water stripping (at the beginning of the

offloading operations) and reduce the volume of unpumpables (at the end of the operation). Deep well could be considered.

4.5 Other liquid storages

Particular attention shall be paid to methanol storage and to the filling operations, including possible heating of methanol tanks by surrounding cargo tanks or piping. The need for cofferdam shall be addressed.

4.6 Piping

On FPSO, because of the trim toward the flare, all pumps should be located at the flare end of the tanks.

On F(P)SO the pumps location shall be such that it allows simultaneous stripping of any combination of tanks for a reasonable set of trim and heel angles.

4.6.1 Piping classes

Piping and fittings requirements for materials, welding, testing shall be carefully assessed. Class III as defined in the Ship Rules of Classification Societies are not representing the level of quality required by COMPANY for cargo piping. Class I should be used.

4.6.2 Piping Interconnections

For new built units, the process systems design code shall be applied to all piping systems. For new systems in existing units (in particular turret and riser systems) a single piping "offshore" system shall be used.

For converted units, where cargo hull systems and process systems are interconnected, a piping design code demarcation point is to be clearly designated. It shall be for example at a 3 m height above the hull deck. Above this point piping system design code is the design code used for production systems; below this point the Classifications Rules shall apply.

4.7 Tandem offloading

Design of the tandem offloading systems shall deal with the definition of mooring by hawser and export by flexible lines, the marine operations for berthing, loading and leaving the site under normal or abnormal conditions.

Risk analysis shall be used to confirm the design and procedures which shall be approved by COMPANY, and determine the need for specific structural protection, and marine means (tugs, etc.).

Minimum starting point for the definition of equipment can be the **GS STR 631** on CALM buoys.

4.8 Flare and vent systems

Design must comply with the General Specifications listed above and special care taken with line slopes and sizing of the flare/cold vent drum(s) which must allow for the movements of the FPSO/FSO. The flare/cold vent and vents system lines must be "self draining" in all position of the FPSO/FSO to avoid accumulations of liquid in low points and parts of the lines.

4.8.1 Flare and Cold vent

The flare/cold vent drum (s) must allow for the movements of the support vessel such as to ensure efficient separation of effluents at all times. This is to avoid the possibility of liquid carry

over through the tip of the flare/cold vent ignited (in the case of the flare) or non-ignited (case of the cold vent). The drums must be positioned such as to minimise the effects of the support vessel's movements.

Flare design must consider non-sequenced emergency decompression of the topsides.

The radiation study shall deal with the safety of the personnel on board in particular in blowdown situations. It shall also check the potential damage of equipment and in particular instruments, and as necessary require local or global protection means such as radiation shields. Also the potential interference of flare (radiation, liquid droplets, etc) with tandem moored export tanker / methanol tanker should be considered.

Design and installation of the "flare" structure on an FPSO must allow for the extreme environmental conditions defined for the Operating site and the transit conditions of the unit from the construction site to the Operating site and for the inspection, maintenance, repair and removal of flare tips.

In anticipation of possible underestimation of radiation at Project phase, welded supports must be systematically provided on the deck and on the topsides support structures to accommodate installation of heat shielding plates when necessary.

4.8.2 Vents

For vents on the topsides, a floating support vessel is no different from a fixed platform, and the same rules indicated in **GS SAF 262** apply.

For the tanks, the venting lines, which discharge a mixture of inert gas and hydrocarbons in varying proportions, are connected to a main vent with a high design rate, higher than those laid down for the topsides in **GS SAF 262**. This discharge rate must consider extreme operating conditions (high tanks filling rate, gas slugs in the process installations discharging substantial amounts of un-stabilised oil to the tanks, failure of heating pipe in slop tanks, tank washing with hot crude oil, etc.). It is effectively important to consider that:

- Admissible overpressure or under-pressure in the tanks when they are filled or offloaded is low
- An explosive mixture may form if there is air ingress in the tanks.

The main vent must be designed for dispersion under the most adverse weather and process conditions, in particular with a low heavy gas rate, and for radiation for a maximum gas flow rate.

