



Exploration & Production

GENERAL SPECIFICATION

STRUCTURAL

GS 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, levelling 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 STR 201](#), [GS STR 301](#) and [GS STR 304](#).

The superstructure design (topsides, modules, bridges, flares) shall be conducted in accordance to specification [GS 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, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published at the EFFECTIVE DATE of the CONTRACT.

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
ISO 19900	Offshore structures
API RP 2A LRFD (ISO 13819-2)	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
API Bulletin 2V	Bulletin on design of flat plate structures
API Bulletin 2U	Bulletin on stability design of cylindrical shells
ISO 1000	International system of units
AISC LRFD	Manual of steel construction - Load and resistance factor design latest edition (subject to COMPANY approval)
AISC ASD	Manual of steel construction. Allowable Stress Design
DNV classification notes n° 30.5	Environmental Conditions and Environmental Loads
DNV Rules	Rules for the design, construction and inspection of offshore structures. Appendix B, Loads, 1977
NF P 22-255 or equivalent	Metal construction. Hollow section welded assemblies on type I and H sections. Design and verification

Professional Documents

Reference	Title
Not applicable	

**Regulations**

Reference	Title
Not applicable	

Codes

Reference	Title
AWS D 1.1	Structural Welding Code - Steel
ASME VIII Div 1	Rules for construction of pressure vessels
PD 5500	Specification for unfired fusion pressure vessel

Other documents

Reference	Title
Not applicable	

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 COR 100	Design of cathodic protection of offshore structures
GS COR 240	Fusion bonded epoxy based coatings works for conductor pipes of drilling platforms
GS COR 350	External protection of offshore and related structures and equipment by painting
GS COR 353	Design and application of passive fire protection coatings
GS GEO 702	Requirements for design and installation of skirted foundations and suction anchors
GS STR 001	Weight monitoring and weighing of offshore units
GS STR 100	Fixed offshore steel platforms - General
GS STR 102	Design of offshore topsides structures

Reference	Title
GS STR 105	Design of Boat landings, bumpers and protections for offshore installations
GS STR 201	Materials for offshore steel structures
GS STR 301	Fabrication of offshore steel structures
GS STR 304	Fabrication of welded plate girders
GS STR 401	Load out, sea-fastening, transportation and installation of offshore structures
GS STR 431	Installation of piles for steel structures. Driven piles
GS STR 432	Installation of piles for offshore steel structures – Drilled and grouted piles
GS 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 shall be designed such that the first natural period of the platform shall be 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 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:

- Setting down after installation and operation
- Tolerance concerning seabed levels and wave crest information on installation site
- 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).

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

Bolted connections between structural members pertaining to special or first category shall be avoided as far as possible.

In case bolted connections have to be implemented, they shall be designed according to AISC "Allowable Stress Design" (latest edition):

- Part 4: Connections (using A 307 bolts)
- Part 5: Specifications and Codes:
 - Chapter J: connections, joints and fasteners
 - Specification for structural joints using [ASTM A 325](#) or A 490 bolts.

For the splash zone and above, the bolting shall be zinc plated or galvanized and then painted.

For immersed zones, the bolting shall be painted only.

Reference shall also be made to section 13 of [GS STR 201](#).

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 shall be achieved via doubler plates with rounded corners and fillet welded to the supporting member.

Doubler plates shall be of the same category as the supporting member;

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.

3.9 Hollow sections

Hollow sections which cannot be serviced from the inside due to their dimensions or their location, are to be made water-tight by closure plate and welding.

Man-holes or trap doors giving access to normally closed spaces (e.g. crane pedestal) shall be equipped with leak-proof seals.

3.10 Marine growth preventers

In order to be able to install initially or at a later stage marine growth preventers along the vertical jacket members (legs and bracings) and the conductor pipes located within the first bay, all the vertical legs and bracings shall be free of obstacles such as anodes and miscellaneous supports. Any temporary supports shall be cut flush on the doubler plates after the installation.

The paint system compatible with the marine growth preventers to avoid wearing shall be extended to the first bay where marine growth preventers may be used.

4. Design loads and loading conditions (API section C)

In general, the design of an offshore steel structure shall be carried out using the definition of loads and loading conditions as per [API RP 2A LRFD](#), section C or [API RP 2A WSD](#), section 2, with the additional requirements stated in the following paragraphs and in [GS STR 100](#).

4.1 Definition of loads and loading conditions

The following loads and any dynamic effect resulting from them shall be used to develop the loading conditions to be considered for the design of an offshore steel structure.

4.1.1 Definition of loads

4.1.1.1 Dead loads

Dead loads are the weights of the platform structure, appurtenances, and any permanent equipment, which do not change with the mode of operation, such as (but not limited to): steel structure, piles, grout, ballast, hydrostatic forces, permanent equipment, etc.

The percentage of contingency and tolerances is defined in [GS STR 001](#), Appendix 1, and is included in the dead loads. This allowance for weight growth shall not be considered for the design of the foundations piles in tension, the on a bottom stability but shall be considered for the mud mat design.

4.1.1.2 Live loads

Live loads are the gravity loads, which may change during the operation of the platform or from one mode of operation to another mode of operation, such as (but not limited to): weight of

drilling equipment, weight of equipment which may be added or removed, weight of consumable supplies, weight of production/utilities equipment and piping contents, blanket live loads as defined in specification **GS STR 102**, forces exerted on the structure during operations such as drilling, material handling, vessel and helicopter landing, crane operation, etc.

4.1.1.3 Environmental loads

Environmental loads are imposed on the platform by natural phenomena such as wind, wave, current, tide, earthquake, snow and ice, and soil movement. Environmental loads shall be anticipated from any direction, unless otherwise demonstrated.

4.1.1.4 Dynamic loads

Dynamic loads are the loads due to the response to an excitation of a cyclic nature or due to an impact or due to the sudden application of a load (impulse type). Dynamic loads may be induced by waves, wind, current, earthquake, crane or lifting equipment operation, drilling operation, boat or helicopter landing, rotating equipment, blast, etc.

4.1.1.5 Construction loads

Construction loads are the loads resulting from fabrication, load-out, transport and installation of a platform, and shall be considered in the design as further indicated.

4.1.2 Definition of loading conditions

The loads defined in 4.1.1 above shall be combined to develop the appropriate loading conditions such as to produce the most severe effects on the structure.

Operating environmental load conditions are those, which are not severe enough to restrict normal platform operation.

Design environmental load conditions are those resulting from the selected design events (i.e. extreme environmental conditions), which may induce a restriction of platform operation.

The design of an offshore structure shall consider load conditions combining environmental loads with appropriate dead and live loads in the following manner:

- Operating environmental load condition (including dynamic loads if any) combined with dead loads and maximum live loads (including dynamic loads if any) appropriate to normal operation of the platform
- Operating environmental load condition (including dynamic loads if any) combined with dead loads and minimum live loads (including dynamic loads if any) appropriate to normal operation of the platform
- Design (Extreme) environmental load condition (including dynamic loads if any) combined with dead loads and maximum live loads (including dynamic loads if any) appropriate for combination with extreme environmental condition
- Design (Extreme) environmental load condition (including dynamic loads if any) combined with dead loads and minimum live loads (including dynamic loads if any) appropriate for combination with extreme environmental condition
- Earthquake environmental condition (including dynamic effects) combined with dead loads and live loads as detailed in section 4.8.

