



Exploration & Production

GENERAL SPECIFICATION

STRUCTURAL

GS STR 655

Requirements for conversion of a tanker to a F(P)SO

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1. Scope

This document defines the minimum requirements for the conversion of an existing tanker into a F(P)SO. It covers the phases of ship selection, the design of repair and conversion, the construction and installation.

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

The following reference documents are applicable as described in the following sections. When not explicitly referred in the following sections they may be used as guidance when relevant.

Standards

Reference	Title
ISO 13819	Offshore Structures, Part 1: General Requirements, 1995.
ISO DIS 13702	Control and mitigation of fires and explosions on open type offshore production platforms
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
NFPA 750	

The document [ISO 19904](#) "Floating offshore structures including stationkeeping, Draft C++, July 2001" 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 and Terminals - Rev 4
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)

Regulations

Reference	Title
IMO Marpol	International Convention for the Prevention of Pollution from ships
IMO Solas	International Convention for the Safety of Life at Sea
IMO ILLC	International Convention on Load Lines
IMO resolution A749 (18)	Intact stability criteria

Codes

Reference	Title
ISPS	Must be applied a voluntary basis, extent of application to be specified by COMPANY
IMO MODU	Code for the Construction and Equipment of Mobile Offshore Drilling Units

Other documents

Classification Society Rules

- The F(P)SOs
- The moorings and anchorings and the yokes, turrets, etc.
- The product transfer systems (side by side or tandem offloading) and the SPM (CALM buoys, etc.).

Must be classed

For the F(P)SOs this includes the following components:

- The hull and living quarters
- The utilities systems of the hull
- The safety and life saving systems
- The cargo systems and in particular the offloading (hawsers, hoses and ancillary equipment)
- The fendering systems (protection against collisions)
- The hull integrated supports of topsides
- The structure integrating the anchoring (turret, chain stoppers, etc.)
- The anchoring.

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

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

Two types of Classification Society Rules are relevant for the conversion of a tanker to a F(P)SO:

- The “ship rules” which have been used at the construction and during the normal operation for oil trading and which are applied under certain conditions for repair of the tanker functions
- The “offshore rules” which normally governs the new function as a F(P)SO and which are referred to here after.

Reference	Title
ABS	Guide for Building and Classing Floating Production Installations
Bureau Veritas	Rules for the Classification of Offshore Units
DNV OSS 102	Rules for Classification of Floating Production and Storage Units
DNV	Guide to conversion of tankers to oil production and/or storage vessels
Lloyd's	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

Total General Specifications

Reference	Title
GS SAF 216	Area classification
GS SAF 221	Safety rules for buildings
GS SAF 228	Liquid drainage
GS SAF 253	Impacted area restricted area and fire zones
GS SAF 311	Rules for the selection of fire fighting systems
GS SAF 321	Fire pump stations and fire water mains
GS SAF 322	Fixed fire water systems
GS SAF 331	Carbon dioxide fire extinguishing systems
GS SAF 351	Escape, evacuation and rescue from fixed installations
GS STR 105	Boat landings and bumpers
GS STR 651	General principles for the design of a F(P)SO Design
GS STR 652	F(P)SO - Steel hull design requirements
GS STR 656	Requirement for Tanker Documentation

3. Tanker selection

3.1 Functional requirements

The main functional characteristics governing the tanker research and their consequences on tanker definitions are summarised here after:

3.1.1 Minimum storage requirements

Refer to spec **GS STR 651** for the determination of tank capacities and global storage.

These values are to be considered as minimum values and a larger tanker may be proposed. The drawbacks of this solution (painting maintenance, mooring design for example) will be identified.

Generally the storage requirement will orientate the selection as follows:

Total Storage requirement	Type of tanker	Typical deadweight
Above 2 Mbbl	ULCC/VLCC	Above 270 000 t
From 1.45 Mbbl to 2 Mbbl	VLCC	From 200 000 t to 270 000 t
From 0.9 Mbbl to 1.45 Mbbl	Suezmax	From 120 000 t to 200 000 t
From 0.6 Mbbl to 0.9 Mbbl	Aframax	From 80 000 t to 120 000 t
From 0.45 Mbbl to 0.6 Mbbl	Panamax	

The topsides weight and other loads due to risers and mooring systems may have a large impact on the selection (1000 operating tonnes grossly equivalent to 7500 barrels to which potential additional stability impact has to be considered).

3.1.2 Planned field life duration

Linked to the function to fulfil, is the time on site without being drydocked for inspection and repair. This life requirement will lead to a fatigue damage estimate which will be added to past trading life damage.

COMPANY rules define a limit of 30 years for total life (tanker + F(P)SO). The use of a converted unit cannot be envisaged for field life longer than 15 years.

For short periods (temporary replacement of an unit, extended well testing) softer criteria may apply as these short duration may be compatible with the tanker normal inspection/classification scheme.

3.1.3 Area where the tanker will be installed

This will greatly influence the motions on site and the structural requirements. Additional modifications may be necessary. The above values are typical for benign environment and not applicable directly to harsher environment such as North Sea.

3.1.4 Complexity of the additional facilities

This will influence in particular the requirements for utilities and the possibility to keep the original tanker equipment.

3.2 Status of the tanker

A tanker will be considered for conversion only if it still satisfies its flag and classification requirements. This will in particular cover the **SOLAS** part.

Conformance to latest **SOLAS** requirements on cargo pump room fire protection will always be requested, even when the age of the vessel was an exempting factor (Regulation II-1/63 June 98).

The case of units already converted and which have already served on a fixed location is specific and needs to be addressed in particular. However same principles shall apply.

3.3 Pre-selection inspection

The phase of pre-selecting a vessel for conversion to an FSO/FPSO necessarily involves the organisation of an inspection. This comprises several steps:

3.3.1 Preparation of the inspection

The objective of the preparation is to define the detailed contents of the inspection. The following actions must be taken to achieve this:

- The list of equipment likely to be kept, define the anchoring characteristics, establish the energy balance. The vessel inspection questionnaire/check-list must then be amended as appropriate
- Documentary investigation. This consists chiefly of examining the classification dossiers of the ship in order to define the list of tanks (cargo or ballast) to be inspected in the light of the inspection reports or thickness measurements produced as part of the vessel classification process (structural surveys and statutory requirement evaluation). More generally, it involves determining the historical record of the ship so that the inspection can be targeted on the weak and critical points (hull and machines) and the repairs previously done (details of corrosion protection system and associated repairs, details of repairs to main structural scantlings, other "condition survey" repair, etc.). In all cases, recommended minimum practice is to inspect the fore peak, the aft peak, a pair of permanent ballast tanks (if the ship is SBT), the CBT tanks (if the ship is CBT) and a cargo tank. The documentary investigation should also comprise examination of the vessel's SIRE questionnaire (OCIMF), and where appropriate, her general design and construction drawings and diagrams (midship section, general arrangement, capacity plan and deadweight scale, trim, stability and longitudinal strength booklet, profile and deck plans, mooring arrangements and details, accommodation lay out, etc.).

3.3.2 Inspection

The inspections usually take place during the ship's commercial operations, and the inspection team usually comes under pressure not to disturb operations. The Group representatives must, however, do everything possible to ensure the inspection plan is complied with (tanks washed and made gas free).

For all the "machine" equipment, the operating records, oil analyses, vibration analyses, maintenance log, etc. must be examined and compared with reference documents, and these components must be visually inspected under operating conditions.

The same applies to equipment installed on the ship's deck: pipeworks, remote measuring equipment, inerting system, lifting/handling gear, valving, etc. and to corrosion protection system.

The inspection procedures implemented shall ensure an acceptable level of safety.

The visual inspection of tanks must evaluate whether the extent of corrosion corresponds to that recorded during inspections by the classification society or is patently different, rendering such information suspect. The inspection should also identify corrosion type and cause and also whether there are any deformations visible in the zones accessible. Guidance for this can be found in the Guidance Manual in reference.

The whole of the ESP dossier must be reviewed in the course of the inspection.

3.3.3 Reporting

On completion of the inspection, the inspection team must:

- Remit an inspection report clearly highlighting any problems and further checks to be implemented to determine the condition of the ship, together with any particular advantages it may offer
- Check and/or complete the ship evaluation questionnaire
- Fill in the evaluation grid for the vessel and make a technical comparison of the ships inspected.