Dispersion will be improved by a high-speed ejection system preventing any heavy gas covering the deck. Alternate solution is to recycle the vent gas into the process system in order to reduce gas emissions and avoid heavy gas on deck in case of low wind conditions. In this case, the Inert Gas mattress in the tank can be replaced by an Hydrocarbon mattress.

In the case of an FPSO, the P/V valve discharge must be positioned (1 per tank, mounted directly without isolation valve) such that dispersion, radiation, toxicity or oxygen content reduction during high degassing do not generate any problems for operations on the deck or topsides (FPSO) or for approach and mooring of service boats on the storage vessel.

Tanks vent openings shall be positioned according to FPSO normal trim so as to ensure their continuous contact with the inert gas mattress. Otherwise this can limit the actually available tank capacity. In case the FPSO trim is by the bow (draft at the bow larger than at the aft), tank vents should be located at the aft of the tanks.

For FSO units, the risk assessment of ignition of the P/V valve vents will determine whether these components must be calculated in consideration of radiation. If the gas is toxic (H₂S components for instance) these vents have to be calculated in consideration of dispersion to fix the most required height and tip location.

4.9 Living Quarter

The F(P)SO is the base for the personnel operating the installations. The so-called living quarters include generally the accommodation, the control stations, offices and some technical rooms. It includes also access to the helideck and temporary refuge.

F(P)SO units are to be considered as offshore platforms.

Living quarters and control rooms shall be in accordance with the requirements of COMPANY **GS CIV 404**. For converted F(P)SOs, existing systems not intended for renewal or modification must be in accordance with the SOLAS requirements.

4.9.1.1 Explosion

This hazard is not covered by SOLAS or MODU code and thus has to be specified through a specific study.

- Design for external explosions must comply with **GS SAF 221** and **GS SAF 253**. In general, blast walls are not required on FSOs
- Critical rooms such as muster and control rooms must be located preferably far from the wall facing cargo to avoid direct damage by external explosion.

4.10 Structural

4.10.1 Hull

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

I 3/3 (-) ✕ Offshore Service Barge – Production and Oil Storage “SITE Notation” Deep Sea
POSA ALM LSA HEL IG COW AUTO MACH COMF 2H

The “Deep Sea” notation is required for voyage.

For benign environment (sheltered water notation) may be considered upon COMPANY 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 agreed by COMPANY.

The certification for the transit voyages will be limited to a minimum. However it is assumed that the tow voyages will be performed with a partial complement of personnel on board.

- **GS STR 652** shall be applied
- Collision hazards must be assessed. They are mainly induced by the off take tankers in tandem and ship to ship offloading configurations and by supply vessels in the vicinity of the cranes. It is recommended to install hull protections and to avoid the location of critical rooms in parts of the hull which may be damaged
- Green water hazards are covered by SOLAS.

4.10.2 Topsides

GS STR 102 shall be applied with the additional following provisions:

- Standard practice is to build topsides as modules or pancakes located above hull deck and supported on supports points
- These support points shall match to primary members of the tanker deck structure, which are usually regularly spaced.

The deck load normally allowable on tankers is low. Support points should therefore be properly located on primary members and, as far as possible, at positions where their loading effect does not burden the primary loading.

Due consideration is to be given to:

- Static & dynamic (motion) loads including module weight variability
- Functional loads from process equipment & piping
- Vibration Excitation from process equipment
- Hull deflection and longitudinal stress distribution (static & dynamic)
- Hull transverse distortion (shear deflection, torsion)
- Accidental loads (dropped objects, blast and fire, etc.).

4.11 Materials

Asbestos and polychlorinatedbiphenyls (PCBs) shall not to be used in the vessel or its equipment.

Detailed requirements for materials are included in the appropriate specifications

4.12 Control and Safety

4.12.1 Load Master

An on-line load-master approved by the Classification Society shall be installed. It shall provide alarms. It shall allow performing loading simulations. It shall be coherent with the tank operation manual.

4.12.2 Signalisation

FPSO must comply with local and international regulations (offshore units) including IMO COLREG and IALA.