- Temporary load condition occurring during fabrication: load-out, transport, installation shall consider combinations of dead loads, maximum temporary loads (including dynamic loads if any) and appropriate environmental loads (including dynamic loads if any).

Environmental loads shall be combined in a manner consistent with the probability of their simultaneous occurrence during the loading condition being considered.

Earthquake loads shall be applied on the structure as a separate environmental condition, and shall not be cumulated with wave, current and wind loads.

Operating environmental condition should represent a moderately severe condition at the platform location; typically, a 1-year return period wave, current and wind shall be used for operating environment, to be confirmed in the particular specification, or unless specified otherwise by national/local regulations.

Extreme environmental condition shall be generated by the 100-year return period wave, current and wind, to be confirmed in the particular specification, or unless specified otherwise by national/local regulations.

Earthquake environmental condition is detailed in the particular specification, or unless specified otherwise by national regulations.

4.1.3 Modelling of loads and loading conditions

In view of their combinations such as to represent loading conditions, the loads shall be classed according to the following principles:

4.1.3.1 Elementary load case

The elementary load case shall be defined as a set of indivisible loads of the same type acting concomitantly on a structure.

As such, dead weights and live or operational loads shall be split in different elementary load cases, such as but not limited to:

- The dead weight of the primary structures
- The dead weight of the secondary structures
- The dead weight of the itemized empty piping
- The weight of the fluid content in the piping
- The weight of the itemized mechanical equipment
- The dead weight of the bulk electrical equipment
- The loads due to operating waves oriented at 90°
- The blanket live load at cellar deck
- The dead weight of the platform crane
- The operating load of the platform crane (force + momentum).

4.1.3.1.1 Traceability of elementary loads

Both calculation note and computer model file shall fully document and trace in detail the origin of each and every load input in the model. As such, individual loads pertaining to each piece of itemized equipment shall be related to the equipment reference number.

Calculation notes shall include elementary loading sketches detailing for each equipment the magnitude of the load, the identification of the structural members supporting the load the location of the load on the structural member and the identification of the equipment. The above is also applicable to the main itemized piping supports, electrical cables supports, etc.

Additionally, loading diagrams summarizing all gravity loads per level for the platform, including dead weights, operational loads and live loads for all itemized and bulk equipment, blanket live loads, shall be issued and updated by the CONTRACTOR throughout the complete duration of the project.

4.1.3.2 Loading types

4.1.3.2.1 Definition

Loading types shall be defined as the combinations of elementary loads cases having the same origin, such as but not limited to:

- Dead loads (or dry weight)
- Normal operational live loads
- Blanket live loads
- Future loads
- Exceptional (or test) operating live loads
- Operating environmental loads
- Extreme environmental loads
- Seismic loads
- Accidental loads such as boat impact
- Loads induced by construction
- Loads induced by transportation
- Loads induced by installation
- Loads induced by settlement
- Scouring effect.

4.1.3.3 Loading condition

The loading condition shall be defined as a combination of different loading types which, acting together, induce maximized stresses on the structure.

The loading condition and the rules for combination of the loading case are defined in paragraph 4.1.2.

Examples of loading conditions are:

- Installed structure in operating conditions
- Installed structure in design condition (i.e. combinations with extreme environmental load)
- Installed structure in seismic conditions
- Structure during load-out phase

- Structure during transportation phase (head seas)
- Structure during installation phase.

4.2 Gravity design loads

4.2.1 Deck loads

The gravity loads transferred from the deck to the jacket are calculated in accordance with the specification **GS STR 102**. A load reduction factor $K_s = 0.25$ shall be applied to the blanket live load used for deck design.

In case a simplified deck model is used in the jacket calculations, CONTRACTOR shall take all measures to ascertain that the modelled deck loads at jacket/deck interface are representative of the true loads generated by the complete deck, taking into consideration the true deck/jacket boundary conditions, and the true jacket/deck relative stiffnesses.

4.2.2 Blanket live loads on top jacket level

A uniform load of 2.5 kN/m^2 shall be applied to the top of jacket floor on circulation area and to any work platform of subsea structure, unless otherwise specified in the project documents. On other locations, when applicable (conductor pipes area, etc.), loads to take into account shall be defined in the project specifications.

4.2.3 Rigging platform

If a rigging platform is used, it shall be designed to support the slings and for a load of 2 kN/m^2 over the entire surface.

4.2.4 Pile weight

Loads used in calculations must include the weight of the piles, including piles in soil and grout weight if any.

4.3 Environmental loads

4.3.1 Definition

The environmental loads encompass all loads induced by actions of atmospheric and marine elements on the whole or parts of the platform. These are essentially produced by:

- Wind
- Waves
- Currents
- Ice
- Snow
- Temperature changes.

The environmental loads shall be calculated based on the oceano-meteo conditions and criteria included in the Particular Specification.

Unless otherwise specified in the Particular Specification or in local/national applicable regulation, environmental loads shall be calculated according to the requirements of [API RP 2A](#) and section hereafter:

- A 1-year return period wave, wind and current characteristics shall be used to derive the environmental loads to be combined in the operating load condition
- The extreme (design) loading condition shall consider the environmental load resulting from the most stringent combination chosen from:
 - 100-year wind and wave + 10-year current
 - 10-year wind and wave + 100-year current

If available, the joint probability 100-year environmental condition shall be used.

4.3.2 Loads induced by waves and currents

In general, and unless otherwise specified in national/local regulation, wave loads shall be modelled according to the requirements of [API RP 2A](#).

Wave loads can generally be modelled by static wave analysis using the most adapted wave theory as per requirements of [API RP 2A](#) to be justified in the calculation note. Dynamic amplification of wave loads shall be considered.

For deep water and/or flexible/slender platforms whose natural period is greater than three seconds, dynamic wave analysis shall be used to reflect the dynamic aspect of the environmental loads generated on the platform in conjunction with the dynamic aspect of the platform response.

Waves, wind and current are always assumed to be acting in the same incoming direction (the resultants of forces generated by each element must be collinear and in the same direction).

Analyses shall be carried out for the case, which produces the maximum stress in the structure member analysed. The penetration of each pile must always be investigated for the case causing the maximum overturning moment on the structure and with the worst case direction for the pile concerned.

For a jacket design, environmental loads shall be considered to act in at least eight different directions:

- Four orthogonal directions perpendicular to the jacket faces
- Four directions perpendicular to the jacket diagonals on the mud line. Additional diagonal waves may be required to maximize the pile loads.

When environmental conditions are given per sector and when the calculation of the wave loads is performed for a wave direction located at the limit of the sectors (within $\pm 15^\circ$ centred on the limit of the concerned sector), the worst environmental condition between the concerned sector and the adjacent one shall be taken for the wave load calculation.

