

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 up to installation on an offshore site.

The relocation of an existing F(P)SO to a new field can be considered as similar in scope to a conversion.

2. Reference documents

The reference documents listed below form an integral part of this General Specification.

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.

External Documents

Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and addendums, is the latest revision published at the effective date of this document.

Reference	Title
American Bureau of Shipping	Rules for Building and Classing Single Point Moorings
BV NI537	Guidelines for the Design of the Means of Access for Inspection, Maintenance and Operation of Commercial Ships
BV NI593	Ship Conversion into Offshore Units - Redeployment and Life Extension of Offshore Units
BV NR445	Rules for the Classification of Offshore Units
DNVGL-RU-OU-0102	Floating production, storage and loading units
IACS	Shipbuilding and Repair Quality Standard (N° 47) dated 1996
IEC 60092-502	Electrical installations in ships - Part 502: Tankers - Special features
IMO COLREG	International Regulations for Preventing Collisions at Sea
IMO ICLL	International Convention on Load Lines
IMO IGC	International Gas Code
IMO IS 2008	Code on intact stability for all types of ships covered by IMO instruments
IMO ISPS Code	International Ship and Port Facility Security code
IMO LSA Code	International Life-Saving Appliance Code

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Reference	Title
IMO MARPOL 73/78	International Convention for the Prevention of Pollution from ships AND AMENDMENTS
IMO MODU	Code for the Construction and Equipment of Mobile Offshore Drilling Units
IMO MSC 151(78)	Adoption of amendments to the International Convention for the Safety of Life at Sea, 1974, as amended
IMO MSC 158(78)	Adoption of amendments to the technical provisions for means of access for inspections
IMO MSC 215(82)	Performance Standard for Protective Coating (PSPC) for dedicated seawater ballast tanks of all types of ships of 500 gross tons and above and for the double-side skin spaces of bulk carriers of 150 m in length and upwards
IMO MSC 288(87)	Performance Standard for Protective Coating of Cargo Oil Tanks of Crude Oil Tankers (PSPC of COT)
IMO resolution A.897(21)	Amendments to the revised specifications for the design, operation and control of crude oil washing systems (resolution a.446 (xi) as amended by resolution a.497(xii))
IMO SOLAS	International Convention for the Safety of Life at Sea
ISGOTT	International Safety Guide for Oil Tankers and Terminals
Lloyd's Register of Shipping	Floating Offshore Installations at a Fixed Location
MARPOL - IMO resolution MEPC 139(53)	Guidelines for Application of MARPOL Annex I requirements to FPSOs and FSUs
NFPA 750	Standard on Water Mist Fire Protection Systems
OCIMF SIRE	Ship Inspection Report (SIRE) Program
OCIMF	Cargo Guidelines for F(P)SOs
UKCAA CAP 437	Standards for Offshore Helicopter Landing Areas-Seventh Edition

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Reference	Title
GS EP EXP 101	Pre-commissioning and Commissioning specification
GS EP EXP 103	Pre-commissioning and Commissioning engineering and preparation
GS EP EXP 105	Pre-commissioning Execution
GS EP EXP 107	Commissioning Execution
GS EP INS 110	Instrumentation for package units
GS EP INS 134	Design and supply of integrated control and safety system
GS EP INS 135	Cybersecurity Requirements for Industrial Information Systems (SII)
GS EP INS 156	Human Machine Interfaces (HMI)
GS EP LSO 201	Towing of Watercraft
GS EP SAF 221	Safety rules for buildings
GS EP SAF 261	Emergency Shutdown and Emergency Depressurisation (ESD & EDP)
GS EP SAF 311	Rules for the selection of active fire protection systems
GS EP SAF 312	Fire and Gas detection
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 fixed fire extinguishing systems
GS EP SAF 380	Safety engineering requirements for an F(P)SO
GS EP STR 100	Offshore steel structures - General
GS EP STR 108	Requirements for evaluation of finite elements analysis and results
GS EP STR 601	Floating Unit Integrity Management System Requirements
GS EP STR 602	F(P)SO - Requirements for the Certification of Compliance with International Maritime Conventions
GS EP STR 651	General principles for a F(P)SO design
GS EP STR 652	F(P)SO - Steel hull design requirements
GS EP STR 653	F(P)SO - Hull fabrication requirements

Reference	Title
GS EP STR 661	FPSO - Design requirements for mooring and anchoring systems
GS EP STR 901	Design rules and construction standards for ancillary structures of offshore and onshore installations

3. General

3.1 Definitions

For the purpose of this document, the following terms and definitions apply.

“Classification Society” designates any of the agreed Classifications Societies responsible for the classification of the F(P)SO.

“PPS” designates the applicable Project Particular Specifications.

“Engineering” designates all drawings, calculations and procedures required for the design, fabrication and installation on site of the F(P)SO.