5. Documentation requirements

The documentation shall include design and fabrication reports, certificates as listed below:

5.1 Design documentation

The following subjects shall be addressed as a minimum:

- Site information (environmental data, geotechnics, survey data)
- General lay out

- Safety concept
- Area classification and escape ways
- Hydrocarbon production and processing systems
- Machinery and process systems
- Electrical installations
- Instrumentation and control systems
- Telecommunication systems
- Fire protection and personnel safety including evacuation plan
- Storage and export systems including relation between hull strength and loading plans (load-master)
- Naval architecture
- Mooring and anchoring systems
- Structure
- Piping systems
- Venting, inerting and flare
- Vibration and noise control
- Personal transfer including helideck
- Material handling plan
- Material selection and corrosion protection
- Fabrication plan
- Temporary phasis (launching, quay side, towing, etc.)
- Operating manual
- Inspection, maintenance and repair
- Interfaces specifications with others contracts (same specification will be part of each contract involved).

5.1.1 Content

For each subject the following points shall be addressed:

- Hypothesis summarising the specific and general data
- Design basis describing the methods, codes used for the design
- Design report including calculation notes, drawings, materials and fabrication requirements. This document shall address the on-site operational phases and the main construction and installation phases
- Materials, equipment and fabrication specification

- Fabrication reports
 - Equipment data
 - VENDOR drawings
 - Operating and maintenance manuals
 - MANUFACTURER's parts list with recommended spares noted
 - Commissioning and test reports
 - Material Information
 - Mill certificates or material reports
 - Fabrication records
 - Dimensional tolerance reports
 - Welding WPS's & PQR's.
- Operation guidelines
- Inspection, maintenance and repair manuals.

5.1.2 Format and support

Project specific needs and the future use to be made of Documentation shall dictate the type of document format (native file, PDF file or scanned document) and support (electronic or hard copy) to be retained.

At the time of the documentation format/support definition, issues to be considered include :

- Whether the documentation is/will be maintained or kept frozen
- How often the documentation will be accessed and updated
- How long the documentation is going to be retained for
- What are the legal requirements
- What will be the practicality of access and the number of parties having access
- Confidentiality and security.

Electronic files compilation on CD-ROM for hand over purpose shall always comprise a master index organised as per a tree structure which allows quick access to any document. General content of the CD-ROM shall be indicated on either the back cover or on the leaflet.

5.1.3 Measurement unit and Language

Metric system shall be adopted for design and construction of hull, machinery and equipment unless otherwise specified in the specifications.

All documents and drawings for design and construction of the Vessel, which are to be submitted to the COMPANY, shall be prepared in the Project specified language or English language.

Nameplates appliance instruction, identification plates and safety plan to be written in the Project specified language and English.

5.2 Quality plan

Schedule for quality check and delivery to COMPANY shall be described.

The following different aspects of checking a document shall be addressed as a minimum:

- Required qualification of personal
- Discipline, multidiscipline check, interface check, HSE plan compliance
- Plan for independent verification if any (internal or external).

5.3 Construction documentation

5.3.1 As built

The CONTRACTOR is to provide at the time of delivery of the vessel a number of complete sets of as built plans that accurately reflect the vessel construction, its equipment and systems.

In addition positioned in the vessel accommodation area a copy of the General Arrangement, Capacity Plan and Safety Plan are to be displayed.

CONTRACTOR shall provide all information related to the traceability of materials

A final weight report shall be established which shall include volumes, weights, centre of gravity and buoyancy, wind screens size and location.

A complete hydrodynamic and a complete detailed structural model shall also be provided as per **GS STR 652**. This model will include the structure and hull studies (scantling and stress, fatigue studies highlighting the critical areas) including bi- and tri- dimensional FE models performed by BV or DnV.

Updated trim and stability manual is also to be provided.

Clear description of marine systems capacities (mooring pads, fairleads, etc.).

5.3.2 Operation manuals

The CONTRACTOR is to provide copies of operational manuals comprising machinery equipment and systems, which is to contain all normal and emergency operating procedures for the vessel. The format and content to be submitted to and approved by the COMPANY before preparation commences. Drafts of the manuals are to be submitted to the COMPANY for approval before delivery of the vessel.