4.3.3 Determination of phase angle to be used (jacket structure)

For each wave direction, the phase angle generating the maximum forces relative to both the wave and current (base shear and overturning moment) should be investigated with maximum and minimum water level values, on the jacket/appurtenance assembly. Wave positions causing the maximum forces must be determined within $\pm 5^\circ$ for each wave condition.

The shear force to be taken into account shall be the highest shear value from the "wave crest" case with the selected direction and the "wave trough" case with the opposite direction.

Other wave positions and water levels shall be determined independently for:

- The maximum shear forces on risers, I-tubes and relevant supports, and on all other appurtenances
- The maximum vertical forces on the two levels nearest to LAT.

Symmetry predictions of forces shall not be allowed to analyse the structures and foundations.

4.3.4 Hydrodynamic model (jacket and subsea structures)

4.3.4.1 Hydrodynamic models

The hydrodynamic model of a platform structure shall represent as closely as possible the exact characteristics of the real structure relatively to wave exposed areas, volumes, masses, buoyancy and hydrodynamic properties. As such, all platform appurtenances including boat landings, bumpers, fenders, walkways, stairs, grout-lines, anodes, etc., shall be taken into account in the hydrodynamic model but with no contribution to the global structural model stiffness. In case hydrodynamic forces on some appurtenances may have an impact on local member design, these appurtenances shall be modelled in detail as non-structural members. In the case of small appurtenances items distributed all over the structure, modelling can be done by modification of hydrodynamic coefficients, to be justified in detail.

4.3.4.2 Hydrodynamic coefficients

Drag and inertia coefficients shall be selected and justified according to [API RP 2A](#). It shall be noted that different sets of coefficients may be required for different types of analysis (particular case of fatigue analyses) or particular structures types (particular case of caisson-type structures), depending on the Keulegan-Carpenter number parameter.

Hydrodynamic coefficients for non-circular members shall be taken from [DNV](#) "Rules for the Design, Construction, and Inspection of Offshore Structures", Appendix B, Loads, 1977.

Hydrodynamic coefficients shall be calculated as a function of surface roughness of tubular members, all submerged members shall be considered rough. Presence of anodes shall be considered.

- Wave kinematic factor: 0.95
- Current blockage factor: 0.80 for perpendicular incidences
0.85 for diagonal incidences
0.90 for tripod
- Slamming coefficient: 5.5 for beams and 3 for circular tubes

Shielding effect on CP should be taken into account.

The apparent wave period shall be determined to account for the Doppler effect of the current on the wave.

The wave kinematics shall be determined based on the apparent period, the water depth and the wave height, using the appropriate wave theory as per [API RP 2A](#), including due consideration to relevant wave kinematics factors, to be justified as per [API RP 2A](#).

Similarly, relevant current blockage factors shall be selected and considered to account for the modification of the current speed in the vicinity of the platform as per [API RP 2A](#).

Particular attention shall be paid to the modelling of the current between the mean sea level (at which the nominal current speed is given) and the wave surface. The stretching method shall be non-linear as recommended by [API RP 2A](#) unless fully justified otherwise.

4.3.5 Marine fouling (jacket and subsea structures)

Effects of marine growth on the geometry and the hydrodynamic coefficients of structural members, conductor pipes, risers and more generally of platform appurtenances shall be modelled and justified in detail. The weight of marine growth shall also be taken into consideration (Density = 1400 kg/m³).

Marine fouling to be taken into account for the structure calculation should be given in the project specifications. Unless otherwise noted, the standard values shall be as follows:

- +2.00 m/LAT to -15.00 m/LAT thickness = 100 mm
- -15.00 m/LAT to -30.00 m/LAT thickness = 50 mm
- -30.00 m/LAT to -50.00 m/LAT thickness = 25 mm
- -50.00 m/LAT to mud line thickness = 0 mm (but assuming rough tubulars for hydrodynamic force calculations)

4.3.6 Loads on anodes (jacket and subsea structures)

Waves loads on anodes shall be taken into consideration preferably by increasing the surface area subjected to wave loads. The method applied shall be specified in the "Basis of design" document.

4.4 Forces generated by risers, I tubes (jacket structure)

The forces generated on the jacket by risers, I tubes shall be considered to include the piping weight and pulling forces. The platform components subjected to these forces should be investigated for these forces in combination with gravity, wave, etc.

4.5 Vortex shedding (jacket and subsea structures)

Casing risers and all slender components shall be checked for vortex shedding effects due to environmental loads in pre-services and in-place conditions. By principle vortex induced vibrations (V.I.V.) shall be avoided. In case of V.I.V., fatigue damage shall be evaluated taking into account sensitivity of the damping factors and the full range of the environmental loads up to 100 year return period.

4.6 Loads on stairs, walkways, outfitings (jacket structure)

Staircases in areas that may be subject to heave shall withstand, in addition to the gravity and traffic loads, all hydrodynamic forces, slamming in particular.

4.7 Combination of loads for in-place design

The following load combinations must be verified for two types of loadings, operating conditions and extreme conditions, noted in the table as:

- Op = Operating conditions
- Ext = Extreme conditions

Load cases	Structure and piles		Max. tension in piles (2)		Stability before piling (2)	Stability after piling before deck installation		Mud mats
	Op	Ext	Op	Ext	Ext	Op	Ext (4)	Ext
Load combinations								
Weight of deck structures (if applicable)	X	X	X	X				
Weight of structures	X	X	X	X	X	X	X	X
Weight of pile introduced in one or more legs								X
Buoyancy	X	X	X	X	X	X		X
Equipment in operating condition	X	X						
Empty equipment			X	X				
Deck live loads (if applicable) (1)	X	X						
Drilling equipment (if applicable) (5)	X	X						
Drilling loads (if applicable) (5)	X							
Environmental conditions for installation (3)					X			X
1-year environmental conditions	X		X			X		
100-years environmental conditions		X		X			X	

Notes:

- (1) Local reduction factor to be applied as per § 4.2.1.
- (2) For tension in piles and stability, no provision on loads is applicable (see section 4.1.1.1.).
- (3) Depending on installation date (Maximum wave encountered during the month of installation, as well as that of each month either side, for a return period of 1 year).
- (4) Results of this combination to be discussed with COMPANY.
- (5) Refer to GS STR 102 section 4.7

4.8 Seismic loads

Whenever mentioned in the particular specification, the design of an offshore steel structure shall consider the effects of the seismic loads, as required by [API RP 2A LRFD](#) or [API RP 2A WSD](#).

Both strength requirements and ductility requirements shall be taken into account in the design.

As a minimum a spectral response analysis shall be performed, according to [API RP 2A LRFD](#) or [WSD](#).

[API RP 2A](#) response spectrum shall be used unless otherwise requested by particular specification.

Seismic loads shall not be combined with other environmental loads.