3.4 Selection inspection

The objective of this step is to confirm that the candidate(s) retained as the result of the previous steps satisfy the specific features of the project, particularly as regards required operating life. Hull condition is a major consideration at this step. However, some of the equipment, especially that to be kept after conversion, must be examined in detail.

The Selection inspection must include several steps:

3.4.1 Preparation of the inspection

The inspection generally proceeds during operations but nonetheless requires entry in all the tanks. It is therefore crucial to define with the OWNER a precise schedule, allowing for operations undertaken by the ship.

In addition, this step call for thickness measurements and it is therefore essential to examine the latest reports available on hull state to determine the zones on which the measurements are to be taken. This can only be done by means of the ship's class dossier and in particular the ESP dossier and the last reports of thickness measurements taken in the framework of classification.

Lastly, as an evaluation of hull quality level is to be made at this stage, a finite element model of the hull must be made to determine the zones most likely to suffer defects (cracks).

A preliminary calculation prior to inspection is therefore recommended in order to orient the inspectors to an attentive examination of these zones.

Similarly, the modifications to be made (installation of a Turret, modifications to tanks, etc.) will contribute to defining the list of zones subject to more detailed inspection.

3.4.2 Inspection

3.4.2.1 Corrosion

Thickness measurements must be taken in all the tanks during the inspection. As these cannot at this stage cover the whole vessel, they must be undertaken in zones reputed critical, those

already found to be corroded when last measured in the classification framework and those highlighted for checks after the pre-selection inspection.

The purpose of the measurements is to obtain a "statistical status" close to the reality. Number of points to be measured attains several thousand for a large vessel (Suezmax, VLCC). The extent of the measuring campaign may be reduced if the last thickness measurements are recent and credible.

Critical equipment, such as that detailed in corrosion datasheet (coating, cathodic protection, piping, valves, etc.) must also be checked.

3.4.2.2 Fatigue

Detailed inspections must be made in all the tanks, with the objective of determining whether the structure comprises cracks. They must be conducted at greater depth in zones reputed sensitive and those pinpointed as such in the finite element calculation.

3.4.3 Calculation

There are two sets of calculations to be made.

First, the finite element model must be built using the original plans and the latest information available on the state of the ship. The calculations made are used, as described above, to orient the inspectors in their inspection.

After the inspection, another calculation has to be made to establish that the ship can be used, after conversion, for the required period, or that the conversion works to be executed are compatible with project schedules and costs.

3.4.4 Reporting

On completion of the selection inspection, the report remitted to the project group must include a abstract of the inspection and of the calculations made and clearly state the inspectors' opinion as to whether the ship may be selected. It must also include indications as to the extent and nature of the conversion works.

4. Design for repair and conversion

4.1 Classification and flag

The selected tanker has been built and operated under a given set of "ship" rules.

Conversion will be performed to given site-conditions as per "offshore rules".

Attention is drawn to the fact that offshore requirements may be different and stronger than ship rules, due to the fact that inspection and repair are more difficult to perform.

4.2 Hull condition analysis

4.2.1 Principle

The purpose of Hull Condition Analysis is to assess the status of an existing hull and to compare it to requirements.

This analysis should be used at four levels:

- **At initial field development strategy:** it can be used as an additional differentiating tool in the trade-off between new build and conversion, in using life and field data to ascertain the required initial strength and fatigue potential of the hull, allowing validation of the principle of conversion and establishment of a target age for the candidate hull.
- **At tanker selection stage:** the Hull Condition Analysis, required from tanker tenderers and performed under controlled fair conditions may serve as a good appreciation criterion in the selection process.
- **At conversion engineering stage:** the Hull Condition Analysis, performed at a detailed level, will be the main input to the repair and renovation specification process.
- **During operation:** the Hull Condition Analysis is a tool for planning/optimisation of inspections and evaluation of repair needs.

4.2.2 Tools and steps

4.2.2.1 Suitability assessment

The suitability assessment is the analytical process that uses the reported hull status as data input to review the capability of the structure.

Analysis is twofold:

- On the basis of ultimate strength

This may be performed at a Rule checking level or at a direct calculation level.

The Rule checking level is easily accessible even at pre-contract evaluation stage. It allows an evaluation of mean wastage of structural elements, initial margins or margins that may result from a benign or moderate environment.

Direct calculation requires a finite element model of the structure. This will not generally be accessible before contract signature. The model should be prepared as part of conversion engineering and be one of the deliverables in the conversion contract.

- On the basis of Fatigue strength

This may proceed at the same two levels as above.

4.2.3 Analysis Software

The following Classification Society software programmes for performing the Hull Condition Analysis shall be used:

- VERISTAR (BV)
- NAUTICUS (DNV).

The use of SAFEHULL (ABS) or SHIPRIGHT (LR) shall not preclude the CONTRACTOR to provide within the project documentation as per **GS STR 651** a complete hydrodynamic and a complete detailed structural model which 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.

4.2.4 Input Data

- At Vessel Selection stage:
 - Mid ship Section, Transverse Bulkhead Scantling Plan, Profile and Deck Plan, Shell Plates and profiles
 - Capacity Plan
 - Inspection report with wastage evaluation summary
 - ESP files
 - Rough vessel history as far as possible: age, trading routes.
- For Conversion Design and further follow-up:
 - Full set of structural drawings (as built after conversion including risers, topsides and mooring)
 - Detailed inspection report (at each inspection step).

If the relevant data are not available for the converted ship from the OWNER/shipbuilder (which is probable for a ship older than five years), preparation of the database requires a significant amount of modelling time (cost and schedule incidence).

4.2.5 Outputs

- At Vessel Selection Stage:

For the Vessel as new and as inspected:

 - Nominal stress levels in the structure according to classification societies' rules and margin, if any, for the vessel
 - Typical fatigue damage at various positions in the structure for a) standard tanker life b) site life duration.
- At Conversion Design Stage:
 - Nominal stress levels in the structure according to classification societies' rules and direct calculations
 - Fatigue damage at various positions based on trading tanker life and planned site operation.

This allows a strategy to be defined for renewal of plates/stiffeners and structural reinforcement if needed.

4.2.6 Requirements for repairs

4.2.6.1 Hull structure

A detailed steel gauging report must be prepared through the inspection. It shall describe the calculated percentage of steel diminution and the rates of corrosion. Depending on the time to the next opportunity to make repairs in dry dock, a repair "to original conditions" of the only critical parts (ex: plates with 10% or more of thickness wastage) will have to be done. By comparison between a fatigue analysis of the previous life of the tanker and search for local cracks, an estimate of the actual remaining life and an assessment of the required repairs can be made. These will include forecast future corrosion wastage. Also, all pitting should be repaired where required by the Classification Society and/or as a result of fatigue calculations.

Sometimes, the repair works will not be performed in the same yard as the conversion works, and there may be a “laid up period” or difficult environmental transfer conditions between the yards. Repair specifications must include all necessary works to cope with these temporary conditions (temporary protection against corrosion, verification of strength, stability, etc.).

Repairing must not be just “stiffening weakened parts”. An assessment must be made to understand the cause of the degradation and to identify the remedial means for eliminating the cause. In addition, it is important to not only repair the defect but also to avoid introducing other new causes of degradation. For example, the addition of a bracket may change the stress distribution locally but accelerate fatigue in a nearby area.

4.2.6.2 Tank integrity

The required structural condition depends on function, site environment, and expected lifetime on site. It can be assessed by considering the new-build equivalent, complying with the most recent requirements.

Differences with a repaired and converted existing unit will then be deduced from the design hypothesis, the ageing of the unit and modifications of design rules.

- Generally the new application of the F(P)SO will be for a zone less environmental-loading demanding than the ones used or the design of the tanker. Addition of topsides on the deck, including a turret or adding chain stoppers and risers introduces new local and global loads and would require reinforcement on a new not purpose built unit. As a minimum, these structural reinforcements have to be made when converting an existing unit; the design criteria and fabrication requirements are those of new units.
- Modifications in design rules are more difficult to assess: structural modifications due to recognised weaknesses (such as cited by IACS for example) should be performed, others have to be assessed.

The structural condition may be acceptable but some tanks or ballasts may be so heavily corroded locally that leakage could occur. This may entail no immediate risk to the safety but is not conform to rules on environment protection, in particular COMPANY rules and MARPOL.

Tank integrity after repair must be maintained during the life onsite if the initial condition is good and the means provided to keep its evolution under control (painting and cathodic protection, as relevant). Both shall be reviewed, and assessed. In addition, an inspection plan must be drawn up to monitor evolution.