The CONTRACTOR is also to prepare sets of data booklets of equipment's containing names and addresses of MANUFACTURERS complete with references to enable maintenance of instruction books and/or spare parts lists.

5.3.3 Inspection and maintenance manuals

The CONTRACTOR is to provide copies of inspection and maintenance plans and manuals comprising hull, machinery equipment and systems. The format and content to be submitted to and approved by the COMPANY before preparation commences. Drafts of the manuals are to be submitted to the COMPANY for approval before delivery of the vessel.

5.4 Required certificates at delivery

- Certificate of Class (as relevant)
- Cargo Ship Safety Equipment Certificate

- Cargo Ship Safety Construction Certificate
- Cargo Ship Safety Radio Telegraphy Certificate including GMDSS (updated)
- International Loadline Certificate (new)
- International Oil Pollution Prevention Certificate (as relevant or statement of equivalence)
- Tank Sounding Certificate and Capacity Certificate (from a sworn authority)
- Certificates for lifting equipment/cranes (from Class) (old equipment kept and new equipment)
- Documentation required by COMPANY to obtain Certificate of Registry (if relevant)
- Other certificates as may be required by Coastal State Authorities
- International Tonnage Certificate (revised)
- Derating Exemption Certificate issued by the Government of the country in which the FPSO is built (if relevant)
- A register of appliances, hooks, lifting lugs, chains and wires for lifting and handling purposes, with complete with test certificates, issued by the CONTRACTOR
- A register of appliances, hooks, mooring bitts, stoppers, lifting lugs, chains and wires for marine operation purposes, with complete with test certificates, issued by the CONTRACTOR
- Inert Gas System Report (statement of fact) issued by the Classification Society
- Crude Oil Washing System Report (statement of fact), issued by the Classification Society
- Shipboard Safety Management Certificate
- Hawsers, flexibles and ancillary equipment certificates of compliance to OCIMF
- The usual minor certificates for materials, components and equipment issued by the Classification Society and CONTRACTOR and his VENDORS.

In addition to the certificates listed above, CONTRACTOR shall deliver a “Letter of Compliance” or Certificate issued by the Classification Society confirming application of each of the following industry Guidelines and Standards:

- IALA, “Recommendations for Marking of Offshore Structures”
- **IMO resolution A749** (18) on Intact stability criteria.

Certificates, test data, plans and manuals shall be formally handed over and checked off before delivery of the vessel.

Additional temporary certificates may be required for towing between the yard and the site.

6. Delivery

This § deals with the delivery ex yard and does not cover the towing to the site, the installation phasis and further operations which are treated elsewhere.

6.1 Preservation

Equipment to be preserved by the CONTRACTOR during storage, dock stage, outfitting stage and towing stage in accordance with recommendations and/or instructions of the MANUFACTURER's.

Such recommendations and/or instructions to be provided to the COMPANY to allow preparation of a preservation manual.

6.2 Inspection, Test and Trial

The inspection, test and trial during construction of the Vessel is to be performed by the CONTRACTOR and/or the MANUFACTURER at the MANUFACTURERS works or onboard in accordance with the requirements of the Classification Society and/or the Regulatory Bodies concerned to demonstrate satisfactory workmanship, suitability for the purpose intended and compliance with the Specifications in the presence of the surveyor of the Regulatory Bodies as far as they are concerned and in the presence of the COMPANY's representative who is to be informed by the CONTRACTOR to attend the inspection, test or trial.

The list of inspection and test items is to be submitted to the COMPANY in advance and their schedule within the construction phase of the Vessel to be informed to the COMPANY.

The results of these inspections, tests and trials shall be submitted to the COMPANY.

6.3 Plans for approval

6.3.1 Plans for approval

Copies of technical documentation produced by the CONTRACTOR and major equipment MANUFACTURERS are to be submitted to the COMPANY for approval during the contract. The list of documentation the CONTRACTOR intends providing is to be submitted with its tender. An outline programme for the submissions is also to be provided at the tender stage.