“Works” means all and any part of the works and services required to be performed by Contractor for the fabrication and installation of the F(P)SO.

“Installation” designates all operations necessary for the safe positioning of the F(P)SO on its operation site, namely all transport, installation works, services and tests.

“Manufacturer” designates any subcontractor that has been awarded a contract for the supply of the F(P)SO or any of its components.

“Approval” means Managing entity of the referential written assent. Approval by managing entity will in no way relieve Contractor of any of his obligations, responsibilities or liabilities. The words "Approve", "Approved" and "Approval" shall be construed accordingly.

3.2 Classification

After conversion the F(P)SO shall be classed as a permanent offshore unit.

See typical requirements in [GS EP STR 651](#).

Minimum requirements for compliance with International Maritime Conventions ([IMO COLREG](#), [IMO ICLL](#), [MARPOL - IMO resolution MEPC 139\(53\)](#), [IMO SOLAS](#), [IMO LSA Code](#), [IMO IS 2008](#), [IMO ISPS Code](#), [IMO MODU...](#)) are defined in [GS EP STR 602](#).

The parts covered by classification are, as a minimum, those which may jeopardise the safety or integrity of the unit:

- Hull: structural integrity, tightness, stability, freeboard (including interface with process plant, permanent mooring, import and export...)
- “Hull” systems: machinery, piping, ballasting and stripping, cargo, inerting, generators Accommodation
- Safety systems (fire-fighting, evacuation)
- The anchoring or positioning system

- Lifting/handling gears
- The product transfer systems (side by side or tandem offloading).

Classification marks and notations are assigned to each unit. They indicate the functions or equipment covered by the classification and the CS' mark of confidence in the unit.

The main marks used for vessels and offshore units are listed and detailed in the respective Rules of the different Class societies. Some are compulsory (for example, BV mark POSA for Permanent mooring of F(P)SOs) and others are optional.

The future F(P)SO marks and notations shall be taken into account for the different analysis, checks and assessments to be done along the project, starting from tanker selection stage.

3.3 Abbreviations

CS	Classification Society
FPSO	Floating Production Storage Offloading
FSO	Floating Storage Offloading
NTE	Not To Exceed
OLS	Offloading System
PPS	Project Particular Specification
ULCC	Ultra Large Crude Carrier
VLCC	Very Large Crude Carrier

4. Tanker selection

4.1 Functional requirements

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

The main expectations for the tanker shall be described in a questionnaire/check-list that will be used by company during the pre-selection phase.

4.1.1 Minimum storage requirements

Refer to **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 tons grossly equivalent to 7500 barrels to which potential additional stability impact has to be considered). Integration from the beginning of proper topsides NTE as per **GS EP STR 100** is of a particular importance, particularly as on a converted tanker the hull carrying capacity is already defined.

4.1.2 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.

Total life (tanker + F(P)SO) shall not exceed a maximum of 30 years. The use of a converted unit cannot be envisaged for field life longer than 15 years.

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

4.1.3 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.

4.1.4 Complexity of the additional facilities

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

4.2 Status of the tanker

An oil tanker will be considered for conversion only if she still satisfies her flag and classification requirements. This will in particular cover the **IMO SOLAS** part.

All vessels candidates for conversion will comply with PSPC (**IMO MSC 215(82)**) (or PSPC of COT (**IMO MSC 288(87)**)).

The Stability analysis of the converted unit in intact and damage conditions will have to comply with **IMO ICLL**, **IMO MARPOL 73/78** and **IMO MODU** requirements.

All vessels candidates for conversion will be double hull.

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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 will apply.

4.3 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:

4.3.1 Preparation of the inspection

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

- Identify the list of equipment likely to be kept, define the permanent mooring system (turret or spread), and establish the energy balance. The vessel inspection questionnaire/check-list shall then be amended as appropriate.
- Undertake a documentary investigation. This consists of examining the dossiers of the ship (class status, ESP files, VPQ/VIQ (OCIMF SIRE (Ship Inspection Report (SIRE) Program) records), Clarkson database, PSC controls, Computerized PMS system, IMO Coating File, ship's own inspection and maintenance records ...) 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. 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, a pair of permanent ballast tanks in the midship area, a ballast tank in the aft area and a ballast tank in the forward area and at least two cargo tanks. The documentary investigation should also include 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.).
- It is recommended that, as far as possible, a 2D model of the midship section is done and a deterministic (conservative) check of the cargo holds structure is run for targeting an inspection in the cargo area. Areas prone to fatigue damage under trading tanker service and to overstress and fatigue under offshore service would be highlighted.

4.3.2 Inspection

Experienced personnel shall be involved in this difficult inspection which is unlikely to benefit of the proper conditions of a close visual inspection, as the preliminary inspection will be done without major disruption of the vessel normal trading activities (short duration, probably en route).