Platform foundations shall also be part of the verification against seismic loads. Elementary pile loads shall be combined as per requirements of [API RP 2A](#) LRFD for both compression and tension, and compared to pile ultimate capacities in compression and tension. The computer model used for seismic response analysis shall take due consideration to the global mass modelling of the platform, and in particular to the hydrodynamic masses (entrapped water and water added masses) of the jacket and appurtenances. Also the right mass location and direction shall be modelled. A global modal participation mass justification in each direction shall be detailed.

Sufficient number of modes shall be generated in order to obtain a global modal participation factor of 90 % in each direction.

The 10 first mode shapes shall be plotted and identified.

Simplified seismic design (such as UBC method) is not acceptable for offshore steel structures.

Resulting spectral accelerations and displacements at each deck levels shall be given.

4.9 Fabrication and installation loads ([API C5](#))

In the following, the weight to be taken into account is the target weight of the weight monitoring plus the weight of temporary components.

4.9.1 Fabrication and erection loads ([API C5](#))

Structural components or sub-assemblies weighing more than 50 tones or presenting a high degree of flexibility shall be verified according to [API RP 2A](#) and [AISC](#) for the fabrication and erection phase (jacket frame roll-up, etc.).

4.9.2 Load-out ([C5.6](#))

The structural calculations shall take into account all the relative motions of the barge and the structure. The quay soil verification, barge grillage/structure and supports as well as the structure itself shall be verified with the structure stiffness and relative displacements.

Load-out operation and design shall comply with the requirement of Specification [GS STR 401](#).

4.9.3 Transportation and sea fastening ([C5.7](#))

Transportation and sea fastening operations and design shall be covered by [GS STR 401](#).

The transportation studies shall include the sea fastening and barge grillage design and calculation. They shall also justify the barge strength (global and local justification). The calculation method shall include the static gravity loads applied to the unfastened structure, and the dynamic loads applied to the fastened structure. When available, the stiffness of the support vessel deck shall be taken into account.

A fatigue analysis shall be performed for transportation time greater than ten days.

The buckling coefficient for sea fastening components shall be not less than 1 in the calculations.

Sea fastening braces shall be welded on structure with intermediate of doubler plates, unless otherwise approved by COMPANY.

All equipment, installation aids such as slings, shackles, etc., shall be sea-fastened by the CONTRACTOR with angle bars and welded on the structure via doubler plates. Cables shall not be used except for small and light pieces, submitted to COMPANY approval.

4.9.4 Launching (C5.8)

The structure shall be designed in accordance with **GS STR 401**.

The structure shall be analysed for the launching phase with the behaviour of the barge and structure in successive positions (sliding, tilting, separation, flotation) given not more than two seconds until final stability.

As a first approach, the speed of the barge in relation to the structure shall be taken as greater than 1 m/s at the time of tilting without sliding assistance.

Clearance to the seabed and spare buoyancy: see **GS STR 401**.

The members shall be checked, according to **API RP 2A**, under hydrostatic pressure at the depth reached, up rated by 30 % to the limit of the site water depth or under damaged condition, whichever is the most unfavourable.

Buoyancy tanks shall be verified according to one of the following codes:

- **ASME VIII Div. 1**, Rules for construction of pressure vessels,
- **PD 5500**, Specification for unfired fusion pressure vessel.

For buoyancy tanks and water tight diaphragms, the design hydrostatic pressure shall correspond to two times the maximum water depth during launch.

4.9.5 Free floatation and upending

The structure shall be designed in accordance with **GS STR 401** with regard to floatation and upending conditions.

4.9.6 Lifting (C5.5)

Lifting design and operations shall be as per requirements of **GS STR 401** and material specification **GS STR 201**.

The first calculation shall be performed using provisional weight and centre of gravity locations (one theoretical and four in an uncertainty pattern) with a sling angle of $60^\circ + / - 5^\circ$.

4.9.7 Wellhead capping

Wellhead capping operations shall be supported by studies, which shall:

- Justify the choice of the method and analyse jacket behavior during capping
- Determine and justify the docking forces on jacket and wellhead
- Justify jacket and wellhead capacity to withstand these docking forces.

4.9.8 Jacket on bottom stability and mud mat design

Jacket on bottom stability (unpiled stability) and mud mat design shall be verified in accordance to **API RP 2A** with a safety factor of 1.5 against the overturning.

Minimum jacket weight (without contingency) shall be considered for the on-bottom stability.

C_d and C_m coefficients of clean members shall be used.

Environmental criteria shall depend on installation date, and will be based on the maximum annual wave and current encountered during three months, centred on the month of installation, unless otherwise specified in the Project particular specification.

On bottom stability and mud mat design shall consider the weight of any pile section hanging at the top of the legs as required by the pile make-up and the pile driving procedure.

The mud mats are required to ensure the stability (overturning, bearing and sliding) of the jacket resting on the seabed before and during the piles installation.

They may be either:

- Wooden or GRP (Glass Reinforced Plastic) mud mats, with carrying frame
- Or metallic mud mats.

In the case of metallic mud mats, the cathodic protection system of the jacket shall consider the mud mat areas for the calculation of the number of anodes.

Calculations shall be conducted according [API RP 2A](#) requirements and based upon:

- Soil conditions at the seabed; maximum settlement considerations should be particularly addressed
- Geometrical shape of the mud mats
- Maximum environmental conditions anticipated during installation
- Jacket gravity and buoyancy loads
- Piles installation method induced loads: weight of several pile sections may need to be taken into consideration.

For decommissioning purpose an additional informative case of on bottom stability shall be done with marine growth and 1 year environmental condition.

4.9.9 Conductor pipe installation loads

The upper level of the jacket shall withstand the loads due to the weight of the conductor pipes during installation and driving according to the installation procedure and the project specification.

4.10 Accidental and other loads (API C6)

4.10.1 Impact loads

4.10.1.1 Impact load on jacket

The jacket structure shall be designed against 2 types of boat impacts:

- An light boat impact based on service boat and 0.5 m/s current. As a minimum, a boat impact of a 1500 T boat at 0.5 m/s shall be considered, unless otherwise specified in the particular project specification.
- An accidental boat impact based on service boat and 1-year current, to be defined in particular specification. As a minimum, a boat impact of a 1500 T boat at 1.0 m/s shall be considered, unless otherwise specified in the particular project specification.

The boat can strike either a jacket leg or a bracing at sea level.

The vertical height of the collision zone shall be determined from consideration of vessel draft, operational wave height and tidal elevation.

Light boat impact

Exposed Jacket legs shall be protected against operational boat impact with telescopic leg fenders, unless otherwise specified in Particular Project Specification and Safety concept/risk analysis.

When a jacket leg is struck, a $1/3^{\text{rd}}$ increase in the allowable stress is permitted for jacket leg verification and for the remaining part of the jacket. Pile axial capacity shall be checked with 1.5 safety factor.

When a bracing is struck, plastification of impacted bracing is allowed, including possibility for the impacted bracing to be deformed to a system, in order to develop sufficient deformation to absorb the energy in direct tension. $1/3^{\text{rd}}$ increase in the allowable stress is permitted for the remaining part of the jacket.

A post damage strength check shall be performed, with impacted bracing(s) damaged or removed, for 1-year return period environment with $1/3^{\text{rd}}$ increase in the allowable stress.