The CONTRACTOR and the COMPANY to agree a procedure for weight control. The report is to be updated and regularly submitted by the CONTRACTOR to the COMPANY during the vessel construction.

A copy of technical correspondence between the CONTRACTOR and the Classification Society regarding approval of plans and documents is to be provided to the COMPANY for reference.

The schedule of technical meetings between the CONTRACTOR and the Classification Society regarding plan approval is to be provided to the COMPANY and the COMPANY may attend these meetings.

6.4 CONTRACTOR Other Items

The following items except those described elsewhere in the specification are to be supplied by the COMPANY and shall be delivered to the CONTRACTOR on the COMPANY's account to meet the CONTRACTOR construction schedule.

The CONTRACTOR shall be responsible for storing and handling of the COMPANY's supply items after delivery to the CONTRACTOR and shall install and/or store those items in the Vessel.

- Bedding and Linen (blankets, sheets, covers pillows, etc.) except mattresses
- Napery (serviettes, table clothes, etc.)

- Cooks and stewards utensils (crockery, cutlery, silverware, earthenware, glasses, pots, pans, etc.)
- Chandlery
- Charts, nautical and radio station books and flags
- Medicines, medical and surgical instruments
- Bosun's and carpenters inventory
- Decorative pictures and paintings
- Consumable stores
- Operating and lubricating oils, grease, hydraulic oil, diesel oil and water except consumed quantities before delivery
- Test kits for diesel oil and lubricating oil
- Offloading hoses, steel wires, mooring ropes other than those mentioned in the specification
- Telecom equipment (if applicable).

All loose items supplied and stowed by the CONTRACTOR to be properly stored and seafastened for towing the Vessel.

6.5 Preparation for Towing

CONTRACTOR shall provide procedure, gearing equipment, sea-fastening, ballasting, installation of equipment, providing documentation for towing gear on the hull, weather forecast, etc. for COMPANY approval.

The CONTRACTOR shall assist the COMPANY in obtaining Classification Society approval to commence the tow.

In addition to one ARGOS beacon with associated regular route reporting, a "blue box" (OCTANS equipment or similar) shall be provided during the towing to monitor/record the motions, accelerations and headings. Not later than three months after the transportation, CONTRACTOR shall provide the results for some specific or severe events to be selected with COMPANY in order to evaluate the actual behaviour and motions of the F(P)SO. The full set of the records and analysis shall be provided to COMPANY.

6.6 Hull monitoring

Associated with the recording and monitoring system of the environmental conditions (wave, current, wind, etc.) CONTRACTOR shall provide a hull monitoring system to monitor/record on site the actual hull motions, accelerations, offsets, deformations and stresses with some local strain gauges, mooring lines tension, etc.

Appendix 1 Glossary

Displacement

The fully loaded displacement is the sum of lightweight and deadweight as acceptable on-site. In particular it includes mooring and riser loads.

Other “temporary” displacements for temporary conditions and different locations can also be defined.

Lightweight

The lightweight includes: the mass of the FPSO hull, accommodation block and dry topsides (i.e. excluding operating fluids), complete and fully equipped including fittings for mooring and risers. This value is also called “final lightweight” or “operating lightweight”.

Definitions of “Temporary” lightweight can also be given to suit the different contractual phases. For example an “ex-yard” lightweight may not include topsides.

Deadweight

The deadweight includes the mass of crew, passengers, effects, stores, tank contents and topsides operating fluids on board, plus the mean static loads of the moorings and risers (with operating contents and at mean tide). Provisions for future growth shall also be included.

Tank content to be assumed as follows:

- Cargo tanks at 98% full with crude oil at a representative specific gravity (by default 0.90)
- Slop tanks at 98% full with sea water
- Methanol tanks at 98% full at specific gravity 0.80
- Chemical tanks at 98% full at specific gravity 1.00
- Fresh water tanks at 100% full
- Diesel Oil tanks at 90% full
- Miscellaneous tanks at 100% full
- Water ballast at required level to maintain required trim.

Reference to a 50% of slop content for deadweight definition should be avoided.

