



Exploration & Production

GENERAL SPECIFICATION

STRUCTURAL

GS EP STR 101

Design of offshore jacket and subsea structures

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1. Scope

This document defines the codes, standards, reference documents, the procedures and the acceptance criteria to be applied for the design of jackets and subsea structures, including the piles and all relevant appurtenances such as, but not limited to:

- Surfer landings
- Mud mats
- Risers, I-tubes and their supports
- Conductor pipes, caissons
- Walkways, stairways, ladders
- Cathodic protection
- Positioning, leveling systems
- Protection frame (subsea structure)
- BOP and CP guides and supporting structure (subsea structure)
- Work platforms (subsea structure).

This document amends, supplements and replaces various clauses/sections of [API RP 2A](#) and [API RP 17A](#) for the studies and works to be performed for jacket and subsea structure design.

The section numbers that appear in the following sections refer to the corresponding section of the [API RP 2A LRFD](#) referenced above.

The design shall be performed according to [API RP 2A WSD](#) or [API RP 2A LRFD](#) which is subject to Company approval, unless otherwise indicated in the present specification.

In all cases, the design principle (i.e. WSD or LRFD) shall be the same for all parts of the platform (jacket, deck, etc.), and for all conditions.

Materials for procurement, welding and associated inspections are covered by specifications [GS EP STR 201](#), [GS EP STR 301](#) and [GS EP STR 304](#).

The superstructure design (topsides, modules, bridges, flares) shall be conducted in accordance to specification [GS EP STR 102](#), and shall utilize the same design principle (i.e. WSD or LRFD) as for the jacket.

2. Reference documents

The reference documents listed below form an integral part of this General Specification. Unless otherwise stipulated in the CONTRACT, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published at the EFFECTIVE DATE of the CONTRACT. References to superseded standards that may occur on technical documents will not over-write this clause.

The structural design of offshore jackets and subsea structures shall be conducted in accordance to the reference documents including codes and standards defined hereafter.

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, subject to prior Company approval.



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 specification and the project documents.

In case the design of a particular structure or part of a structure is not covered by any of the listed reference documents, Contractor shall propose the use of a reputed and fit for purpose international code or regulation, subject to Company approval.

In all cases, Contractor shall avoid to mix the requirements of several different codes or regulations when designing a particular item of a structure.

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.

Standards

Reference	Title
AISC	Steel Construction Manual
API Bulletin 2V	Bulletin on design of flat plate structures
API Bulletin 2U	Bulletin on stability design of cylindrical shells
API RP 2A LRFD	Recommended Practice for Planning and Constructing Fixed Offshore Platforms Load and Resistance Factor Design
API RP 2A WSD	Recommended Practice for Planning and Constructing Fixed Offshore platforms, Working Stress Design
API RP 17 A	Recommended Practice for design and operation of subsea production systems
ASTM A 307	Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength
ASTM A 325	Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
ASTM A 490	Structural Bolts, Alloy Steel, Heat Treated, 150 ksi Minimum Tensile Strength
DNV-OS-A101	Safety Principles and Arrangements
DNV-OS-C101	Design of Offshore Steel Structures, General (LRFD method) and subsequent references
DNV-OS-C201	Structural Design of Offshore units (WSD method) and subsequent references
DNV-RP-C203	Fatigue strength analysis of offshore steel structures
DNV-RP-C204	Design against Accidental Loads
DNV-RP-C205	Environmental conditions and environmental loads
EN 10164	Steel products with improved deformation properties perpendicular to the surface of the product - Technical delivery conditions
EN 10204	Metallic products - Types of inspection documents



Reference	Title
NF P22-255 or equivalent	Metal construction. Hollow section welded assemblies on type I and H sections. Design and verification
ISO 898-1	Mechanical Properties of Fasteners Made of Carbon Steel and Alloy Steel - Part 1: Bolts, Screws and Studs
ISO 1000	SI units and recommendations for the use of their multiples and of certain other units
ISO 19900	Petroleum and natural gas industries - General requirements for offshore structures
ISO 19901-1	Petroleum and natural gas industries - Specific requirements for offshore structures - Part 1: Metocean design and operating conditions
ISO 19901-2	Petroleum and natural gas industries - Specific requirements for offshore structures - Part 2: Seismic design procedures and criteria
ISO 19901-4	Petroleum and natural gas industries - Specific requirements for offshore structures - Part 4: Geotechnical and foundation design considerations
ISO 19901-5	Petroleum and natural gas industries - Specific requirements for offshore structures - Part 5: Weight control during engineering and construction
ISO 19901-6	Petroleum and natural gas industries - Specific requirements for offshore structures - Part 6: Marine operations

The document [ISO 19901-6](#) is nearing completion and formal issue.

