

GENERAL SPECIFICATION

STRUCTURAL

GS EP STR 103

Design and fabrication of skids and equipment supporting structures

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1. Scope

This specification defines the requirements applicable to the design, supply, fabrication and construction of any steel structure package having a steel frame for supporting one or more elements such as:

- Machines or mechanical assemblies
- Boiler room equipment
- Piping
- Other accessories (electrical, instrumentation, etc.).

The special provisions specific to each Project (layout, climatic conditions, schedule, function, equipment, etc.) shall be defined in one or more detailed specifications pertaining to the said Project.

This General Specification shall apply to:

- Assemblies weighing less than 300 tonnes
- Support structures for medium-sized rotating machines.

This package structure is supposed to be a structure comprising a number of levels interconnected by posts and trusses. This specification can also be used for more simple structures.

The package is to be installed:

- At an onshore or offshore site
- On deck of a fixed or floating offshore structure.

Within this document the term “module” is used generally to mean the structure of an installation upon which or within which an item of equipment is placed and supported. The term “package” is used for all supported components complete with the equipment’s own base frame or supporting structure.

For Equipment on Floating structure subject to Classification all requirement of Class shall apply if more stringent.

The design shall be performed according to [API RP 2A-WSD](#), but LRFD method, according to [DNV-OS-C101](#), is acceptable.

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

2. Reference documents

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

The structural design of skids and equipment supporting structures shall be conducted in accordance with 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 specification.

External Documents

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

Reference	Title
AISC 325	Steel Construction Manual
AISC 360	Specification for Structural Steel Buildings
API BULL 2V	Bulletin on design of flat plate structures
API RP 2A-WSD	Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms - Working Stress Design
API Spec 2C	Offshore Pedestal-mounted Cranes
ASTM A307	Carbon Steel Bolts, Studs, and Threaded Rod 60 000 PSI Tensile Strength
ASTM A325	Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
ASTM A490	Structural Bolts, Alloy Steel, Heat Treated, 150 ksi Minimum Tensile Strength
ASTM A578/A578M	Straight-beam ultrasonic examination of rolled steel plates for special applications
ASTM E165/E165M	Liquid Penetrant Examination for General Industry
ASTM E709	Magnetic Particle Testing
ASTM F1166	Human engineering design for marine systems, equipment, and facilities
AWS D1.1/D1.1M	Structural Welding Code - Steel

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Reference	Title
CSWIP/PCN	Requirements for the certification of personnel engaged in NDT
DNV VMO Standard	The VMO Standard supersedes and replaces "DNV Rules for Planning and Execution of Marine Operations.
DNV-OS-C101	Design of Offshore Steel Structures, General (LRFD method)
DNV-OS-E303	Offshore Fiber Ropes
DNV-OS-H101	Marine Operations, General
DNV-OS-H102	Marine Operations, Design and Fabrication
DNV-OS-H201	Load Transfer Operations
DNV-OS-H203	Transit and Positioning of Offshore Units
DNV-OS-H204	Offshore Installation Operations (VMO Standard Part 2-4)
DNV-OS-H205	Lifting Operations (VMO Standard Part 2-5)
DNV-RP-C203	Fatigue design of offshore steel structures
EN 10160	Ultrasonic testing of steel flat product of thickness equal or greater than 6 mm (reflection method)
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
EN 287-1	Qualification test of welders - Fusion welding - Part 1: Steels
EN 571	Non-destructive testing - Penetrant Testing
FEM 1.001 (or equivalent)	Rules for the design of hoisting equipment
IMO	Code of Safe Practice for Cargo Stowage and Securing
ISO 10816-1	Mechanical Vibration - Evaluation of Machine Vibration by Measurements on Non-Rotating Parts - Part 1: General Guidelines
ISO 11666	Non Destructive Testing of welds - Ultrasonic testing - Acceptance levels
ISO 148-1	Metallic materials - Charpy pendulum impact test - Part 1: Test method
ISO 15607	Specification and qualification of welding procedures for metallic materials - General rules

Reference	Title
ISO 15614-1	Specification and qualification of welding procedures for metallic materials - Welding procedure test - Part 1: Arc and gas welding of steels and arc welding of nickel and nickel alloys
ISO 17637	Non-destructive testing of welds Visual testing of fusion-welded joints
ISO 17638	Non-destructive testing of welds Magnetic particle testing
ISO 17640	Non-destructive testing of welds - Ultrasonic testing - Techniques, testing levels, and assessment
ISO 6507-1	Metallic materials - Vickers hardness test - Part 1: Test method
ISO 7919-1	Mechanical Vibration of Non-Reciprocating Machines - Measurements on Rotating Shafts and Evaluation Criteria - Part 1: General Guidelines
ISO 80000-1	Quantities and units - Part 1: General
ISO 898-1	Mechanical properties of fasteners made of carbon steel and alloy steel - Part 1: Bolts, screws and studs with specified property classes - Coarse thread and fine pitch thread
ISO 9712	Non-destructive testing - Qualification and certification of NDT personnel

Total General Specifications

Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published in the applicable yearly collection.