“Temporary” deadweight can also be defined to suit contractual phases. When a yard delivers a hull without the topsides (and mooring and risers loads), an “ex-yard” deadweight can be defined.

Payload

This wording should not be used unless a clear definition is given.

Appendix 2 Maximum operating design condition

Table 1: Maximum operating design conditions

For Condition after Installation at the Operating Site

Condition	Maximum Single Amplitude Displacement						Maximum Combined Linear Acceleration		
	Metre			Degree			m/s ²		
	Surge	Sway	Heave	Roll	Pitch	Yaw	Long.	Trans.	Vert.
Normal operation									
Reduced operation									
Survival									

The range of periods to which these values are associated shall be specified.

Table 2: Maximum operating design conditions

For Conditions during Transit to the Operating Site

Condition	Max. Single Amplitude Displacements						Max. Combined Linear Accelerations		
	(Metre)			(Degrees)			(m/sec ²)		
	Surge	Sway	Heave	Roll	Pitch	Yaw	Long.	Trans.	Vert.
Operating	~	~	~	~	~	~	~	~	~
Survival	~	~	~	~	~	~	~	~	~

The range of periods to which these values are associated shall be specified.

Appendix 3 Hazardous Areas

ZONE 0

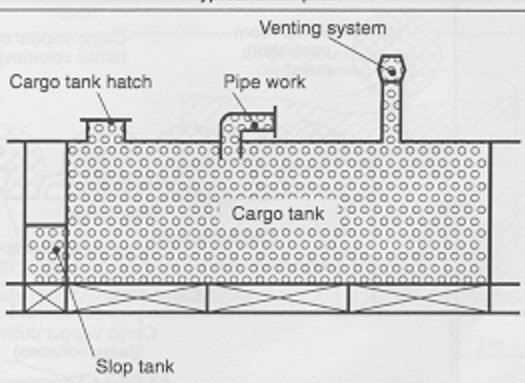
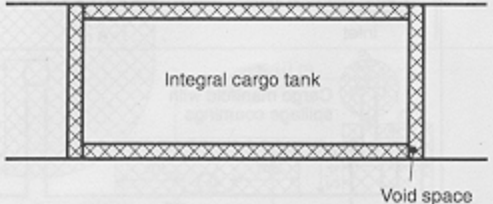
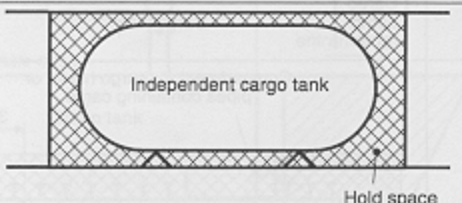
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Annex B (informative)

**Examples of hazardous area classification –
Tankers carrying flammable liquids other than liquefied gases
having a flashpoint not exceeding 60 °C, for example,
crude oil, oil products, chemical products**

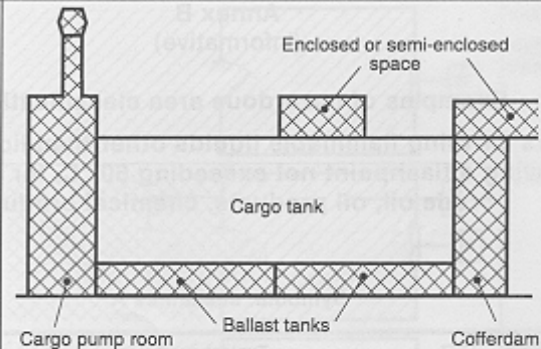
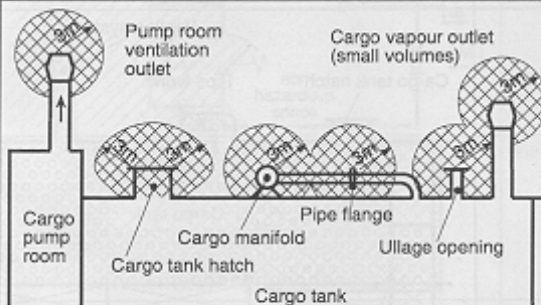
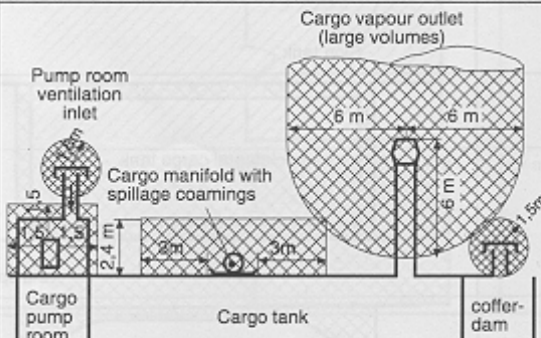
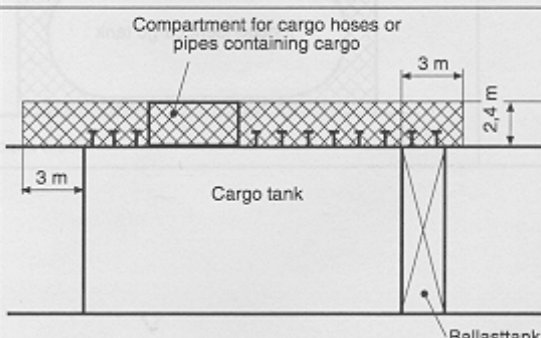
Symbols: see annex A