The minimum requirements on corrosion protection depend largely on the time the vessel is to spend on site. This subject is not necessarily under direct COMPANY control on a rented vessel. However, to prevent problems during the time on site, the following critical points at least should be assessed and upgrading required as relevant.

- Full coating of ballast tanks
- Cargo tank bottom and top coating (1.5 m up or down minimum)
- Deckhead area
- Compatibility of external cathodic protection with mooring
- Sea chest protection
- Bell mouths areas reinforcement
- Reinforcement installed during conversion (to support the topsides for example).

4.3 Tanker equipment removal or modification

4.3.1 Principles

Original equipment can be maintained provided it meets the new needs with the required degree of availability and economy.

Even if it is in excellent condition, its improvement or replacement must be done, if its original design cannot adequately provide the required services (for example frequent shutdowns for maintenance, leading to unacceptable production losses).

The following analysis must be adapted to fit the true requirements of the new service. Hence, cargo-heating requirements may vary depending on the products being stored or the environment.

It is therefore necessary to identify the functions to be fulfilled in the framework of new utilisation and to ensure that the existing equipment can meet these needs, or otherwise to modify or replace it.

Uniform solutions, i.e. creation or full replacement are preferred to the addition of complementary capacities which can result in compatibility and maintenance problems.

Equipment which will not be used must be removed, or cocooned with a view to later use. Follow-up of equipment which is not used should be avoided.

4.3.2 Castle

The design of tanker castle does not exactly fit with FSO/FPSO requirements.

The bridge with wide visibility for manoeuvres is not warranted. Outward openings and windows at this level may have to be revised depending on the protection required for living quarters and the classification of nearby zones. In any case, this visibility is insufficient for service boat or offloading manoeuvres, which must be monitored locally.

4.3.2.1 Accommodations

The accommodation must be revised according to needs. Accommodation can be supplied for a greater number of persons on an F(P)SO, provided that it is used as a base for field production, including conventional fixed platforms.

Control room requirements are covered in other parts. Requirements of the command room, crisis management room, offices and workshops must be covered in the Design Basis. Hot works require a special room, extent and frequency shall be detailed in the Design Basis and according to the maintenance philosophy.

Funnel can be problematical for locating the helideck. Removal and repositioning of the funnel can be envisaged (as well as improved protection against bad weather).

4.3.2.1.1 Regulations

The construction method used for the tanker accommodation must be identified in terms of the **SOLAS** (IC, IIC or IIIC) code.

Living quarters and control rooms shall be at least in accordance with the most stringent requirements of Total **GS SAF 221**, **MODU** code and **SOLAS** safety regulations of tankers and passenger ships.

For converted F(P)SOs, existing systems not intended for renewal or modification must be in accordance with the latest revision of **SOLAS**.

4.3.2.1.2 Gas leaks

This hazard is not covered by **SOLAS** (there is no major gas risks on tankers) and thus has to be specified.

- If gas may reach living quarters or control rooms, standard safety requirements must be specified to avoid the consequences of gas ingress such as pressurisation, gas detection, air locks and air intakes (Cf. details in **GS SAF 221**).
- Doors and air intakes must be located out of reach of a direct gas jet.

4.3.2.1.3 Fires

External fires:

- The wall facing the cargo must be certified minimum A60 (possibly H60 and above) and equipped with a water deluge system
- Other external walls shall be certified minimum A60 in case of risks of jet fire (turret, import/export pipes, etc.) and fire at sea (rupture of the hoses, fire aboard the off-take tanker, etc.). Additional active fire systems may be installed
- Fresh air intakes must be equipped with smoke detectors and fire dampers. Automatically closing fire louvers are required on air intakes (manual systems to be modified)
- The roof of the living quarters must be certified minimum A60 if a helideck is installed above (the helideck should be in accordance with CAP 137 or ICAO with specific safety requirements).

Internal fires:

- Fire integrity of decks and bulkheads separating adjacent spaces shall be in accordance with **MODU** § 9.1 "Structural protection" (**MODU** code is somewhat more restrictive than **SOLAS** reg. 58 II-2).
- Nevertheless, attention must be paid to a clear definition of each category of spaces, as they differ from **MODU** to **SOLAS**.
- Any specific room such as muster and control rooms (and associated electrical and instrumentation rooms if any) must be categorised in reference to **SOLAS** regulations 26 and 58 II-2 and **MODU** code § 9.1.
- Any rooms with risks of hydrocarbon leaks must be specified as "machinery spaces of category A" as per the **SOLAS** definition.
- Categorisation of rooms is also important for requirements concerning means of escape (ref. **SOLAS** regulation 45 II-2).
- For new build living quarters, the whole surface of any one deck must be of same fire rating to avoid propagation of fire from one deck to another. HVAC ducts and dampers must be in accordance with wall and bulkhead fire rating.

4.3.2.1.4 Explosion

This hazard is not covered by **SOLAS** or **MODU** code and thus has to be specified.

Internal explosions are assumed to occur in engine rooms equipped with fuel gas supplied devices. In this case, IMO safety rules for LNG carriers apply (IMO IGC code).

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.

4.3.2.1.5 Structural

- 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 hazardous parts of the hull.
- Green water hazards are covered by **SOLAS**.

When converting a tanker into an FSO:

The living quarters are preserved and will be adapted, depending on the case, to the in-house standard (to be issued through a GS) or to offshore unit regulations (fire detection, gas detection, over-pressure for the HVAC function and where necessary for sprinklers).

When converting a tanker into an FPSO:

The living quarters may need to be extensively modified to be adapted to the following:

- Number of persons aboard (about 80 or 90)
- Regulations governing offshore units (fire detection, gas detection, overpressure for HVAC function and sprinkler where required, reinforcement of structure or of its protection against fire due to vicinity of treatment facilities).

Under these conditions, the opportunity of preserving and modifying in depth the bridge castle must be weighed against the advantages of having new or additional living quarters prefabricated (gain in time for simultaneous operation), even though the preference often goes to preserving the bridge castle.

4.3.2.2 Incinerator

New tankers are equipped with an incinerator. However, this is not always the case for a 25 year-old ship.

If the tanker is not equipped with an incinerator, one must be added for sludge, sewage and, if applicable, decantation tank residues.

4.3.2.3 Sewage

The tanker to be converted must be equipped with a sewage treatment unit which complies with IMO.

And additional caisson must be installed when converting the tanker into an FPSO.

4.3.3 Machinery and systems

4.3.3.1 Engine room

The principle to bear in mind as regards engine compartments is that they must be able to be controlled from a centralised common control room. It must not be necessary to keep them permanently manned.

4.3.3.2 Equipment

The condition and obsolescence of certain types of equipment must be considered in terms of the availability of spare parts over time.

4.3.3.2.1 Design recommendations

When converting a tanker into an FSO:

The following functions are preserved **and equipment acceptance is required for the following:**

- Auxiliary boilers if required (see chapter on boilers) and possibility of modifying burners with a view to using gas
- Electrical power generation
- Seawater cooling circuits
- Drainage circuit
- Oily waters treatment
- Fresh water production
- Hot and cold freshwater distribution
- HFO and DO purification
- Waste water treatment
- Ventilation
- Air conditioning
- Fire detection and extinction
- Engine room.

Seachests are modified to make possible their maintenance on site + installation of chlorination.

Functions concerning propellers, propeller shafts and steering gear and rudder **are removed or cocooned if:**

- On-site towing is available
- Anchoring cannot be disconnected.

When converting a tanker into an FPSO:

The following functions are preserved and **equipment acceptance is required:**

- Auxiliary boilers if required (see chapter on boilers)
- Stripping system

- Treatment of oily waters from machines
- HFO and DO purification
- Ventilation
- Fire detection and extinction
- Engine control room.

The following functions must be modified:

- Electrical power generation (increased capacity or replacement by new units on the topsides)
- Sea water cooling (adaptation and increased capacity)
- Freshwater production (increased capacity)
- Hot and cold tap water distribution (increased capacity)
- Wastewater treatment (increased capacity)
- Air conditioning (increased capacity)
- Adaptation of seachests for maintenance on site and installation of a chlorinating unit
- Compressed air production.

The functions below are not used and should therefore be either removed (to-site towing of the F(P)SO is a near certainty) or cocooned with partial removal of the following, if required:

- Propellers and propeller shaft
- Steering gear and rudder
- Propulsion engine, reduction gear assembly and shaft line if more volume or weight has to be recovered in terms of deadweight capacity.

The following function is added:

- Gas detection.

