



Exploration & Production

GENERAL SPECIFICATION

STRUCTURAL

GS EP STR 661

FPSO - Design requirements for mooring and anchoring systems

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1. Introduction

1.1 General

This specification intends to clarify the basis on which the positioning by means of anchor lines shall be designed. It shall apply to spread or turret moored F(P)SOs. The present specification apply also to FPU, covered under the acronym F(P)SO in the text. Application to other type of floating units is subject to Company approval. Mooring of F(P)SOs shall always be considered as "long term mooring".

In case of F(P)SO moored to a CALM Buoy, reference is to be made to **GS EP STR 631**.

The document [ISO 19901-7](#) "Petroleum and natural gas industries - Specific requirements for offshore structures - Part 7: Station-keeping systems for floating offshore structures and mobile offshore units," is the main reference.

It is reminded that the Monitoring, Inspection, Maintenance and Repair features are integral parts of the mooring system design.

1.2 Interfaces

1.2.1 Interfaces related to mooring installation

Interfaces related to installation have a strong impact on design of the mooring, typically on the anchor piles and connectors. They shall be indentified at basic design. The battery limits shall be set out between the different parties involved in the installation. During detail engineering, impacts on mooring design shall be addressed and receive validation from the party in charge of mooring installation.

1.2.2 Interfaces related to F(P)SO hook up

Interfaces related to F(P)SO hook up may have impact on top chain length, deck layouts, deck operations, rigging and underwater operations at fairleads level etc. These interfaces shall be identified between the involved parties early in the detail engineering.

1.2.3 Interfaces with mooring equipment

F(P)SO Contractor shall manage all interfaces between the F(P)SO structure and the mooring equipment. Typically the underwater fairleads attachments to the hull shall be checked compatible with the hull stiffeners spacing. The interfaces shall be addressed in detail for equipment such as:

- Fairleads
- Chain stoppers
- Tensioners and associated equipment
- Pre-tensioning winches and associated equipment.

1.3 Units

SI units shall be used in all documents. Nevertheless, standardized diameters for cable and chain may be expressed in inches. When applied, the symbol for inches (" or in.) shall be clearly mentioned.

1.4 Abbreviations

The following abbreviations are used in the present specification:

ALARP	As Low As Reasonably Practicable
BV	Bureau Veritas
Class, or CS	Classification Society
CoG	Centre of Gravity
DNV	Det Norske Veritas
FE(A)	Finite Element (Analysis)
F(P)SO	Floating, (Production), Storage and Offloading unit
FPU	Floating Production Unit
GS	Company General Specifications
HF	High frequency (associated with wave frequency)
ICSS	Information Control and Safety System
IMO	International Maritime Organization
LF	Low frequency (associated with mooring frequency)
MBL	Minimum Breaking Load
MMS	Mooring Monitoring System
MWS	Marine Warranty Surveyor
NDE	Non Destructive Examinations
OOL	Oil Offloading Line
PPS	Particular Project Specification
QA/QC	Quality Assurance / Quality Control
QTF	Quadratic Transfer Function
RAO	Response Amplitude Operators
ROV	Remote Operated Vehicle
SMCB	Subsea Mooring Connector (ball type)
SWL	Safe Working Load
SSW	Spiral Strand Wire
VCG	Vertical Centre of Gravity

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.



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.

If there are no national regulations covering all or part of the subject of this document, the reference documents shall be strictly applied, as supplemented by the provisions of this document.

Only the main reference documents are mentioned; the Contractor shall be responsible for complying with all secondary reference documents dealing with the subject of this document.