Item	Subclause	Typical examples	Remarks
B.1	4.2.1	 Cargo tank hatch Pipe work Venting system Cargo tank Slop tank	
B.2	4.2.2.1	 Integral cargo tank Void space	
B.3	4.2.2.2	 Independent cargo tank Hold space	

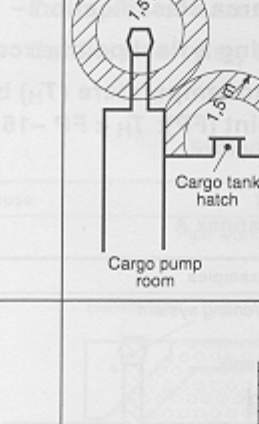
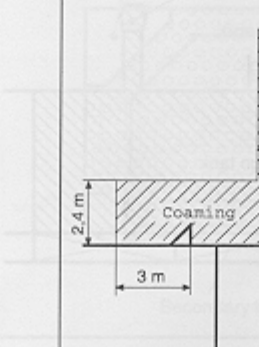
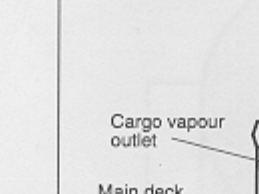
ZONE 1

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B.4	4.2.2.3 4.2.2.4 4.2.2.5 4.2.2.6	 Enclosed or semi-enclosed space Cargo tank Cargo pump room Ballast tanks Cofferdam	
B.5	4.2.2.7	 Pump room ventilation outlet Cargo vapour outlet (small volumes) Cargo manifold Pipe flange Ullage opening Cargo tank hatch Cargo tank	Cargo vapour outlet caused by thermal variation
B.6	4.2.2.8 4.2.2.9 4.2.2.10	 Pump room ventilation inlet Cargo manifold with spillage coamings Cargo vapour outlet (large volumes) Cargo pump room Cargo tank cofferdam	Cargo vapour outlet caused by loading, ballasting or discharging
B.7	4.2.2.11 4.2.2.12 4.2.2.13	 Compartment for cargo hoses or pipes containing cargo Cargo tank Ballast tank	When natural ventilation is restricted

ZONE 2

B.8	4.2.3.1	Pump room ventilation outlet  Cargo vapour outlet (small volumes) Cargo tank hatch Cargo manifold with spillage coamings Cargo tank Cargo pump room	Cargo vapour outlet caused by thermal variation
B.9	4.2.3.2 4.2.3.4 4.2.3.5	 Cargo vapour outlet (large volumes) Coaming Cargo tank	Cargo vapour outlet caused by loading, ballasting or discharging
B.10	4.2.3.6	 Cargo vapour outlet Main deck Cargo tank entrance ≤ 10 m ≤ 5 m	Space not mechanically ventilated and opening less than 0.5 m above main deck