The provisions of this specification shall apply in addition to the supplementary documents supplied by Company, including:

- Country specificity appendices
- Project Particular Specification (PPS)
- Data sheets
- Articles and conditions; list of tasks
- Quality assurance provisions.

Reference	Title
GS EP COR 350	External protection of offshore and coastal structures and equipment by painting
GS EP COR 353	Design and application of passive fire protection coatings
GS EP MEC 300	Noise and Vibration of Rotating Machine Packages
GS EP SPS 009	Corrosion protection of subsea stations

Reference	Title
GS EP STR 001	Weight monitoring and weighing offshore units
GS EP STR 100	Offshore steel structures - General
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.) and Box Girders (B.G.)
GS EP STR 901	Design rules and construction standards for ancillary structures of offshore installations

3. Design methods

3.1 Functional definition

The package structure shall:

- Satisfy the service conditions imposed by the equipment such as permitted deflection, vibration (displacement, speed, acceleration), natural frequency of supporting steel structure and machine alignment adjustments
- Protect the package during the operations of loading and off-loading
- Guarantee the integrity of the assembly under the stresses induced by the different transports from the fabrication plant to the final location
- Where installed on a floating offshore structure, guarantee the integrity of the assembly under the stresses induced by movement of the floating support
- Allow for the assembly to be lifted for installation at an onshore site (onshore installation or construction site lifting) or offshore site
- Allow easy maintenance of the equipment installed and access to piping and valves
- Provide and permit safe access
- Allow easy connection of components to the equipment on the support structure.

3.2 Materials

3.2.1 Main and secondary structures

- The structures shall be made of fully killed carbon steel. The materials used shall comply with American (ASTM) or European (EN) standards and the requirements contained in Table 1. The following applies with steel with SMYS less or equal to 355 MPa. For any steel with higher SMYS or forging or casting, **GS EP STR 201**, **GS EP STR 202**, **GS EP STR 203** shall be applied.

This table applies when ambient temperature is not below 0°C at time of any lifting operation. Otherwise, impact test temperature shall be agreed with the Company.

Table 1 - Impact test requirements in Base Materials and Welds

Structural Member	Thickness range (mm)	Material (1)	CHARPY Impact Energy (Joules) (2)	
			Min. Avge	Min. Single
Lifting points and incoming members to lifting points (special)	$t \leq 19.5$ $19.5 < t \leq 38.1$	KT 0 KT -20	$\left\{ \begin{array}{l} 28 \text{ J (3)} \\ 36 \text{ J (4)} \end{array} \right.$	$\left\{ \begin{array}{l} 21 \text{ J (3)} \\ 27 \text{ J (4)} \end{array} \right.$
Main beams/girders and main tubular braces (primary)	$t \leq 12.7$ $12.7 < t \leq 25.4$ $25.4 < t \leq 38.1$	KL +20 KL 0 KL -20	$\left\{ \begin{array}{l} 28 \text{ J (3)} \\ 36 \text{ J (4)} \end{array} \right.$	$\left\{ \begin{array}{l} 21 \text{ J (3)} \\ 27 \text{ J (4)} \end{array} \right.$
Other structural members (secondary)	$t \leq 25.4$ $25.4 < t \leq 38.1$	KL +20 KL 0	$\left\{ \begin{array}{l} 28 \text{ J (3)} \\ 36 \text{ J (4)} \end{array} \right.$	$\left\{ \begin{array}{l} 21 \text{ J (3)} \\ 27 \text{ J (4)} \end{array} \right.$
(1) KT means impact test made transverse to main rolling direction at the stated testing temperature (i.e. 0°C, -20°C). KL means impact test made parallel to main rolling direction at the stated testing temperature (i.e. +20°C, 0°C, -20°C). (2) CHARPY V-notch impact test with full size 10 x 10 mm specimens. Impact test in weld to include WM, FL and FL + 2 mm. (3) Applicable to steel (and relevant welds) with MSYS ≤ 255 MPa. (4) Applicable to steel (and relevant welds) with MSYS ≤ 355 MPa.				