The Company recognizes these documents as a source of sound recommendations on good practice. However, in some cases the requirements of these International Standards do not comply with the requirements of the Company's General Specifications. Furthermore, there exists within these International Standards the requirement for the owner or operator to define certain parameters which may override suggested default values.

In general terms, the requirements of formally issued [ISO 19901-X](#) when available shall be applicable in context to the design of new structures for Company and to the insurance that operations are performed within defined and recognized safety/confidence levels where these requirements are additional to or are more onerous than the requirements stated in the Company's General Specifications and Project Particular Specifications. In this context, the default values of parameters are recommended by these International Standards shall apply, unless more onerous values are stipulated within the Contract documents.

Any other proposal based on the content of these International Standards shall be subject to Company approval.

**Professional Documents**

Reference	Title
Not applicable	

Regulations

Reference	Title
Not applicable	

Codes

Reference	Title
ASME VIII Div 1	Rules for construction of pressure vessels
AWS D1.1	Structural Welding Code - Steel
BSI PD 5500	Specification for unfired fusion pressure vessel

Other documents

Reference	Title
OTH 92 379	A criterion for assessing wind induced crossflow vortex vibrations in wind sensitive structures

Total General Specifications

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

- Country specificity appendices
- Particular specification
- Data sheets
- Articles and conditions; list of tasks
- Quality assurance provisions.

Reference	Title
GS EP COR 100	Design of cathodic protection of offshore structures
GS EP COR 222	Fusion Bonded Epoxy (FBE) external coating for pipelines
GS EP COR 350	External protection of offshore and coastal structures and equipment by painting

Reference	Title
GS EP COR 353	Design and application of passive fire protection coatings
GS EP GEO 702	Requirements for design and installation of skirted foundations and suction anchors
GS EP SPS 009	Corrosion protection of subsea stations
GS EP STR 001	Weight monitoring and weighing offshore units
GS EP STR 100	Offshore steel structures - General
GS EP STR 102	Design of offshore topside structures
GS EP STR 105	Boat landings and bumpers
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 304	Fabrication of welded plate girders (W.P.G.)
GS EP STR 401	Loadout, seafastening, transportation and installation of offshore structures
GS EP STR 431	Installation of piles for offshore steel structures. Driven piles
GS EP STR 432	Installation of piles for offshore steel structures. Drilled and grouted piles
GS EP STR 901	Design rules and construction standards for ancillary structures of offshore installations

3. General design requirement

3.1 General principles

The following principles shall be taken into account in the design of structures:

- Principles for load-out, transportation, installation, lifting, launching or for any particular phase or condition, which has a major impact on certain component of the structures, shall be integrated in the design at the very beginning of the design phase
- Hook-up works shall be reduced to a minimum and shall be made as easy as possible. Consequently each element, even if of secondary importance, shall be analysed in order to maximize the amount of work to be carried out on the fabrication site
- Inspection and maintenance works of installed structures shall be easily accomplished. Maximum access to all elements and at all phases of platform life should be provided
- Unnecessary or duplicated permanent loads (skids + flooring underneath, modules + flooring underneath, etc.) shall be avoided



- Safety shall be considered as priority and shall be taken into consideration from the beginning of the design, including for the temporary phases (load-out, transport and installation). Particular attention shall be paid to accessibility, circulation routes, escape routes, muster areas, partitions, fire resistance, finish materials, etc
- Future extensions and additional loads (if any such as Company reserve) shall be considered and the consequent design arrangements shall be made
- The platform should be designed such that the first natural period of the platform is less than 3 seconds, unless otherwise agreed by Company.

3.2 Importance of structural members

3.2.1 Structural members

The structural members of the resisting structures are distributed into three categories of importance, mainly in regard of the consequences of their possible failure during platform production or during installation of constituting parts of the platform (lifting of packages, etc.), as defined in **GS EP STR 100**.

This distribution of structural members into categories of importance shall be submitted to Company for prior approval.

3.2.2 Non structural members

Accessory and finishing elements, i.e. not participating in the overall strength of the platform structures (catwalks, hand-rails, stairs, ladders, grating, false flooring, etc.) constitute a class separate from that of Structural Members defined above.

3.3 Air-gap

The bottom of the lowest superstructure (deck) or piece of equipment shall be located at an elevation such as to provide a clearance “air-gap” above the highest foreseeable wave crest elevation superimposed on the maximum surge height plus the normal Mean High Water Springs (MHWS) (or HAT if required by project documents).