Accidental boat impact

When a jacket leg is struck, a part of the impact energy shall be absorbed by the leg fenders, if any, and the remaining energy shall be dissipated through leg plastic deformation (local and bending deformations). Plastification in the jacket can be accepted but shall be limited in order overall collapse is avoided. Pile axial capacity shall be checked with 1.5 safety factor.

When a bracing is struck, plastification of impacted bracing is allowed, including possibility for the impacted bracing to be deformed to a system, in order to develop sufficient deformation to absorb the energy in direct tension; Plastification in the jacket can be accepted but shall be limited in order overall collapse is avoided;

A post damage strength check shall be performed, with impacted and or damaged leg or bracing(s) damaged or removed, for 1-year return period environment with 70% increase in the allowable stress. For information, 100-year return period environment with 70% increase in the allowable stress will be considered and at COMPANY discretion local reinforcements may be required.

4.10.1.2 Impact loads on riser protector

Unless otherwise noted risers shall be protected, either inside the jacket or by riser protectors.

Unless otherwise noted, the risers protector shall be able to withstand a boat impact of a 1500 T boat at 0.5 m/s without riser damage. The induced stresses should be compared with the allowable stresses increased by $1/3^{\text{rd}}$ for the jacket. Plastification of riser protector is acceptable but plastic deformation of protector shall leave a clearance of 30 cm with riser edge.

4.10.2 Other

4.10.2.1 Jacket structure

Unless otherwise specified, for inspection or underwater work, temporary mooring of a support boat may be required (see particular specification).

Jacket shall be verified for two horizontal loads of 80 Tons applied on top of two adjacent legs, cumulated with 1-year environmental conditions, using allowable stresses increased by $1/3$. Four directions at 90° should be considered.

4.10.2.2 Subsea structure

Mud slides should be considered as an accidental load if specified in the Project documents (i.e. soil data).

Risks of accidental loads should be specified in Project documents.

Accidental loads may result from fishing activity (trawling equipment), mooring of vessels (anchors, cables, chains) or dropped objects.

The structural shape and strength should be designed to avoid damage to critical equipment. Therefore plastic domain calculations may be acceptable.

In the absence of specified accidental loads, in preliminary design of the complete structure and external structural members, the following loads should be used.

- Loads due to trawling equipment: Pulling force: $6 \cdot 10^4$ N (Equivalent to ship bollard pull)
Impact energy: $9 \cdot 10^3$ Joule
- Loads due to mooring of vessels: None (actions should be taken to forbid mooring in the vicinity of installations)
- Loads due to falling objects: Impact energy: $50 \cdot 10^3$ Joule

4.11 Summary of loads factors for LRFD design

Members shall be checked with a force Q such that:

$$Q = \gamma_1 D + \gamma_2 L_1 + \gamma_3 L_2 + \gamma_4 (W + \gamma_5 D_n)$$

The following coefficients shall apply unless otherwise noted in the particular specification.

	γ_1 (D)	γ_2 (L1)	γ_3 (L2)	γ_4 (W)	γ_5 (Dn)	γ_6 (E)
Annual environmental conditions (Operating)	1.3	1.5	1.5	1.2	$1.25^{(*)}$	0
100-years environmental conditions (Extreme)	1.1	1.1	0	1.35	$1.25^{(*)}$	0
	0.9	0.8	0	1.35	$1.25^{(*)}$	0
Load out	1.3	0	0	1.3		0
Transport	1.3	0	0	1.35	$1.25^{(**)}$	0
Lifting	1.3	0	0	1.3		0
Launching	1.3	0	0	1.3		0
Seismic	1.1	1.1	0	0	0	0.9
	0.9	0.8	0	0	0	0.9

(*) Dn may be disregarded when the platform's natural period is less than 3 seconds.

(**) Dn is the effect of dynamic amplification due solely to structure eigenvalues (the transportation loads are considered static and included in W adjusted by γ_4)

5. Structural steel design (API sections D and E)

5.1 General

The studies shall be supported by all the documents required for the complete definition of the structure: static in-place analysis including foundation and modal response, fatigue analysis, seismic analysis, load out and transport analysis, installation analysis (lifting/upending or launching, positioning, on-bottom stability, pile driving studies), fabrication studies, all associated design, fabrication and installation drawings. This list is not exhaustive.

The assumptions and methods used at each stage of the calculations must be collected in a document named "Basis of design" submitted to the COMPANY or its representative for approval before starting any calculations. The CONTRACTOR should be responsible for collecting all the necessary information as required from others (Construction, Transportation, Installation matters, etc.).

Aspects of design requiring special attention include:

- Corrosion protection system (paint, coatings, cathodic protection, etc.)
- Access route, floors and gratings
- Inspection of hot-work (welding and cutting)
- Difficult-to-inspect areas
- Survey operations during lifetime
- Node construction details.

5.2 Structural modelling

The structure shall be modelled by entering node coordinates, member incidences and properties. CP, risers, I tubes, caissons, boat landings and equipment supports shall be modelled but shall not be incorporated in the overall structure stiffness.

The detailed deck model should preferably be added to the jacket model, or a representative deck stiffness could be part of the structural model, subject to verification of deck load transfer mentioned in paragraph 4.2.1.

5.2.1 Modelling limits (API Section E)

Connections: Additional nodes shall be modelled if the eccentricity exceeds one quarter of the chord diameter. Stress concentration shall be minimised. Overlaps shall be avoided. The theoretical gap (g) between braces shall be 75 mm minimum in order to account for fabrication tolerances and achieve a final 50 mm gap between weld toes.

Except in the area of conductor pipe frames, members with nominal diameters less than or equal to 6" may not be modelled, provided that wave exposed area is otherwise considered.

5.2.2 Piles

Piles shall be modelled. If they are not grouted, they are considered connected at the upper end of the leg and guided at the other levels. When they are grouted to the leg, the pile-leg modelling shall be based on steel section only.

Pile in soil shall be modelled according to section 7.

5.2.3 Conductor pipes

Conductors should be considered in all slots. They shall be guided at the lower deck level and all levels in the jacket with cone guides, except at the lowest level where sufficient gap will be provided to avoid interference between conductors and shear load distribution. They shall be shimmed at the two first jacket upper levels and lower deck level unless otherwise specified. At the other guide levels, the gap between the conductors and the cone guides shall not exceed 50 mm on the diameter with respect to V.I.V. and buckling to be checked accordingly.

The connections shall be modelled.

The upper parts of conductor pipes shall be modelled up to the lower deck.

The conductor nodes at the mud line shall not be horizontally supported, as the horizontal loads shall only be transferred to the soil by the piles.

The conductor pipe frame members shall be modelled.

The conductor pipes shall be modelled with a negligible stiffness.

If guides are required at the lowest level, local load and fatigue will be considered, in assuming the horizontal loads are transferred to the soil by the piles and the conductor pipes. Nevertheless the piles shall still be designed in assuming the horizontal loads shall only be transferred to the soil by the piles.

VIV shall be considered and additional restraints at the guides shall be considered if required.