4.3.3.3 Boilers

There are basically two types of boilers on board tankers:

- Main boilers (60 bars) used for propulsion, cargo pumps, electrical power generation and heating of cargo (steam ships)
- Auxiliary boilers (12 to 16 bars) used for heating the cargo and for cargo pumps (thermal engine ships).

On-site revamping of a boiler is a heavy and very costly operation in terms of shutdown time. The overhaul must therefore be conducted very carefully and the function must not be confused with the equipment.

4.3.3.3.1 Design recommendation

If the boilers are to be preserved, they must be designed (especially as regards the number of burners) such that they can provide full-time operation at low capacity or they must be modified accordingly.

As the ship is immobile, scoop circulation is not possible and the cooling circuits (condensation) must therefore be checked and adapted.

When converting a tanker into an FSO:

If the cargo heating function is required, then the boiler function is preserved.

If the cargo does not require heating, the advantages and disadvantages of preserving the cargo heating function must be examined. The minimum condition is to maintain the cargo turbo-pumps.

When converting a tanker into an FPSO:

If the cargo heating function is necessary, the boilers must be preserved or possibly adapted for gas heating. The gas supply to the boiler is carried in a pressurised double-shell pipe.

If no heating is required for the cargo or during treatment: the same remark as for FSO applies. If the cargo system is re-designed (immersion of new pumps or new pumps installed) then the boilers are to be removed.

4.3.4 Hull and hull equipment

4.3.4.1 Tanks

4.3.4.1.1 Cargo system

4.3.4.1.1.1 Regulations

Classification and **SOLAS** for F(P)SO.

4.3.4.1.1.2 Pressure

The pressure required to load an offtake tanker must include consideration of:

- Pressure drops as a function of the maximum discharge output
 - On the storage tanker (pipes, metering skid)
 - In the flowlines to the buoy (where applicable)
 - In the floating hose (flexibles, break-away coupling)
 - On the offtake tanker (diameter reduction, piping).
- Hydrostatic back-pressure
 - On the storage tanker (pumps located at the bottom of the tanks)
 - Differences in freeboard between the storage tanker and the offtake tanker (dependent on the size of the latter)
 - On the offtake tanker (cargo tanks filled to 98%).

Depending on the type of loading scenario (tandem or buoy offloading), needs may turn out to be very different and require additional booster pumps.

4.3.4.1.1.3 Other services

The pumping system may need to be used for other services, which must consequently be taken into account:

- Crude oil or water washing of the tanks (COW)
- Tank stripping
- Tank-to-tank transfers
- Cargo re-circulation for heating
- Metering tests
- Specific procedures (e.g. pumping for hydrate formation prevention in subsea lines).

4.3.4.1.1.4 Maintenance

There is generally a greater demand on pump works on a F(P)SO than on a trading tanker. With regular offtakes every 4 to 5 days, the annual rhythm may reach 80 offloads as against twenty annual trips for a standard tanker.

The pumping system must therefore be reliable but must also allow maintenance/repairs on the spot with the means available on the site (materials and personnel) without disturbing offloading.

4.3.4.1.1.5 Common pumping system

Characteristics:

The cargo pumps are grouped in the same area (pump room) located at a low point of the hull, the engines being placed behind a separation wall in another area (engine room). The cargo tanks are usually collected through a piping network passing through them.

Principal advantages:

- Few pumps (generally 3 or 4)
- Direct access to equipment for maintenance/repair.

Principal drawbacks:

- Zone 1 classified area as high risks of hydrocarbon leakage (flanges, filters, packings, valves, etc.)
- Many potential hot points (bearings, packings, bulkhead connectors, etc.)
- Gathering network crossing through several cargo tanks (problem of tank isolation, leakage at joints, at bulkhead connectors, valves, etc.)
- Confined space, difficult of access and difficult to evacuate quickly in emergency
- Necessity for an ancillary tank stripping system as the cargo pumps are not adapted for this function (heavy flow rates).

Safety recommendations:

The risks arising from this pumping configuration require implementation of:

- Process safety devices
 - Pump bearings temperature
 - Casing temperature
 - Packing temperature
 - Bulkhead crossing temperature
 - Leak detection on packing
 - SDV up- and downstream
 - Shutdown push-buttons.
- Detectors
 - Gas
 - Smoke
 - Heat
 - Hydrocarbons (drip pan level)
 - H₂S where applicable.
- Safety logic
 - Retransmission to the control room (cargo room) of process and safety detectors
 - Automatic pump shutdown on activation of process and safety detectors
 - Automatic Stop/Start of ventilation on activation of process and safety detectors.
- Fire-fighting
 - Extinction by CO₂ flooding is not advised as it can be toxic depending on concentration and can disturb evacuation of personnel. Systems to be used in preference are:
 - Foam discharge (which also limits hydrocarbon emanations)
 - Water mist (see standard [NFPA 750](#) of 1996)
 - Release of extinguishing gases other than CO₂ such as INERGEN for example (Halon and halogen substitutes such as FM200 are not permitted).
- Safety equipment
 - Breathing apparatus
 - Extinguishers
 - Oxygen analysers.
- Entry procedures
 - To be drawn up according to the purpose of the inspection (routine control, maintenance, repair works). Limit access during offloading operations and define the conditions of access and works in emergency (procedures, equipment, communications, surveillance, etc.)

- Oxygen measurements before entry by control from the outside
- Communications with the control room (walkie-talkie, telephony).
- Design of the pump room
 - Isolation and fire-proofing (cofferdam)
 - Lighting for Zone 1 classified area
 - Ventilation to be coupled with the lighting so that personnel are alerted in the event of extractor fans failing (recently adopted SOLAS recommendation applicable as of 01/07/02). Check out the risks arising from any dispersion of hydrocarbon vapours outside (cf. Definition of classified areas).
 - Emergency evacuation means and routes
 - Audible and visual alarms.
- Equipment design
 - Replace flange-joined pipes by welded pipes
 - Install secondary sealing on the pump bearings and packing
 - Confine the pump bearings in an inerted enclosure fitted with hydrocarbon detection
 - Ascertain that the extraction fans cannot generate hot points (insulation of bearings, temperature alarms, etc.).

4.3.4.1.1.6 Drive power

- Steam
 - Few potential hot points in the pump room
 - Requires boilers in the engine room.
- Electricity
 - Few potential hot points as the engines are housed in the engine room
 - Gas
 - The use of combustible gas as the supply system shall be designed to the IMO standard IGC code (pressurised double-wall pipes, etc.).

4.3.4.1.1.7 Submerged pumping system

This arrangement is not frequent on tankers, but may be found on other floaters proposed for conversion.

Characteristics:

Each cargo tank is fitted with at least one submerged pump which discharges vertically to a manifold located on the deck.

Safety recommendations:

The main safety constraint concerns the way of tackling a maintenance/repair or replacement job on a pump.

These operations must be analysed so that, whenever it is practically possible, they do not involve entry in the tank. To achieve this, the pump must be technically accessible for lifting from the deck (no permanent tie in at the bottom of the tank, vertical lifting, space below the topsides for bringing up the different parts, etc.).

On an FSO:

In the case of an FSO, an operational risk analysis should determine whether the tank can be opened for the pump removal operation, and define the protective measures to be implemented throughout the process (isolation of the tank, inert gas sweeping, use of breathing apparatus, access delimitation, procedures, etc.).

On an FPSO:

For an FPSO with little equipment on its deck, the same approach can be adopted as for an FSO.

However, for an FPSO vessel with extensive topsides (considerable equipment, double deck, etc.), the above approach cannot be applied as:

- There is a higher risk of potential hot points (presence of rotating machinery, electrical equipment, simultaneous operations conducted by personnel, and so on)
- The gas detectors have to remain in service
- Ventilation on the tweendeck is limited (risk of inert gas and hydrocarbon vapours stagnating).

It is necessary therefore:

- To have airlock type equipment available to lift the pump out
- Or to secure the cargo tank by emptying and inerting it.

To empty the tank when the pump is not running, a standby mobile pump (with much lower duty than that of the cargo pump to facilitate implementation) is used. However, Installation of this involves opening the tank unless an airlock or other system for limiting gas emanation is available.

Drive power:

- Hydraulic
 - Non-combustible hydraulic oils are available on the market
 - Make sure no crude can infiltrate into the hydraulic fluid.
- Electric
 - Additional potential hot points on the deck.