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

Standards

Reference	Title
EN 287-1	Qualification test of welders - Fusion welding - Part 1: Steels
EN 288-3	Specification and Approval of Welding Procedures for Metallic Materials - Part 3: Welding Procedure Tests for the Arc Welding of Steels
EN 473	Non destructive testing - Qualification and certification of NDT personnel - General principles
EN 571	Non destructive testing. Penetrant testing
EN 970	Non-destructive examination of fusion welds. Visual examination
EN 1290	Non-destructive examination of welds - Magnetic particle examination of welds
EN 1435	Non-destructive examination of welds. Radiographic examination of welded joints
EN 1714	Non destructive examination of welds. Ultrasonic examination of welded joints
ISO 3730	Shipbuilding - Mooring winches
ISO 19901-7	Petroleum and natural gas industries - Specific requirements for offshore structures - Part 7: Station-keeping systems for floating offshore structures and mobile offshore units

Professional Documents

Reference	Title
API RP 2I	In-service Inspection of Mooring Hardware for Floating Structures
API RP 2SK	Design and Analysis of Station-Keeping Systems for Floating Structures
API RP 2SM	Recommended Practice for Design, Manufacture, Installation, and Maintenance of Synthetic Fiber Ropes for Offshore Mooring



Reference	Title
API RP 2FP1	Recommended Practice for Design, Analysis and Maintenance of Moorings for Floating Production Systems
API SPEC 2F	Specification for Mooring Chains
BV NI 461	Quasi-dynamic Analysis of Mooring systems
BV NI 493	Classification of Mooring Systems for Permanent Offshore Units
BV NI 432	Certification of Fibre Ropes for Deepwater Offshore Services
BV NR 216	Rules on Materials and Welding for the Classification of Marine Units
BV NR 445	Rules for the Classification of Offshore Units
Det Norske Veritas OSS 102	Rules for Classification of Floating Production, Storage and Loading Units
Det Norske Veritas OS E301	Position Mooring
Det Norske Veritas OS E302	Offshore Mooring Chain
Det Norske Veritas OS E304	Offshore Mooring Steel Wire Ropes
Det Norske Veritas RP E302	Design and Installation of Drag-in Plate Anchors in Clay
Noble Denton / TTI	Deep water Fibre moorings, an engineers' design guide First Edition Rev 0 - January 1999
OCIMF	Prediction of Wind and Current Loads on VLCCs

Regulations

Reference	Title
Not applicable	

Codes

Reference	Title
AWS A5.01 - 93	American Welding Society - Filler metal procurement Guideline
AWS D1.1	American Welding Society - Structural welding code - Steel



Other documents

The provisions of this document shall be applied in the light of the supplementary documents supplied by the Company, including:

- Country specificity appendices
- Project specification
- Site data information (Bathymetry, Metocean, soil conditions).

Reference	Title
Not applicable	

Total General Specifications

Reference	Title
GS EP COR 100	Design of cathodic protection of offshore structures
GS EP COR 350	External protection of offshore and coastal structures and equipment by painting
GS EP GEO 702	Requirement for the design and installation of skirted foundations and suction anchors
GS EP EXP 311	Plant integrity - Minimum Inspection Requirement
GS EP INS 135	Cyber Security requirements for design and supply of ICSS and Package Systems
GS EP STR 002	Permanent Lifting and Handling Devices for Offshore Installations
GS EP STR 004	Riser / Umbilical Pull-in Rig and Mooring Winches
GS EP STR 201	Materials for Offshore Steel Structures
GS EP STR 202	Cast Materials for Steel Structures
GS EP STR 203	Forged Materials for Steel Structures
GS EP STR 301	Fabrication of Offshore Steel Structures
GS EP STR 402	Anchorage for support vessel on an offshore site
GS EP STR 601	Floating unit integrity management system requirements
GS EP STR 611	Determination of the location of an offshore terminal
GS EP STR 631	Installation of piles for offshore steel structures. Driven piles
GS EP STR 652	F(P)SO - Steel Hull Design Requirements
GS EP STR 653	F(P)SO - Hull Fabrication Requirements



3. Classification

The F(P)SO mooring system shall be covered by Classification.

The scope of the Classification shall cover all the activities necessary to obtain the CLASS Notation (equivalent to Bureau Veritas POSA Notation) of the mooring system inclusive of the review of the specification of the equipment to be installed on board the F(P)SO.