5.2.4 Risers, casings and I-tubes

These shall be modelled up to the lower deck level and linked to this level; all jacket connection modelling shall be representative of the existing links. They shall be modelled with negligible stiffness.

5.3 Additional requirements

5.3.1 Slamming

All members in the vicinity of water level should be checked against slamming loads and up-lift loads (in-place conditions, during transport, temporary working decks).

5.3.2 Connections

Calculations of non-tubular joints (beam/tubular joints), shall be performed using proven and sound engineering practice. Specific attention shall be paid to the method of design (WSD or LRFD) to be carried out.

5.4 Allowable displacements

5.4.1 Jacket structural allowable displacements

The admissible horizontal displacement of the upper platform deck, as calculated under extreme environmental loads, must be less than 1/200 of its own level above the seabed and relatively to the displacement at the sea bed level.

5.4.2 Subsea structure allowable displacements

Vertical or horizontal deflections, types of deformations:

- d_0 = pre camber (hogging) of a beam or element in the unloaded state
- d_1 = the value of deflection from the permanent loads
- d_2 = the value of deflection from the variable loads
- $d_{\max} = d_1 + d_2 - d_0$

Condition	$d_{\max}$	d_2
Frame beams	1/200 th	1/300 th
Equipment supports, posts, receptacles	1/200 th	1/300 th
Wall flat plate (thickness = t)	t (between stiffeners)	

5.4.3 Foundation displacement

The maximum displacement at mud line of each pile must be less than 1/10th of the pile diameter, limited to 20 cm in clay soils and 10 cm in sandy soils.

P-Delta effect shall be considered for a displacement higher than 1/10th of the pile diameter.

5.4.4 Modal response

The modal responses of the platform (including deck and equipment) shall be determined up to the first mode whose natural period is less than 1 second.

The weight of conductor pipes and risers shall be taken into account as well as their content.

As the determination of the modal response implies to use a linear model of the foundation (piles and conductors pipes if applicable), the foundation model (PY and TZ curves) shall be linearised in order to be representative of the soil behaviour for the applied loads case magnitude, and proper justification shall be provided, taking into account lower and upper bounds soil criteria.

5.5 Weights and weight monitoring

The weights shall be monitored at each stage of design according to specification **GS STR 001**. All the gravity loads included in the studies shall correspond item for item to the target weight of the weight monitoring. Any further changes shall be incorporated and a new weight report and COG supplied to COMPANY according to specification **GS STR 001**. The weight report shall contain the location of the centre of gravity for the in-place, load-out, transportation and installation lift configurations. The in-place weight report shall clearly define the dry weight, the operating weight (including fluids) and the weight of future equipments.

6. Fatigue design (API section F)

6.1 Jacket structure

Unless otherwise stated, the API simplified method is **not** applicable, and as a minimum, a deterministic fatigue analysis shall be performed.

The main requirements are:

- **Service life of the structure:** 20 years, unless otherwise specified in project document. The design fatigue life should be not less than the service life times the design fatigue factor which is as follows pending on the node failure criticality, the location, the inspection accessibility, the repair feasibility :

Node failure criticality	Inspection access	Above MSL possible repair	Below MSL possible repair	Fatigue factor
No	Yes	Yes		2
No	Yes		Yes	3
No	No	No		3
No	No		No	5
Yes	Yes	Yes		3
Yes	Yes		Yes	5
Yes	No	No		5
Yes	No		No	10

- **Forces:** wave forces and buoyancy only shall be taken into account.
- **Material:** the SN curves of [API RP 2A](#) shall be used for tubular intersections. In case of non tubular connections, conical connections, fatigue sensitive connections requiring weld profile grinding, other appropriate SN curves may be used, subject to prior COMPANY approval.
- **Corrosion:** Half the corrosion allowance shall be considered in reducing external diameter and wall thickness.
- **Water depth :** Half one-year tide elevation shall be used, unless noted otherwise.
- **Wave period:** the period is the most probable period associated with the wave height considered. Period slightly smaller and greater shall be considered in order to well obtain the peak of resonance of the platform dynamic behaviour.
- **Wave heights:** sufficient number of wave height and associated periods shall be taken into consideration in order to closely calculate stresses. For each wave height two phase lags corresponding to maximum and minimum shear will be considered, and six intermediate phase lags will be added.
- **Wave direction:** eight wave directions shall be generated.
- **Stress concentration factor:** Efthymiou formulations shall be used and the validity domains shall be verified for each connection. A minimum SCF value of 2 shall be used for tubular intersections. They shall be calculated on eight points distributed along the tubular intersection, i.e. 8 points on brace side and 8 points on chord side.

For grouted joints, $t_e = (5.D + 134 t)/144$ (according to API section C5.5.4), use $\gamma = \frac{1}{2} D/t_e$ for saddle SCF calculation for chord and brace. A minimum SCF value of 2 shall be considered for all locations.

- **Hydrodynamic coefficients:** shall be calculated in accordance with [AP RP 2A](#) as a function of the surface roughness of tubular members.

	Smooth	Rough
Cd	0.5	0.8
Cm	2	2

- **There is no group effect, nor shielding effect, nor wave kinematics factor to be taken into account for fatigue analysis.**
- **Marine fouling:** No reduction of the marine growth thickness is allowed for fatigue analysis.
- **Foundations:** If the foundation model (PY and TZ curves) is linearised, it shall be representative of the soil behaviour for the applied loads case magnitude, and proper justification shall be provided, taking into account lower and upper bounds soil criteria.

A particular local fatigue assessment shall be carried out for the jacket upper horizontal level close to MSL, which is subject to out of plane loads.

In case of static wave analysis due consideration shall be given to dynamic amplification, and calculation of dynamic amplification factors shall be duly documented.

Presence or not of work over/drilling rig (if any) shall be considered in the design (natural period, fatigue damage). Unless other wise defined in particular specification, the rig shall be considered for 5 years.

Fatigue cumulative damage, according to Palmer-Miner's law, shall include the in-place and transport damages if applicable.

All the nodes with a fatigue life of less than 50 years without safety factor shall be listed in the calculation note.

6.2 Subsea structure

Fatigue is mainly due to riser stresses. A fatigue analysis is therefore required in such configuration. Supporting structure and CP should be considered with the following main requirements:

- **Service life:** 20 years, unless otherwise specified in the job specification. The design fatigue life should not be less than the service life multiplied by the design fatigue factor, which should be 10.
- **Material:** the SN curves of [API RP 2A](#) shall be used.
- **Stress concentration factor:** shall be used and formulas shall be given in the "Basis of design" document. They shall be calculated on eight points distributed along the tubular intersection. For non-tubular joints, the method used should be approved.

The fatigue damage shall include the transportation damage if applicable.

7. Foundation design ([API](#) section G)

Soil conditions are defined in the project specification.

7.1 Foundation modelling

For piles foundations either with main piles or skirt piles, the foundation shall be modelled by PY and TZ curves. If foundations are modelled by stiffness matrix, they shall be representative of the soil behaviour for the applied loads case, and proper justification shall be provided.