Cargo systems:

Tanker cargo systems are usually composed of extraction circuit with piping located at the bottom of tanks using turbo-pumps installed in the pump room. The evacuation pipes are installed on the main deck. The tanks are filled through cross pipes located on the deck which lead to headers located at the bottom of the tanks.

Some tankers have an architecture designed for free-flow, which must be removed.

When converting a tanker into an FSO:

If the equipment and cargo piping are not obsolete and are still in good condition, the system is kept. The simultaneity of the production loading and discharge operations must be checked as this often requires the addition of a loading line on the deck with one “drop line” per tank.

When converting a tanker into an FPSO:

Depending on the size of the topsides, the requirement of a production oil loop and an hot oil loop, the architecture of a conventional tanker is not adapted and under these conditions the cargo system must be either partially or totally redesigned.

Should the cargo system be re-used, it has to be checked that the new ship movements will not significantly hinder the pumping efficiency, as a result of the position of the pump intake.

Recommendations for conversion:

All pipes will have to be tested regardless of whether or not they have been modified (to be tested during the inspection phase in dry dock).

Valves will undergo a tightness test after the packings are replaced, if applicable. The liners and manual remote controls must be inspected and replaced when necessary.

Tank isolation:

For tank entry, it must be possible to isolate the tanks reliably from the other networks and especially from those containing hydrocarbons or inert gas. In this case, isolation on a single valve, even with double sealing, is not acceptable. Efficient means, excluding any risk of handling errors, should be provided, such as:

- Double block and bleed valves
- Spectacle blind, ram blind (type ONIS)
- Removable spool pieces
- Blind flanges.

The type of isolation should be chosen based on a risk analysis on the relevant product (crude, inert gas, washing water), the characteristics of the network to be isolated (content, pressure, service), and the frequency at which the isolating device is to be used.

If conventional tanker architecture is preserved, the major disadvantage resides in the fact that hydraulic valve controls located at the bottom of the tanks are difficult to access for maintenance or repairs (the tank must be bled and ventilated). Replacement must always be envisaged.

The replacement of gland sleeves of the type “pont à mousson” by expansion loops must always be envisaged. The decision not to replace them can only be justified in case of short term utilisation and of good equipment condition.

Bulkhead cross ties will be systematically inspected and refurbished.

4.3.4.1.2 Ballasting**Design recommendations:**

The ballasting system of the tanker hull is composed of pipes, distinct from the cargo system, located at the bottom of the vessel, which run across cargo tanks. The pumps are located in the pump room. There is no link with the engine room.

When converting a tanker into an FSO or FPSO:

An estimation of the needs in terms of capacity and positioning of the ballasting tanks must be made, as well as a comparison with the original capacities.

This function can usually be preserved without modification. However it is likely that the age of the equipment would render it unsuitable in terms of reliability and safety. In this case a new system should be installed, and preference will be given to system which does not penetrate into the cargo tanks.

See also § on occasional inerting circuits in the ballasts (FPSO version). A dual-circuit solution is preferable.

4.3.4.1.3 Inert gas**Regulations:**

Classification and **SOLAS** for FSO and FPSO.

Design recommendations:

Old tankers use only gases produced by boiler combustion, which can lead to problems of availability.

Converting a tanker into an FSO:

It is essential to know the installation date of the inert gas system on board the tanker to be converted in view of the amendments made by the **SOLAS** in 1981. Control systems and alarms must be installed for compliance with current regulations. The layout of headers on the deck will remain unchanged.

For tankers which use only washed flue (combustion) gas, a generator must be added.

Converting a tanker into an FPSO:

Same remark as for FSO.

Moreover, ballasting tanks and adjacent cofferdams are not topped up with inert gas when the ship is old.

The existing generator must be adapted to be run with gas.

The arrangement of inert gas headers and venting masts on the main deck may not be compatible with topsides. The pipe network on the main deck must be redesigned with two lines and new positions for vent tips.

4.3.4.1.3.1 Generators**Generating system:**

The inert gas generating system installed on board the selected vessel will generally be used after conversion. As the efficiency of the inert gas system is crucial on an FSO/FPSO, it will be important to check during selection or definition of the conversion works that there will be two independent inert gas sources (2 x 100% of nominal output) available: two auxiliary boilers, a boiler and an inert gas generator, etc. For situations where few offloads are anticipated and where maintenance works (scheduled or otherwise) can be undertaken between offloading operations, it is possible to have only one main production source of inert gas. However, to ensure the possibility of completing the volumes needed to maintain the cargo tanks under inert gas between two offloads, the FSO/FPSO must have a "topping up" generator.

For cases in which new inert gas generators are installed to supplement or replace existing units, the new equipment should be installed in preference on the deck. The possible advantages of dual-fuel supply should be examined in all cases.

Inert gas ventilators:

Owing to the number of offloading operations on an FSO/FPSO, usually higher than on a ship, and to the fact that dry-docking is not regularly scheduled, back-up inert gas ventilators are strongly recommended. Consequently, it is required the following equipment be available:

- 2 ventilators, each with an output capacity equivalent to the regulatory one
- 3 ventilators, each with an output capacity equivalent to 50% of the regulatory one.

Deck water seal:

As maintenance is more difficult on the installations present on FSO/FPSO vessels (more or less no dry-docking), the simplest, most reliable design, requiring the least maintenance: "Wet type deck water seal" should be chosen. This recommendation is all the more important that the deck water seal is crucial to safety of the installation.

Oxygen Analyser:

Duplication of this equipment is recommended, as the inert gas system has to be shut down if it fails to operate properly. If two generators have been installed, there must be appropriate means for running the two oxygen analysers simultaneously on either one of the generators.

Sea Water service pump:

Back-up is recommended on the water supply to the inert gas washing tower.

4.3.4.1.3.2 Inert gas distribution**Spectacle flange:**

It is recommended to fit a section shut-off valve (with blocking and locking system) and a spectacle flange on each individual cargo tank. These fittings allow operations to proceed in a cargo tank (servicing, inspection, etc.) while maintaining the inert gas system operational for the other tanks.

Individual P/V valves:

It is recommended all the cargo tanks be fitted with a protection against overpressure or under-pressure separate from the protection installed on the inert gas line. The P/V valves must, in all cases, be conform to regulatory requirements and of "High Velocity" type, guaranteeing an adequate gas expulsion speed.

For FPSO vessels, opening of this valve must activate an alarm (monitoring operating anomalies on the cargo tank).

Breathing valve:

Installation of a "breathing" P/V valve on the mast vent is recommended. The set-point of the P/V valve must be adjusted such as to trigger before the other safety devices (individual P/V valves, P/V breaker, etc.) in the event of over- or under-pressure.

Inerting of other vessels:

It is recommended an appropriate system be available for inerting tanks into which hydrocarbons may infiltrate accidentally: ballast tanks, cofferdams, double hull, and structural



voids. This system may include the use of **flexibles to be installed exclusively for such operations** to limit any risk of inert gas or hydrocarbon infiltration in the tanks, which could occur with a permanent tie in. However, the cargo tanks must remain under inert gas throughout such operations.

Bear in mind that passing inert gas containing CO₂ into ballasts or tanks operating in a damp environment can cause rapid corrosion in them.

An additional system must be installed on the FPSO vessels for the following tanks: slops tanks, methanol tank (usually slightly blanketed with N₂) and for all other service tanks which need to be inerted.

Inerting of headers:

The inert gas system must be connected to the main storage and discharge headers to enable them to be quickly inerted before operations on them.

Second inert gas line:

A second inert gas line must be installed whenever safety dictates that no hydrocarbon vapours must be allowed to spread over the deck of the unit (especially in the case of an FPSO) during inert gas sweeping operations or in the event of over- or under-pressure in the tanks. It must be connected to all the cargo tanks and to the mast riser. The second line could be also installed in order to simplify the inert gas sweeping operations prior to inspection. This inspection will not proceed until the tanks have first been vented.

Gas freeing of the tanks:

The cargo tanks need to be ventilated to allow routine inspections and any maintenance works to be undertaken. Ventilation means should be chosen such that ventilation can proceed while maintaining the inert gas line operational: portable water-powered fans for example.

Inspection of the inert gas line:

As FSO/FPSO vessels do not go regularly to dry-dock, it is recommended that inspection orifices be provided on the inert gas line to allow regular inspection. It is also recommended that provision be made for the possibility of replacing sections of the line, with limited hot works: short lengths for example. Lastly, care should be taken to avoid any low points on these lines which may corrode in the presence of condensation water containing CO₂.