Unless stipulated otherwise, the air-gap shall be taken as 1.50 m minimum from the lowest part of the structure or piece of equipment, and shall also take into account any known or predicted long term seafloor subsidence.

100 years return period wave crest elevation shall be used unless otherwise noted.

Whenever it is unavoidable to have a minor part of the superstructure or a piece of equipment located within the air-gap defined above, wave loads shall be taken into consideration on this part of the structure or piece of equipment. However they will not be cumulated to the global wave loads acting onto the jacket and the foundations unless noted otherwise in the project specification.

Local verification of this part of the superstructure or piece of equipment, and its connection to the rest of the structure, shall also be carried out.

These wave forces affecting the items located in the air-gap may be evaluated as per **API RP 2A WSD**, section 2.3.4g.

In case of large equipment located in the air-gap, Company may request to consider global wave load effect (i.e. effects on deck, jacket and pile design).

It is also a requirement unless waived by Company that the main topside structure is not struck by the crest of a 1,000-year return (positive air gap).

In addition, for a rare-event wave of 10,000-year return all resulting forces shall be considered in the global analysis to demonstrate no progressive collapse, and that water doesn't threaten personnel's life or damage pipes and other equipment which may lead to environmental damage.

3.4 Splash-zone

The splash-zone to be considered for structural design shall extend between:

- The crest level of the 100 years wave superimposed on the maximum surge height plus the normal Mean High Water Springs (MHWS)
- Below the Lowest Astronomical Tide (LAT) minus 3 meters or the annual swell trough whichever is the greater.

3.5 Corrosion allowance

Unless otherwise specified in the particular specifications, a corrosion allowance equal to 6 mm shall be added to the thickness of the special or first category members located in the splash zone including:

- Jacket legs
- Piles above jacket
- Deck legs
- Transition pieces
- Diagonal braces and nodes pertaining to the faces of the jacket
- Peripheral members and nodes pertaining to the upper horizontal level
- Members pertaining to second horizontal level if located in splash zone.

Note: Diagonal members pertaining to the upper horizontal level shall not have a corrosion allowance.

For fatigue analyses, the corrosion allowance may be considered equal to one half of the above values (3 mm).

Corrosion allowance for subsea structures shall be defined in the project documents.

3.6 Minimum thickness

The minimum thickness shall be:

- 8 mm for special and first category components and jackets
- 5 mm for other components
- 3.7 mm for handrails.

3.7 Maximum slenderness ratio of members

The maximum slenderness ratio for jacket tubular members shall be limited to 120. For sensitive non-redundant members Company may limit the maximum slenderness ratio to 90. For jacket located in particular seismically active areas the maximum slenderness ratio shall be limited to 80 ([API RP 2A WSD](#) Earthquake design requirements).

3.8 Connections

3.8.1 Welded connections

The connections shall be designed in such a way that:

- They shall allow for a direct, straightforward and simple load transfer from one structural member to another, avoiding stress concentration and induced bending stresses as far as possible
- Their fabrication shall be as simple as possible; constructability and welding access shall be particularly verified during design
- Notching effects are eliminated
- Corrosion is reduced to a minimum. This means avoiding shapes or arrangements that induce retention or ponding of water or hydrocarbons, in order to avoid hazards and ease inspection and maintenance/painting.

All structural connections shall be justified by calculations.

3.8.2 Bolted connections

1. Bolted connections between structural members pertaining to special or first category shall be avoided as far as possible. Bolts in tension should not be used for lift points and bolted connections should not be located in splash zones or zones otherwise subject to intermittent wetting, or in other zones where inspection is difficult or impossible. If such connections are unavoidable their use and detailing shall be subject to Company Approval.
2. Mechanical/locking devices of nuts shall be provided for bolted connections between structural members pertaining to special or first category, to masts, to equipment superstructures, to vibrating equipment, etc.
3. In case bolted connections have to be implemented, they shall be designed according to [AISC](#) Steel construction manual (latest edition):
 - Part 7: Design considerations for bolts
 - Part 9: Design of connecting elements
 - Part 10: Design of simple shear connections
 - Part 11: Design of flexible moment connections
 - Part 12: Design of fully restrained moment connections
 - Part 13: Design of bracing connections and truss connections
 - Part 14: Design of beam bearing plates, column base plates, anchor rods and column splices



- Part 15: Design of hanger connections, bracket connections, and crane rail connections
- Part 16: Specifications and Codes:
 - [AISC](#) Specification for structural steel buildings, chapter J: connections, joints and fasteners
 - RCSC Specification for structural joints using [ASTM A 325](#) or [ASTM A 490](#) bolts for High Strength (HS) bolting
- 4. Bolting shall generally be in carbon steel to [ASTM A 307](#), [ASTM A 325](#) or to [ISO 898-1](#). [ASTM A 490](#) bolting can be used where it is confirmed that bolt materials are limited to have an actual yield strength no higher than 950 MPa and hardness no higher than HRC 34.
- 5. The use of High Strength bolts shall be subject to prior approval of the Company.