For other types of foundation, the model shall be representative of the soil behaviour for the applied load case. Method shall be fully documented and approved.

Scouring shall be modelled if any is specified in the project specification.

In the case of wellhead platforms where a jack-up drilling rig will approach the jacket or any jack-up close to a jacket at a distance less than 1.5 spud can diameter (from spud can centre) to the edge of pile, the jacket and pile design shall take into consideration the interference resulting from the penetration of the spud-cans in the soil, and modification/degradation with or without jack-up. The methodology is subject to COMPANY approval.

7.2 Pile design

The axial capacity of piles (and subsequently, pile penetration) shall be defined from the point where the soil has an elastic behaviour. The calculation sheet shall give a table of the stresses imposed on **each** pile at the bottom of the scouring crater and for **each** elementary load case and **each** combined load case. Stresses and forces in each pile shall also be supplied separately.

Pile design shall take into account a shift of the jacket & topsides Centre of Gravity within the uncertainty pattern and a COMPANY reserve.

The uncertainty pattern of the calculated location of the centre of gravity is a rectangle whose sides equal 10 % of the overall width and length for a deck, and 5 % of the overall width and length for a jacket, but not less than within a 2.0 m x 2.0 m square area for a deck and 1.0 m x 1.0 m for a jacket.

Piles shall be designed according to [API RP 2A WSD](#), section 6⁽¹⁾ and General Specification [GS STR 431](#) and [GS STR 432](#) "Installation of piles for offshore steel structures".

Whenever piles cluster are anticipated at each leg of the jacket, pile group effects shall be investigated in detail.

7.2.1 Driven piles

For driven piles, the true slope shall be limited to 1/7.

The piles shall have a constant wall thickness along their overall length.

In particular cases, use of piles with different thickness over their length may be contemplated subject to prior COMPANY written approval.

The pile wall thickness shall be adequate to resist the axial and lateral loads, as well as the stresses induced during pile driving and to avoid buckling.

Fatigue assessment during driving shall be performed.

⁽¹⁾ The methodology for the determination of the ultimate bearing capacity, the ultimate capacity for pullout, the t-z curves and the p-y curves shall be discussed with COMPANY on a case by case basis depending upon the type of soil encountered, and no pile design shall start without prior written approval of the method by the COMPANY.

When piles are “reinforced” at the jacket legs (or sleeves) bottom extremity, the reinforced parts shall be provided with an over-length such as to cover any driving tolerance or inaccuracy and ensure an adequate reinforcement at the required location.

For this purpose the vertical positioning tolerance shall be clearly specified on the piles drawings (for example by the indication of levels to be matched).

7.2.2 Drilled and grouted piles

For drilled and grouted piles, specific attention shall be given to the grouting of the pile/soil and pile/leg annular spaces.

Gravity grouting is not authorized, and pressure grouting from the bottom of the pile shall be contemplated.

Grouting method and all necessary grouting equipment such as manifold, lines, nozzles, packers, etc., shall be defined in detail at the beginning of engineering stage.

7.3 Pile driving design

The analysis shall be carried out according to specification **GS STR 431**. Fatigue design during driving shall be performed.

7.4 Mud mat design and on-bottom analysis

Mud mats shall be dimensioned under the load combinations defined in the table in section 4.7. The mud mats should ensure total stability of the structure during pile installation.

7.5 Conductor pipe design

Above requirements from sections 7.1 to 7.3 shall be applied for conductor pipes design. Relative motion between jack-up drilling rig and platform shall be considered.

8. Selection of materials for offshore structures (**API RP 2A** section I)

8.1 General

Unless otherwise specified, the resisting structural elements shall be distributed into three categories as per requirements of specification **GS STR 100**, and selection of material grade and quality for each category shall be carried out as per requirements of specification **GS STR 201** and/or **GS STR 202**.

8.2 Through-thickness property (quality Z)

In complete joint penetration groove welded angular connections or cross joints, and for which the equations $1.5e + s \geq 55$ and $e \geq 20$ (s = main member thickness, e = branch member thickness, expressed in mm) are simultaneously satisfied, the main member shall have a minimum average reduction of area in the through-thickness direction of 35%.

In this case, the steel quality shall be Z35 according to GS STR 201.

9. Detailed engineering documents (API section J)

9.1 General

Engineering design documents should conform to the Quality Plan in respect of the procedures.

The documents shall be self-contained and contain all the information needed to assess the design.

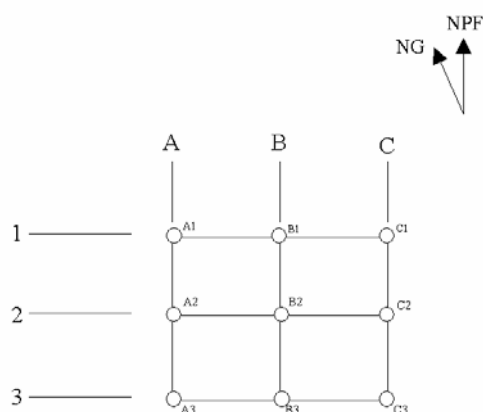
The document(s) shall be checked and approved by the CONTRACTOR following the procedures outlined in its quality plan.

The engineering design file shall be submitted to the COMPANY or its representative for review.

All engineering documents shall use the SI system of units. Stresses shall be given in MPa.

The use of inches is allowed for tubular sizes.

Unless otherwise noted in the project specification, files shall be marked as follows:



9.2 Calculation notes

The calculation notes shall include but not to be limited to:

- Basis of design (main characteristics of the structures, assumptions of each calculation)
- In-place
- Fatigue
- Seismic
- Accidental such as boat impact
- Load-out
- Transportation
- Lifting
- Installation, launching, free flotation, up-ending, on-bottom stability
- Fatigue under transport conditions
- Others studies depending of the structure type.

9.3 Content of the detailed engineering calculation notes

The engineering document shall clearly state at least the following information for each of the cases analysed (in-place including foundations, fatigue, boat impact, seismic, load-out, transportation, installation, etc.):

- Hypotheses
- Conclusions and recommendations
- Software used and references
- Resultants of loads (basic cases and combinations)
- The computerised weight and centre of gravity of the structure for each configuration, and for each discipline (main structure, secondary structure, equipment, piping, etc.)
- Reactions at joint supports
- Forces in all members for all combinations
- Forces in all piles for all elementary load cases and all combinations including a sketch showing the curve of the bending moment and shear load
- Pile and conductor pipe driveability and predicted soil resistance to driving (SRD) curve, driving simulations, fatigue.
- Displacements of main nodes of the structure for annual and 100-years conditions
- Stresses in members other than the usual prismatic beams (box girders, etc.) for all combinations
- Member stress API ratios greater than 0.5 for the most stringent combinations
- Punching shear API ratios greater than 0.5 for the most stringent combinations
- SCF values for each node
- Node fatigue, the lifetime of which is less than 50 years without fatigue design factor
- Natural periods
- All hand verifications.

The results shall be provided on a CD Rom in a WORD format.