Positioning of the header:

In the event of the cargo tanks being overfilled, crude oil can invade the conventional tank pressure control network. To prevent tank resistance being adversely affected by overpressure due to the hydrostatic column of crude, the manifold must be positioned slightly above the deck level but not so high as to hamper its maintenance (inspection, painting).

4.3.4.1.4 Access

When converting a tanker into an FSO:

Access ways are not modified provided they comply with offshore work legislation and allow inspection and maintenance of equipment.

When converting a tanker into an FPSO:

Access ways are modified to take into account the topsides when necessary.

4.3.4.1.5 Tanks washing

When converting a tanker into an FSO:

The system is preserved and improved depending on the desired effectiveness of the washing.

When converting a tanker into an FPSO:

Location of the system may have to be modified to take into account a possible interface with the topsides supports.

Fixed installation:

It is recommended that the “crude oil washing” installation be fixed and not require flexibles for its implementation, including for use on slop tanks.

Layout of tank cleaning guns:

It is recommended to calculate the shadow diagram of the tank cleaning installation in compliance with regulations. However, for crudes with high viscosity, pour point, etc., it is recommended to increase the number of tank washing guns to guarantee minimum accumulation of residues during operations on site.

Type of tank cleaning guns:

It is recommended, especially if the tank washing guns are to be replaced as part of the conversion works, to use programmable guns, offering the possibility of defining different washing sequences according to the operation required: crude oil washing after offloading, washing prior to inspection, etc.

The tank washing guns and washing circuit must be designed to work under a minimum pressure of 10 bars.

Water washing:

The washing circuit must allow water washing, which is necessary before maintenance operations inside the tanks. The standard system used will comprise pumping of the “clean” water (sea or process water) to a slop tank, intake to the washing circuit by a cargo pump, and stripping of the washed tanks to a second slop tank. Alternative systems may be put forward, but special care must be taken to assess their efficiency.

It is important to bear in mind that systematic recourse to water washing may have extremely adverse consequences on the evolution of corrosion in the tanks, so that water washing should be used only in the context of preparation for tank works.

Maintenance:

To enable the washing guns to be dismantled for maintenance, the following are recommended:

- Provide enough sectioning devices to be able to isolate one tank from the rest of the crude oil washing circuit
- Install flanges on the piping close to the deck crossing to facilitate disassembly of the washing guns
- Leave enough space below the topsides deck to allow ready removal and handling of guns and piping.

Inner tank structures:

To facilitate the elimination of washing liquids and sediments, it is recommended that the slot holes and other outflow holes be as wide as possible and located such as not to trap deposits and allow them to accumulate at the bottom of the tank.

COW notation:

In the case of a classified FSO/FPSO, it is recommended the notation COW be kept.

4.3.4.1.6 Cargo tank gauging**When converting a tanker into an FSO:**

The Wessoe system is preserved if it is equipped with contacts which allow direct readings in the cargo control room.

When converting a tanker into an FPSO:

The system is replaced.

Any manual probes which may exist are removed.

Remote gauging with compressed air is removed.

4.3.4.1.7 Cargo heating

On a tanker, cargo heating is provided by a separate steam circuit for every tank. The feed collector is installed on the upper deck with hydrocarbon detectors. Pipes are generally made of Yorcalbro, and the steam is produced by recovery boilers and auxiliary or main boilers (ship steam).

For a FSO installed in West Africa, installations are oversized for conventional crudes which generally are stored only for short periods.

When converting a tanker into an FSO:

If cargo heating is required, the existing heating system on the tanker is preserved.

When converting a tanker into an FPSO:

If cargo heating is required, the existing heating system on the tanker is preserved provided it is compatible with topside installations.

On the contrary case, this function is removed.

Heating:

If a system is installed for heating the crude or the water used for washing the cargo tanks, it is recommended the system should not be installed in the machine room, but rather in the pump room or another safer area in order to preclude the risk of hydrocarbon vapour leakage in the machine room. The piping should allow the injection of chemicals to assist the washing operation.

4.3.4.2 Helideck platform

Existing tankers have a zone for hoisting but no helideck.

4.3.4.2.1 Regulations

As for new.

4.3.4.2.2 Design recommendations

Converting a tanker into an FSO or FPSO:

Refer to dedicated document.

4.3.4.3 FSO/FPSO access

Boarding ladders on tankers are removed or in some cases replaced by one or two boat landings, on fields where this solution is used.

4.3.4.4 Cranes

Handling means on board tankers are not adapted to offshore units (regulations concerning offshore operations and capacity).

MODU type cranes must be installed on the main deck to cover the new needs.

4.3.4.4.1 Crane location and lay-down area

At least one crane must be installed near the living quarters and utilities area with a lay-down area for equipment storage and handling. Dropped objects and ship collision must be taken into consideration for this area, and cargo tank and piping must be protected there (deck plating, double side).

4.3.4.5 Mooring and anchoring

The mooring and anchoring system of the tanker, including piping, must be removed or cocooned. A dedicated new anchoring system designed for permanent station-keeping on the site, shall be designed as for a new unit.

4.3.4.6 HFO and DO filling

This function is usually located in the cargo bulkheads for tankers.

4.3.4.6.1 Design recommendations

When converting a tanker into an FSO:

This equipment is preserved.

When converting a tanker into an FPSO:

A bunkering station will be set up in the service boats berthing area.

4.3.5 Safety and fire protection

4.3.5.1 F(P)SOs

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

Minimum guidelines are:

- SOLAS regulations
- Rules of a pre qualified classification society (ABS, DNV, Lloyd's, BV)
- Total general specifications and amendments described hereafter
- Specific requirements.

Fire-fighting systems shall be in accordance with the most stringent of the above requirements.

In the case of a converted F(P)SO, existing systems which should not require renovation or modification must have been built in accordance with the latest revision of SOLAS.

Remarks:

- If the F(P)SO has no flag or classification, it shall be contractually stated that the SOLAS term "administration" means here "Total project team".

4.3.5.1.1 Specific requirements

Anchoring and riser systems (up to ESDV) above the minimum draft of the vessel shall be protected from the consequences of a fire at sea.

Pump room, if any, shall be protected by a remotely activated, fixed fire-fighting system.

Any compartment with fuel oil or gas equipment situated below accommodation and/or control room shall be protected with an automatic, fixed, active fire-fighting system (in addition failsafe closed valves shall stop fuel supply).

The design of the fire-fighting system shall take into account:

- Variations of the vessel draft (e.g. for the fire pump suction pressure)
- The location of the fire-fighting equipment (e.g. risks of low flow rate at helideck level and high pressure at lower deck).

Fire pumps may be installed on deck or inside the hull provided the fire pump systems are not simultaneously exposed to the same hazard.

If the fixed deck foam system required by SOLAS regulation II-2-61 to provide foam "into any cargo tank the deck of which has been ruptured" cannot be installed due to topside structure, another equivalent system shall be proposed. This system shall remain operational whatever the causes of the cargo deck rupture.

Diesel and methanol transfer areas shall be protected with special fire fighting equipment.

The cargo deck shall be partitioned with bunds, at least below process equipment, in order to contain and limit spreading of liquid leaks and reduce maximum firewater needs.

CO₂ flooding system in rooms/compartments where personnel may be normally present should not be used. Any other efficient system without danger to personnel, such as other extinguishing gas, foam or water mist is recommended. If a CO₂ system is kept (e.g. tanker conversion), it shall be in accordance with SOLAS and with GS SAF 311 as amended, and its conformity shall be precisely ascertained.

4.3.5.1.2 Amendments to the General Specifications

GS SAF 311 "Rules for the selection of fire fighting systems":

§ Permanently manned and not permanently manned room: "pump room" and "machinery room" must be mentioned in the list (these rooms are not common on platforms).

GS SAF 321 "Fire pump stations and fire water mains":

§ Offshore facilities: firewater pumps may be of another type than "submerged vertical type installed in a pump caisson".

§ Pumping capacity and distribution: the configuration of the pump station may be different from 3 x 50% or 2 x 100% provided n + 1 pumps are installed.

GS SAF 322 fixed fire water systems:

§ Equipment with deluge protection: storage tanks shall be fire protected as required by SOLAS.

§ Equipment with deluge protection - Note 5: the restriction is also applicable to structures whose integrity is a pre-requisite for avoiding catastrophic events from hull deck or/and mooring or/and hazardous risers.

§ Dilution water curtains: they may be installed if efficiency is demonstrated and offers significant reduction of the maximum firewater needs.