High Strength bolts shall be in full compliance with the testings and requirements of [ASTM A 325](#) or [ASTM A 490](#). The mechanical properties shall be subject to sample inspections using the "shipping lot method" and a copy of the inspection test report for each shipping lot shall be furnished to the Purchaser and Company.

Use of HS bolts subject to shearing stresses shall not be permitted in non-sheltered areas opened to projections or dripping of liquids. Utmost care shall be taken to ensure assembly resistance to corrosion.
- 6. Where components in materials other than carbon steel are joined with bolts then the bolting material should match so far as possible. Company approval for such bolts shall be gained.
- 7. Connections shall be classed as "pretensioned joints" or "slip critical joints" where so required by section J.1-10 of the [AISC](#) Specification for structural steel buildings and/or section 4.3 of RCSC Specification for structural joints using [ASTM A 325](#) or [ASTM A 490](#) bolts. Drawings of bolt connections shall in all cases identify the joint type as "snug-tightened", "pretensioned" or "slip-critical" as applicable, and shall define associated requirements.
- 8. Fabrication procedures for Company Approval shall be developed accordingly, to define procedures for bolt handling, coating provisions and joint assembly.
- 9. Anti-corrosion measures shall follow the following requirements unless noted otherwise:
 - For areas in and above of the splash zone, the bolting shall be galvanized and then painted. All threaded components of the fastener assembly must be galvanized by the same process.
 - For areas in the splash zone and below, all contact surfaces shall be painted even for slip resistant joints with a reduced friction coefficient.
 - For immersed zones, the bolting shall be painted at least for corrosion protection during fabrication, and painted or oiled during storage. Electrical continuity shall be provided with serrated washers or similar to be approved by Company.
 - Zinc plated bolts shall be avoided due to QA/QC problems (hydrogen embrittlement).

Anti-corrosion measures shall have prior approval of the Company.

10. For joints with controlled tightening bolts:

- The ratio of the Tightened Length (TL) to the bolt diameter (d) shall not be less than 5 ($TL/d \geq 5$).
- The friction coefficient(s) between nut and washer, measured by bolt manufacturing mill on the supplied production lot(s), shall be reported on bolt mill certificate(s) and on bolt individual lot packing.

Note: The friction coefficient is defined as follows:

$$K = 1000 C / (d \times P \times 0.88)$$

Where:

- K is the friction coefficient
- C (in N.m) is the torque to be applied to obtain a pre-load P (in N) in the bolt
- d (in mm) is the nominal bolt diameter.

11. Only three clearly different bolt diameters shall be used per structure.

12. The responsible party for supply shall provide full certification in accordance with the reference standard, meeting Type 3.1 of [EN 10204](#) or equivalent.

13. Bolting in clamps for risers, riser bend restrictors, and similar applications shall comply with [GS EP SPS 009](#) (§ 5.1).

3.8.3 Doubler plates

Connection of all jacket appurtenances such as, but not limited to anodes, bumpers, boat landing, surfer landing, any type of protective frame, mooring bollard, sea-fastening, etc. to jacket main structure (Special and First category members) shall be achieved via doubler plates with rounded corners and fillet welded to the supporting member.

Doubler plates shall be of First category.

With a maximum of 50 mm the doubler plate shall be twice its thickness all around the dimension of incoming brace foot print and shall have 50 mm radius corner.

Doubler plate thickness shall not be less than the incoming bracing wall thickness.

When necessary for high forces, doubler plates shall be annular plates with inner and outer welds.

For punching shear checking, the equivalent diameter of the incoming brace with a doubler plate shall be the brace diameter plus 4 times the doubler plate thickness with a maximum of 100 mm. No increase of the wall thickness of the chord or of the brace shall be considered due to the doubler plate without more detailed analysis.

Doubler plates thickness and size shall be designed and justified against tension, punching and bending for all load conditions, and for fatigue condition. For those verifications, the thickness of the doubler plate shall not be cumulated with the thickness of the supporting member.

Similarly to the above, the strength of the fillet weld between the doubler plate and the supporting member shall be fully justified for all load conditions and for fatigue condition.