- b) Steel of lifting points will preferably be of type 355 MPa MSYS.
- c) The use of steel with MSYS higher than 355 MPa shall be subject to prior approval of the Company.
- d) All steels shall have a max Carbon Equivalent (IIW formula) (ladle) of 0.43% and max Pcm (ladle) of 0.23%, whichever the greater.
- e) For plates or rolled sections with thickness > 25 mm (or less if deemed necessary by structural design) which are heavily stressed in the through thickness direction due to large welding shrinkage or heavy service stresses, cross assemblies with complete/full or partial joint penetration and for cans, with possibility of inducing lamellar tearing, shall be of Z 35 quality of standard [EN 10164](#).

Z35 steel shall also be required in complete/full or partial joint penetration groove welded angular connections or heavy fillet weld for the through member when the two following conditions are simultaneously met:

- $1.5e + s \geq 55$
- $e \geq 20 \text{ mm}$

(s = main member thickness, e = branch member or effective throat weld thickness, expressed in mm)

Types and number of tensile specimens to be cut as well as their sampling location in the product shall comply with standard [EN 10164](#). However, for plates three tensile tests shall be cut and tested at each end of mother plate¹ whatever the sulphur content. When traceability (regarding rolled plate) of individual plates is not ensured, then three tensile specimens shall be cut at each end of individual plate.

Acceptance criteria: the required minimum average reduction of area shall be 35%, without any single value lower than 25%. In addition, the Tensile Strength measured at each test shall not be lower than 80% of minimum specified tensile strength.

For special and first category plates or rolled sections with thickness ≥ 16 mm, the sulphur and the phosphorus contents in the ladle analysis shall not exceed 0.005% and 0.020% respectively.

All Z35 steel with thickness above 20mm shall be UT tested against delamination according [EN 10160](#) S1/E2 or [ASTM A578/A578M](#) Level B.

Delivery condition for Z35 steels shall be Normalized or TMCP.

Minimum areas requiring Z 35 steel shall be clearly identified on drawings.

- f) The Contractor shall prepare a material procedure describing his organization for receiving, storing and permanent identification of materials (including transfer of markings). This procedure shall form part of the Manufacturing Procedure Specification (MPS) defined hereafter.

3.2.2 Other secondary structures and non-structural items

Refer to construction standard [GS EP STR 901](#) which defines requirements for ladders, access platforms, handrails, etc.

3.3 Equipment supports

Equipment mountings onto module structures shall be designed to permit continuous all-round welding, and shall provide sufficient access for effective corrosion prevention coating of all surfaces. Details of dimensions and locations of all equipment supports shall be agreed between equipment vendor and designer of the supporting structure within an agreed milestone point on the package planning. The equipment vendor shall supply support loading for all design conditions within an agreed milestone point on the package planning.

Design of equipment-supporting structure shall take appropriate account of fabrication tolerances and stiffness interactions with the supporting module structure. The equipment vendor shall agree with the module designer the tolerances to be allowed for in the design, and shall make provision in the design of the supports for shimming or other levelling where required to achieve the functional requirements of the equipment.

3.4 Reporting

Engineering documentation shall be submitted to include:

- Overall design of the frame to provide the functions specified in section 3.

¹ The term "mother plate" (or, otherwise, "rolled plate" or "parent plate") designates the whole of the plate which has the same thickness and heat treatment (if any) as that of the finished product, obtained from one slab.

- Detailed construction drawings showing overall structural arrangement, joint configurations, supports and lifting points, with identification of materials, and a definition of weld details.
- Preparation of calculations to justify the arrangement and types of main and secondary members in the frame for the following cases:
 - Structure in place, no load on equipment
 - Structure in place, equipment in service
 - Structure in place, equipment under test
 - Structure during blast and seismic (if applicable)
 - Structure when skidding the package
 - Structure during any type of transportation
 - Structure during lifting
 - Structure during installation (guides and bumpers, skid placement).

Calculation reports shall include general arrangement drawings of the equipment and the structural drawings or engineer's sketches of the components which are analysed. Reporting shall address design of frame members, joints, lift points, support points, mechanical handling aids, lifting beams and other components as applicable.

- Evaluation and verification of the acceptance of mechanical vibrations (dynamic and/or test calculations) to match the structure to the equipment, particularly for assemblies including rotating machines.

Verification methods and assumptions (permissible distortion) shall be clearly described beforehand in a calculation procedure and accepted by the Company.

All analysis stresses shall be compared to the AISC or [API RP 2A-WSD](#) basic allowable stresses.

Through stress shall be avoided when possible, otherwise use of Z35 steel shall be considered (see paragraph 3.2.1).

3.4.1 Individual load cases to consider

The loads and stresses on the structures shall be clearly explained in the design documentation.

This section defines the individual loads that shall be used in the general verification of the structure.

3.4.1.1 Gravity loads

The gravity loads used in the studies in each of the configurations considered shall comply item-by-item with the envelope weight (weight of an element or assembly including tolerances and contingencies according to Appendix 1).