GS SAF 331 "Carbon dioxide fire extinguishing systems":

§ Inhibition: The system shall be designed to render discharge of CO₂ impossible when personnel are present in the room.

4.3.5.2 Protection against fire on main deck**4.3.5.2.1 Regulations**

Classification and SOLAS for F(P)SO.

When converting a tanker into an FSO:

Installations made for the tanker are preserved.

- Spraying of seawater on the front wall of the bridge
- Seawater collector on deck
- Foam spray guns for tank area.

When converting a tanker into an FPSO:

Existing systems on the tanker (foam spray gun, firewater taps) are preserved if their effectiveness is not impeded by the topsides. Additional systems must be provided for (water spraying, foam) for the topsides.

4.3.5.3 Life boats**4.3.5.3.1 Regulations**

Classification and SOLAS for FSO and FPSO

Lifeboats must be adapted to comply with in-house regulations.

4.3.5.3.2 Design recommendations**Converting a tanker into an FSO or FPSO:**

Lifeboats must be able to accommodate the number of persons on board.

A workboat must be added.

4.3.5.4 Gas detection

When a tanker is converted into an FPSO, a gas detection system will protect all enclosed rooms concerned by gas ingress. For FSOs, this is to be determined on a case by case basis.

4.3.5.5 Control and emergency shut down systems

Depending on the age of the tanker, it may be necessary to install new hydraulically-operated cargo and ballast tank valves, which will be controlled from the new cargo control room. A new mimic control panel will be installed in this room to identify controls for all deck valves, cargo and ballast pumps, stripping pumps and bilge pumps.

Upgraded loading computers (2) will be installed in the new cargo control room. These computers will monitor and display the cargo and ballast tank capacities and ullages. Using this data, the computers will monitor the FSO/FPSO sheer and bending moments and display the draft.

4.3.5.5.1 Integration of existing and new marine and process control/Safety systems

Examples of the areas that must be considered in the integration of the control/safety systems include:

- Increased potential for disrupted operation, liable to cause field shutdown/spills/accidents
- Additional training of operations and maintenance personnel to handle different systems
- Cost of maintenance and spares warehousing.

The degree of automation must also be addressed in the F(P)SO operating philosophy and incorporated into the new control systems. While as a trading tanker, the ship's systems are usually manually operated, it is not practical to maintain them as such for safe F(P)SO operations.

In what follows, it is assumed that the **existing systems are kept and modified** for safe operation in accordance with COMPANY rules and project control philosophy.

If the systems are difficult to modify or cannot be interfaced with the DCS for remote operations (too old or based on pneumatic/hydraulic technologies), their replacement should be considered.

4.3.5.5.2 Safety/Critical systems

COMPANY safety system rules compliance:

The first step is the analysis of the existing tanker safety rules (tanker safety logic and corresponding equipment). Modifications will have to be implemented in order to ensure a general safety level conform to COMPANY safety rules. However, the extent of these modifications should be analysed in the light of specific project features such as the FPSO/FSO operating period (short period or the whole field life), ownership (rented or not) and, when appropriate, a request for exemption from the COMPANY rules must be submitted.

The COMPANY safety rules include as a minimum:

- **Fail safe position** for both safety valves (including sea chest valves) and output from the Distributed Control System or Programmable Logic Controller.
- **Safety logic:** the loss of a safety input signal must trigger the same actions as those initiated by the relevant transmitter when detecting an abnormal situation. This point is considered a general rule, but may be adapted according to the specific area: process, subsea.
- **Fire-fighting system operation:** in existing tankers, fire-fighting systems for machine or electrical rooms are hand-operated. The fire detection system sends an alarm to the

operator who must analyse the situation and then initiate the corresponding actions from a dedicated panel, not always located in the control room. Moreover, the extinguishing system can be manually disconnected by means of a key installed not at the room entrance but on the dedicated panel. This is not in line with COMPANY philosophy, which aims to minimise manual operations on confirmed fire detection (except in specific situations such as releasing extinguishing gas).

- **Safety override:** the safety function must always override the control function, whatever the operating mode (automatic or manual). Generally, in the existing tanker control logic, when automation is made inactive, the equipment mode reverts to manual position **without** any safety function override. This kind of situation will have to be modified.

4.3.5.5.3 Location and design of safety systems

Safety systems should be located whenever possible in the safest area, which is normally the living quarters, where the probability of gas ingress is lowest compared with other areas on the FSO/FPSO.

However, in the case of a tanker conversion, it may not be possible to locate them all in the same place. Therefore, special attention must be paid to the following:

- Each safety system must be fully stand alone: for instance, it will not only include detection of abnormal situations (concerning process, fire or gas) but also all the relevant response actions (e.g. cut-off of electrical supplies in a room where gas has been detected)
- As a consequence, there may be a **functional split** or segregation between the different safety systems.

4.3.5.6 Critical systems availability

Some critical systems need to remain live as long as possible to allow safe operations control in an emergency situation, for example in the case of gas detection in the general technical room, especially if located inside the process area.

For that reason, a dedicated room, protected by a stand-alone gas detection system, may be designed to house critical systems. In this way, equipment considered critical will remain operational and continue to supply information under abnormal situations, until gas is detected actually inside the protected room.

The following systems are concerned (non exhaustive list): Public Address/General Alarm, navigation aids, FPSO/FSO positioning, telecommunication links, ballast control, etc.).

Preserving the integrity of critical systems also means avoiding damage by fire in their command cabinets. This can also apply to some critical process functions, such as subsea flow assurance. In this case, an early fire detection system can be designed and installed to monitor the following cabinets: marshalling, control and safety system, electrical generation and distribution for relevant consumers.

4.3.5.7 Operating philosophy

4.3.5.7.1 Control room design

Generally, tankers are not equipped with a Distributed Control System (DCS), but with several dedicated systems each with its own Man-Machine Interface (MMI), which may be located in different control places (machinery room, electrical room, living quarters, etc.).

In the case of a tanker conversion to FPSO, operating philosophy is of the utmost importance to guarantee safe operations. Because production, storage, offloading and marine operations may take place simultaneously, it is essential all of them should be organised, monitored and initiated from a single Central Control Room.

Moreover, overall ergonomics of the Central Control Room must be closely examined in order to facilitate communication and coordination, without any disturbance between the different teams.

If it is impossible to have only one Control Room, special attention has to be paid, firstly, to the functional split between these different control rooms and, secondly, to their respective responsibilities and autonomy, especially in emergencies. Furthermore, communications and available remote data between these control rooms need to be carefully analysed, to avoid misunderstanding and inconsistent operations.

The Central Control Room (CCR) should be located whenever possible in the living quarters or in a sheltered safe area.

For tanker conversion to an FSO, the above analysis does not fully apply, since the additional systems are much more limited than for an FPSO: metering system, inlet and outlet ESDVs, extension of the fire/gas system, mooring system, berthing aid system including telemetric buoy control.

4.3.5.7.2 Control philosophy

Assuming the new DCS provides the main Man-Machine Interface, **it is recommended that** the major information and commands for the supervision, start-up and stop, and safety shut-down states of both the existing and new systems should be displayed on the **new** DCS operator's workstation monitors located in the C.C.R.

Operating a complete function (e.g. offloading) from both new DCS workstation and former separate MMIs (for existing equipment) is not easily conceivable, since the operator will have only a partial overview of the whole process.

The local and dedicated MMIs (usually located in different rooms) should be **exclusively** for maintenance operations and, where appropriate, for normal operations in the case of communication loss between the package and the DCS or in case of partial DCS failure.

No equipment can be operated from both MMIs (DCS and local one) simultaneously: interlocks must be provided through soft/hard switches (remote/local or automatic/manual modes).

Data exchanges between new DCS and existing systems must be either by hardwired signals, in the case of limited amounts of data, or by digital links. For standardisation and maintenance reasons, the same type of link, i.e. based on the same protocol, must be used for all communications.

4.3.5.7.3 Operator interface requirements

MMI Standardisation

The following are recommended:

- A single type of operator workstation
- Standard graphics and data presentation rules common to both new and existing systems.

If the same operator is required to control different production equipment using the topsides DCS and the existing MMI, non-standardised MMIs will cause confusion and operation risks, even under a normal situation.

Safety and alarm monitoring must be user-friendly: in case of shutdown, the first fault must be clearly identified and displayed, and alarms must be ranked and sorted by equipment type.

Several programmable levels of alarms allow segregation between safety and control functions.

