



Exploration & Production

GENERAL SPECIFICATION

STRUCTURAL

GS EP STR 655

Requirements for conversion of a tanker into 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 19900	Petroleum and natural gas industries - General Requirements for Offshore Structures
ISO 19904-1	Petroleum and natural gas industries - Floating offshore structures - Part 1: monohulls, semisubmersibles and spars
ISO 13702	Petroleum and natural gas industries. Control and mitigation of fires and explosions on offshore production installations. Requirements and guidelines.
IEC 60079-10	Electrical apparatus for explosive gas atmospheres - Part 10: classification of hazardous areas
IEC 60092-502	Electrical Installations in ships - Part 502: Tankers - Special features
NFPA 750	Standard on Water Mist Fire Protection Systems

Professional Documents

Reference	Title
ISGOTT	International Safety Guide for Oil Tankers and Terminals
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)
OCIMF	Ship Inspection Report (SIRE) Programme

Regulations

Reference	Title
IMO MARPOL 73/78	International Convention for the Prevention of Pollution from ships
IMO Res. MEPC 139(53)	Guidelines for Application of MARPOL Annex I requirements to FPSOs and FSUs
IMO SOLAS	International Convention for the Safety of Life at Sea
IMO ICLL	International Convention on Load Lines
IMO 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
IMO IGC	International Gas Code

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 (topsides) 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 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

Total General Specifications

Reference	Title
GS EP SAF 216	Area classification
GS EP SAF 221	Safety rules for buildings
GS EP SAF 228	Liquid drainage
GS EP SAF 253	Impacted area, restricted area and fire zones
GS EP SAF 311	Rules for the selection of fire-fighting systems
GS EP SAF 321	Fire pump stations and fire water mains
GS EP SAF 322	Fixed fire water systems
GS EP SAF 331	Carbon dioxide fire extinguishing systems
GS EP SAF 351	Escape, evacuation and rescue from fixed installations
GS EP STR 105	Boat landings and bumpers
GS EP STR 601	Floating units integrity management system requirements
GS EP STR 651	General principles for a F(P)SO design
GS EP STR 652	F(P)SO - Steel hull design requirements

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 EP STR 651** for the definition 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 (Appendix 1 lists documentation and data to be provided for review). This consists 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 an 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 EP STR 601** a complete hydrodynamic and

a complete detailed structural model which shall also be provided as per **GS EP 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).