9.4 Drawings

In addition to the calculation notes, the following documents shall be provided:

- AFC drawings and relevant material take-off.
- Weight reports with the location of the centre of gravity for the in-place, load-out, transportation and installation configurations.

9.4.1 Drawing general recommendations

Minimum areas requiring the use of Z 35 steel shall be clearly identified.

Jacket legs shall be paint marked according to the principle described in section 9.1 (height of letters and numbers: 500 mm).

Access should be provided to the legs, and the conductor pipes when applicable, at the top jacket level.

Each structure component shall normally be accessible for inspection.

Overlaps of bracings shall be avoided.

If the cutting of "window" in structural pipes or hollow sections is necessary, written approval shall be obtained from the COMPANY.

Inaccessible hollow bodies shall be hermetically sealed and withstand hydrostatic pressure.

Plates and Stiffeners that do not have rounded edges shall have their exposed edges broken to facilitate painting.

At legs and all vertical surfaces all gratings shall be adequately supported.

All grating penetration (piping, cables, etc.) shall be protected by a flat bar to avoid foot traps.

Unless otherwise noted on the Construction Drawings, all handrail welds shall be ground smooth. When removable, all handrail sockets shall be fitted with the panels and the sockets welded in place.

All supports (piping, cables tray, lights, etc.) less than 100 mm high welded on special and first category elements shall be with doubler plate. With a maximum of 50 mm the doubler plate shall be twice its thickness all around the dimension of incoming foot print and shall have 50 mm radius corner. All welds on special and first category elements shall comply with a qualified welding procedure and be executed by a qualified welder. Non-structural components such as all supports of piping, cable trays, lights, etc. higher than 100 mm shall be addressed and welded as structural items.

9.5 Appurtenances

9.5.1 Anode fixings

Anodes shall, wherever possible, be installed in a substantially vertical plane of the structure (note that anodes must be installed in casings and sumps too).

- Doubler plates: connection of anodes to jacket structure shall be made via doubler plates, with a thickness greater than twice the thickness of the anode tube, and with a fillet weld size of 0.7 x doubler plate thickness.
- Doubler plates shall be 35 mm more (all around) than the dimension of incoming brace foot print and shall have 50 mm radius corner.
- Anode connections shall be designed for all applicable load cases, including fatigue induced by vibration during pile/CP driving, fatigue during transportation and for installation loads (launching). It is recommended that the core tube is ϕ 114 mm by 8.6mm (ϕ 4", sch. 80).

The anode tube shall be welded onto the doubler plate by a full penetration weld.

9.5.2 Riser fixings

Risers should be fixed to the jacket by clamps. A coating of 8 mm thick Neoprene or similar according to the temperature of the riser in service shall be inserted between the riser and the collar (coating hardness: 40 to 60 Shore). The fixing shall:

- Immobilise the riser horizontally but not axially, except at the anchor point
- Not damage the coating on tightening, on movement due to axial or radial expansion
- Be provided with lock nuts
- Provide electrical continuity.

Provision for future risers: the diameter of the riser is liable to change. The provision shall comprise greased plates and retaining plates.

9.5.3 Surfer Landing

Unless otherwise stipulated, fixed structures shall not be designed to absorb the mooring forces generated by support vessels.

The type of personnel transport vessel that may be berthed on the jacket shall be defined in the project specification.

The landing stage shall be designed for the type of boat normally used. The mass, shape and the protection of the boat shall be taken into account, with the corresponding water mass added and a rate of advance. Limiting operational conditions shall then be specified.

- Landing stage for supply boats: shock absorbing devices, arranged axially or at right angles to the landing stage shall be provided
- Light landing stage: provided for light personnel transports of the SURFER, TROLL or ZODIAC type.

A typical drawing of a surfer landing is given in specification **GS STR 901**.

9.5.4 "I" and "J" tubes for electrical cable

The "I" and "J" tubes and their fixings shall be sized to avoid V.I.V. and to absorb the dragging forces of the lines for which they are intended. The particular characteristics of these lines shall be taken into account in defining diameters, curvature and both ends.

Ventilation openings in the top part shall be provided to cool electrical cables.

A messenger line should be provided in each tube.

A typical drawing of an I-tube is given in specification **GS STR 901**.

9.5.5 Installation aids

Installation aids shall be provided as defined by the installation procedure, and shall include, but not be limited to:

- Final piles make-up and piles/legs mark-up as defined in the AFC drawings.
- A mounting giro base plate shall be installed at the upper level of the structure aligned with the platform North for structure positioning. Dimensions, locations and fabrication tolerances shall be given by Positioning CONTRACTOR.
- A guide shall be installed on top of the leg for pile installation.

- Funnels for CP installation shall be provided at all CP guide levels.
- All installation aids to be cut offshore shall be welded on legs with doubler plates. They shall be ground to allow painting. Doubler plates shall be justified by adequate calculations.
- If lifting trunnions are used, the sling shall be positively secured.
- Sockets to allow handrails to be installed all around the top level.

9.5.6 Standards of Construction

Standards of Construction are collated in specification **GS STR 901**. They define the minimum requirements to be applied in the design and construction of standard ancillary structural elements on petroleum installations.

The OWNER may accept proposals for recommendations based on international standards and codes or national or foreign standards and codes. These documents shall be subject to the OWNER's approval.

The standards cover:

- Stiffened plates for floors and bulkheads
- Decking plates
- Gratings
- Handrails including drawing
- Staircases including drawing
- Fixed vertical ladders including drawing
- Service hatches on wells
- Penetration through class A and/or H bulkheads
- Splash protection/flameproof/fire wall
- Skidding beams for the drilling rig
- Surfer landing drawing
- I-tube for electrical cable drawing
- Steel wires
- Skid mounted equipment
- Helistation
- Protection of transformers
- Protection of flowlines
- Identification panel
- Helideck safety mesh including drawing.

10. Engineering supervision plan

The COMPANY shall, as a minimum, require a Hold Point or a Review Point on the following activities (to be completed after review of the CONTRACTOR's Quality Plan):

- Design premises: hold point
- Calculation notes: review
- AFC drawings: hold point
- Weight report: review
- Material Take Off: review

11. Fabrication principles

The fabrication specifications are covered by the specification **GS STR 301**. The following requirements referring to the fabrication stage are given to the **design CONTRACTOR** in order to ensure that a consistent structure design is obtained.

11.1 Fabrication studies

These shall be carried out in accordance with **API RP 2A**. Erection procedures during the course of the fabrication shall be documented by calculations and subject to the COMPANY for approval before proceeding with the work.

Load-out equipment such as skidding beams, spreader bars, etc. shall be checked by calculations.

The load-out studies shall include the ballasting calculations and procedure of the support vessel.

A fully documented load-out procedure shall be submitted to COMPANY for approval by COMPANY and Warranty Surveyor. The content of the procedure shall be strictly in accordance with specification **GS STR 401**.

11.2 Weight monitoring

A weight monitoring report must be issued in accordance with specification **GS STR 001**. This shall be a direct continuation of the weight monitoring carried out during the Engineering phase.