The scope of Classification for the F(P)SO Mooring System shall include:

- Mooring line components (anchors, chains, wire and accessories, etc.)
- Hull mounted equipment (fairleads, stoppers, etc.)
- Mooring line handling equipment (winch, sheaves, etc.).

All equipment covered or not by CLASS, shall be provided with relevant certifications and track record evidence for Company and CS (Classification Society) review and approval.

4. Mooring analysis

4.1 General

This section provides methods for implementing and modelling operating and environmental extreme loading conditions on the F(P)SO, design criteria and minimum requirements for the calculation approach and software to be adopted.

Frequency domain approach alone is not accepted at detail engineering stage. Low frequency motions calculation shall be based on time-domain simulations.

Line dynamics for the most loaded line can be analysed separately using time-domain software.

If line dynamics are shown to be negligible, line tension computation can be based on a quasi-dynamic approach.

The results of model tests shall be used to calibrate the numerical models.

The effect of the risers & Offloading lines (Non linear restoring force, drag force and damping) in the F(P)SO response shall be accounted for in the mooring analysis

A full Risers/Mooring coupled analysis shall be then carried out to assess and verify the moored F(P)SO dynamic behaviour under a number of fatigue and extreme sea states.

The mooring system shall be optimised through:

- Mooring pattern (line arrangement and spread angle) and layout
- Chain and steel wire rope grade, diameter and length of each segment of the mooring line
- Mooring anchors shall be placed at appropriate depths in accordance with the field bathymetry. Seabed slope shall be modelled into the analysis.

The anchor location with respect to existing or future subsea equipment (such as pipelines, flowlines, umbilicals, manifolds, PLEM, wells etc.) shall be in accordance with requirements defined in the **GS EP STR 402** section 4. For suction or driven piles, the minimum distance shall not be less than 200 m unless specified otherwise in project specification.

In principle, mooring line crossing over pipeline/flowline, subsea equipment shall be avoided.



The Particular Project Specification (PPS) shall define the field layout constraints (sub-sea equipment, pipelines, flowlines, umbilicals...) and minimum exclusion zone around mooring lines.

4.2 Design/Analysis Cases

Analysis cases shall cover extreme and operating, intact and damaged mooring conditions.

Environmental and operating loads shall be combined in order to determinate the most onerous loading scenarios on the mooring system for the following conditions as a minimum:

- a) Intact Mooring - F(P)SO at ballast draught
- b) Intact Mooring - F(P)SO at full draught
- c) Damaged Mooring - F(P)SO at ballast draught
- d) Damaged Mooring - F(P)SO at full draught
- e) Installation conditions: to be addressed within project execution phase.

Intermediate loading conditions shall be investigated to confirm that they are less severe than the above design conditions.

This investigation shall take into account that the cargo distribution in the tanks can significantly affect the hydrodynamic behaviour of the F(P)SO (free surface and inertia effects).

Contractor shall document, for Company and CS approval, the methodology used to identify the controlling load cases for the mooring design. The design cases shall include (but not be limited to) the design cases mentioned within this chapter. Extra cases may also be required by the Classification Society.

4.3 Combinations for mooring design

4.3.1 Environmental combinations and headings

Combination of wave, wind and current shall be selected from metocean specification subject to Company and CS approval.

Environment shall be applied in both collinear and non-collinear cases from 0deg to 360 degrees relative to the F(P)SO bow.

A minimum of 16 directions spaced around and covering all non-symmetrical environmental combinations shall be analysed for the selection of the design cases.

Heading for non-collinear cases shall be represented by the wave direction (a sufficient number of cases shall be selected spread from 0deg to 360 deg according to metocean available data). Non collinear wind and wave directions shall be referred to the wave incidence. Non-collinear environmental extremes shall be determined in accordance to [DNV-OS-E301](#). Additional load cases may be required by Classification Society.

4.4 Design loads

Design environmental forces shall be calculated for all incidences. Collinear environmental conditions and non-collinear combinations of environmental extremes shall be considered.

Design environmental loads on the F(P)SO Hull and Superstructure shall be validated and calibrated against model test results.