The inspection team shall comprise:

- A team leader (HQ Naval Architect senior specialist from Structures, Naval Architecture and Civil Engineering Department)
- One inspector: hull and structure from T&S/TM/Technical
- One inspector: marine equipment from T&S/Vetting
- One inspector: Marine specialist from HQ logistics and Operational support.

Ballast tanks inspection can be done in any loaded voyage providing the weather conditions are good but also during a planned stopped (e.g. afloat Intermediate Survey), while the cargo tank inspection can be done during a planned stopped (e.g. bunkering, afloat IS) providing sufficient time is given for the preparation of the cargo tank. General inspection can be done in any loading/offloading operation or during all type of voyage.

For all rotating/static equipment, the operating records, oil analyses, vibration analyses, maintenance log, technician reports etc. shall be examined and compared with reference documents, and these components shall be visually inspected under operating conditions.

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

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

The visual inspection of tanks shall 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. The Group representatives however, do everything possible to ensure the inspection plan is complied with (tanks washed and made gas free). Sufficient time shall be allowed for this first inspection (minimum two days).

4.3.3 Reporting

On completion of the inspection, the inspection team shall:

- Issue an inspection report clearly highlighting any problems and further checks to be implemented to determine the ship condition together with any particular advantages she 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.
- The final conclusion of the report shall be validated by the authorised entity which is the Floating Unit Integrity Surveillance team (FUIS Team).

4.4 Selection inspection

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

The Selection inspection shall include several steps:

4.4.1 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

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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 shall 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.

4.4.2 Inspection

4.4.2.1 Corrosion

Thickness measurements shall be taken in the tanks during the inspection. As these cannot at this stage cover the whole vessel, they shall 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 measurement points will exceed several thousands 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.) shall also be checked.

4.4.2.2 Fatigue

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

4.4.3 Calculation

The preliminary forecast of the degradation of the hull structure (corrosion, fatigue...) is particularly important in this step to ensure that after conversion works, there won't be any major structural failures due to the previous life as a trading tanker. A finite element model is recommended for pointing out the weak areas as trading tanker and the expected future weak areas during offshore service life.

There are two sets of calculations to be made.

First, the finite element model shall be built using the original plans and the latest information available on the ship status. The calculations made are used, as described above, to guide the inspectors during 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 budgets.

The Finite Element Analysis shall be performed and reported following the requirements of the **GS EP STR 108**.

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4.4.4 Reporting

On completion of the selection inspection, the report issued to the project group shall 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 shall also include indications as to the extent and nature of the hull conversion works.

5. Design for repair and conversion

5.1 Classification and flag

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

Conversion will be performed to given site-conditions as per "offshore rules". The converted unit shall be reassessed entirely based on the offshore rules criteria and based on [BV NI593](#) (or equivalent, if unit is not classed BV). Existing design cannot be just validated on the principle that it was checked at the time of new building on ships' rules in spite of the fact that some Classification Societies may allow for this.

Attention is drawn to the fact that offshore requirements may be different and more stringent than ship rules, due to the fact that on-site inspection and repairs are more difficult to perform.

5.2 Hull condition analysis

5.2.1 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 building 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.

This assessment is the analytical process that uses the reported hull status as data input to review the capability of the structure and is twofold:

- On the basis of ultimate strength

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

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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.

5.2.2 Analysis Software

The following Classification Society software programs 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.

5.2.3 Input Data

- At Vessel Selection stage:
 - Mid ship Section, Transverse Bulkhead Scantling Plan, Profile and Deck Plan, Shell Plates and profiles
 - Capacity Plan
 - Trim and Stability booklet
 - Inspection report with wastage evaluation summary
 - ESP files (close-up survey, thickness measurement...)
 - Rough vessel history as far as possible: age, trading routes, any lay-up period...
- For Conversion Design and further follow-up:
 - Full set of structural drawings (as is as per ESP code, and preliminary engineering drawings after conversion including risers, topsides and mooring)
 - Detailed inspection report (at each inspection step)
 - Future site conditions: metocean, topsides weight estimation and distribution, mooring arrangement, loading/offloading cycle...

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).

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5.2.4 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 (impact of conversion modifications (topsides) to be included).

- 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 cumulated trading tanker life, transit to site and planned site operations.

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

5.2.5 Requirements for repairs and conversion

5.2.5.1 Hull structure

A detailed steel gauging report shall 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 shall include all necessary works to cope with these temporary conditions (temporary protection against corrosion, verification of strength, stability, etc.).

Repairing shall not be just "stiffening weakened parts". An assessment shall 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.

5.2.5.1.1 Block joints

The block joints shall be inspected with particular attention to the transverse horizontal mega block joints. Methodology and tools developed shall be approved by CPY.

All flaws identified having the potential to lead to structural failure shall be repaired.