Equipment- or system-related alarms can be globally masked when the relevant item of equipment or unit is at standstill. The safety or alarm overrides are managed with prioritised keys or passwords and are traceable.

Equipment identification:

To prevent any confusion in a tanker conversion project, rules have to be enforced to ensure unique identification of the various items of equipment on the different Project deliverables: SUPPLIER drawings, lay-out, label plates on equipment, local panels, graphic displays on the different operator stations, etc.

In most cases, the original names must be maintained, since it is neither realistic nor practical to replace them everywhere.

For the same reason, as long as the original language is generally understood, it should be adopted. This may lead to having two languages. However, regarding safety (equipment names/marks and warnings), the same language must be used.

DCS Interface factory acceptance test:

A Factory Acceptance Test with a partial DCS must be planned for each marine system in order to check the whole interface with the DCS, with both DCS and package SUPPLIERS present, providing technical assistance.

4.3.5.7.4 Instrumentation design

Although it extends beyond the control/safety systems, integration of the existing installations is important to ensure a satisfactory safety level and more efficient operability and maintenance.

In terms of safety instrumentation, the following points are a minimum: use analog transmitters instead of switches, and cable types which are fire-resistant or flame-retardant or mechanical protected cables with safe routing in critical areas. Risk analysis results may conclude on the necessity of certain modifications: new cable types, redundant routing, etc.

Standardisation of instruments and controllers is another important issue, for which some effort is required to reach a "reasonable minimum".

4.3.5.8 External communications

4.3.5.8.1 Regulations

As per a new unit.

4.3.5.8.2 Design recommendations

Converting a tanker into an FSO or FPSO:

The tanker must be checked for compliance with the **SOLAS** (GMDSS, ARPA).

Generally, modifications should not be required and installations are preserved.

Special communication means between the different units of the site or the onshore base are added.

4.4 Conversion and additions

4.4.1 Design of new items

Ship rules are the basis for repair works. Offshore rules are the basis for the design and construction of new items such as mooring and topsides.

GS STR 651 applies directly to all new parts.

4.4.2 Construction

The construction follow-up shall be conducted as for an offshore project.

4.4.2.1 Tagging and labelling

A tagging and labelling of all existing and new systems shall be applied for existing and new equipment, piping and cabling. The tagging system shall be consistent with that adopted for the topsides. Existing and new documentation, plans and manuals shall include the appropriate tag numbers for identification of components.

4.4.2.2 Materials

CONTRACTOR shall provide a certificate verifying that the vessel has been converted free of the following materials:

- Asbestos and asbestos based compounds
- Polychlorinatedbiphenyls (PCBs)
- Halogenated Fluorocarbons.

Detailed requirements for materials are included in the appropriate sections of this **specification**. Where a material has not been specified for a system or components, CONTRACTOR or MANUFACTURERS standard may be used subject to **approval**.

4.4.2.3 Commissioning and testing

Commissioning procedures and testing programs shall be submitted to COMPANY. Vessels' new and existing machinery, systems and equipment provided as part of this Contract shall be fully commissioned prior to delivery, to an **approved** standard and shall include, but not be limited to:

- Verification of existing and new mechanical completion
- Chemical cleaning and/or flushing of existing and newpiping and equipment
- Conduct energised or pressurised checks and tests on mechanical, electrical and utility systems or equipment, new and existing
- Operational checkout and physical testing of existing and new cables, electrical switchgear, instrumentation and controls, cargo and ballast systems, hull utility systems, marine equipment, communications equipment and emergency and safety systems
- Load testing of existing and new rotating equipment
- Existing and new Instrument calibration and loop checks
- Existing and new Valve assemblies lubrication, stroking and calibration
- Install final equipment fluids, lubricants, filters and media for proper operation



- Hand over to COMPANY of documented records of commissioning activities
- Details and procedures for outstanding commissioning activities that can only be completed later at the integration site after the installation of topsides or offshore at the field.

CONTRACTOR shall develop a detailed commissioning plan for existing and new equipment that includes pre-commissioning and commissioning activities. For each system a clear set of minimum acceptance criteria shall be agreed with COMPANY to form the basis of the commissioning program. Specifically:

- CONTRACTOR shall prepare and utilise a series of system checkout procedures (SCP'S) that shall define the systems or equipment (existing and new) to be commissioned, the procedures to be followed, and any specific support required
- CONTRACTOR shall obtain any locally applicable environmental permits required in support commissioning
- CONTRACTOR shall include COMPANY personnel in the commissioning process to provide training for facility staff
- CONTRACTOR construction fabricators and/or equipment VENDORS shall provide support for commissioning activities
- During commissioning, a system of safety lock out and tag out procedures for existing and new equipment shall be developed and strictly adhered to for the safety of personnel.

Final commissioning shall be on a system basis after individual component testing. Special attention shall be paid to demonstrating the operational effectiveness of the inert gas and gas freeing system arrangements.

Commissioning shall include a fully documented record commencing at individual component pre-commissioning (including flushing and pre-starting mechanical and electrical verification checks) through component power up, safety checks and final system testing.

Where final commissioning can only be carried out at the integration site or offshore, CONTRACTOR shall, to the maximum extent possible, complete necessary pre-commissioning checks and tests prior to delivery so as to minimise commissioning at any such location.

For commissioning activities that cannot be performed at the shipyard, CONTRACTOR shall provide detailed procedures for commissioning activities and shall arrange for its own personnel (including specialist VENDOR attendance as required) to be in attendance at any such activity.

4.4.2.4 Working documentation

CONTRACTOR shall submit a comprehensive list of documents to be submitted to COMPANY for review or approval. Instructions for preparing a list of documents is included in Appendix D3. A preliminary list is part of the tender submission. Format of the documentation shall be approved. Documents shall show the interfaces between existing and new equipment/facilities and systems.

Process and Instrument Diagrams (P&IDs) shall be prepared in an **approved** format compatible with topside prepared P&IDs. P&IDs shall show as a minimum, on a single diagram for each discrete piping system:

- Piping system diagrammatic arrangement
- Equipment

- Valves and fittings
- Instrumentation connection points and shut-off valves
- Instrumentation.

Each P&ID shall include labelling of equipment and key features, detail of piping materials, piping pressure rating and nominal bore, instrument type and duty. Tag numbers shall be indicated.

Test and trials procedures and VENDOR instruction manuals are to be available in their final format at least three months before testing and commissioning commences.

CONTRACTOR shall submit for confirmation before work commences a final version of **approval** documentation interfaces incorporating all comments, amendments and revisions.

4.4.2.5 Final documentation

CONTRACTOR shall submit a comprehensive list of final interface documentation to COMPANY. Final documentation shall include at least the following:

- Design documentation for the converted vessel:
 - Design and analysis procedures
 - As per **GS STR 651** 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
 - Analysis results and design reports for the new systems
 - Deadweight calculation and result of inclining experiment with the new equipment installed
 - Loading and stability information
 - Revised key plans and drawings
 - New equipment data
 - VENDOR drawings (new equipment)
 - MANUFACTURER's parts list with recommended spares for new equipment noted
 - Commissioning and test reports
 - Fabrication records (conversion)
 - Dimensional tolerance reports (Final Survey Reports)
 - Welding WPS's
 - Certificates for new equipment, systems and modifications to the vessel.
 - The format of final documentation shall be **approved**.

4.4.2.6 Operational manuals

CONTRACTOR shall prepare or commission from an approved specialist COMPANY a comprehensive set of Operational Manuals for the converted FPSO. The format and contents are to be approved and based upon the conversion requirements below.



The format shall be generally based upon bound A3 elasticised landscape sheets with illustrations facing descriptive text. The manuals for new equipment are to be as concise and self-contained as possible such that the operator can obtain all required information with recourse to other documentation. Illustrations shall be in colour to indicate different systems and fluid flows. Text shall describe the operating philosophy and operating procedures with, where appropriate, alarm lists, set points, operating points, etc.

Symbols and identification are to be in accordance with COMPANY's standard format.

The manuals for all existing and new equipment interfaces shall cover all normal and emergency operating procedures for the vessel. They shall be in three volumes as follows:

- Safety Systems and Equipment
 - Machinery and Domestic Utility Systems
 - Cargo and Ballast Systems - including pumping, inert gas, venting, tank cleaning, gas freeing, etc.
 - Drafts of each manual are to be submitted for **approval** at least three months before the start of testing and commissioning.

4.4.3 Installation

Installation shall be conducted as for a new-built unit.