



Exploration & Production

GENERAL SPECIFICATION

STRUCTURAL

GS STR 103

Design and fabrication of skids and equipment supporting structures

03	10/04	§ 1, 2, 3.3.1.3, 3.3.1.6, 3.4, 4.3, 5.1.2.4, 5.1.3.1 revised
02	10/03	§ 3.2.1, 3.2.2, 3.3.1.3, 3.3.1.6, 5.1.1, 5.1.2.3, 5.1.3, 5.1.3.1, 5.1.4, 5.1.5.2 revised – Change of Group name and logo
01	10/02	Up-dated for Materials and Fabrication, revised sections: 3.3.1.3, 3.3.1.6, 3.3.3, Table 2, 4.3, 5
00	03/01	First issue
Rev.	Date	Notes



Contents

1. Scope	3
2. Reference documents	3
3. Design methods	6
3.1 Functional definition	6
3.2 Materials	6
3.3 Studies	8
3.4 Weight monitoring	11
4. Fabrication	12
4.1 General	12
4.2 Manufacturing Procedure Specification (MPS)	12
4.3 Welding	12
4.4 Bolted connections	15
4.5 Corrosion protection	15
4.6 Dimensional tolerances	15
5. Installation methods	15
5.1 Lifting studies	16
6. Quality	22
6.1 Quality plan	22
6.2 COMPANY Supervision	23
7. Technical Queries/Non-Conformance Reports	24
Appendix 1 Percentages of contingency + tolerances	25

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.

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 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.

Standards

Reference	Title
API RP 2A WSD	Recommended Practice for Planning and Constructing Fixed Offshore Platforms Working Stress Design
API Bulletin 2V	Bulletin on design of flat plate structures
API SPEC 2C	Specification for offshore cranes
ISO 1000	International system of units
ISO 10816-1	Mechanical Vibration - Evaluation of Machine Vibration by Measurements on Non-Rotating Parts - Part 1: General Guidelines
ISO 7919-1	Mechanical Vibration of Non-Reciprocating Machines - Measurements on Rotating Shafts and Evaluation Criteria – Part 1: General Guidelines Second Edition
ISO 14964:2000	Mechanical vibration and shock -- Vibration of stationary structures -- Specific requirements for quality management in measurement and evaluation of vibration
AISC	Manual of steel construction - Load and resistance factor design latest edition
FEM 1.001 (or equivalent)	Rules for the calculation of hoisting equipment
NF P 22-255 (or equivalent)	Metal construction. Hollow section welded assemblies on type I and H sections. Design and verification
EN 288	Welding Procedure Qualification
EN 287	Welder Qualification
EN 473	Qualification of NDT personnel
EN 970	Visual Examination
EN 571	Liquid Penetrant Examination
EN 1290	Magnetic Particle Examination
EN 1714	Radiographic Examination
EN ISO 6507	Hardness Test. Vickers test - Part 1: HV5 to HV10
EN 10 045-1	Charpy impact test on metallic materials
CSWIP/PCN	Requirements for the certification of personnel engaged in NDT

**Professional Documents**

Reference	Title
Not applicable	

Regulations

Reference	Title
Not applicable	

Codes

Reference	Title
AWS D 1.1	Structural Welding Code - Steel
CSWIP/PCN	Requirements for the certification of personnel engaged in NDT
ASTM E 165	Liquid Penetrant Examination
ASTM E 709	Wet Magnetic Particle Inspection

Other documents

Reference	Title
Not applicable	

Total General Specifications

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 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 STR 001	Weight monitoring and weighing of offshore units
GS STR 100	Fixed offshore steel platforms - General
GS STR 201	Steel materials for offshore structures
GS STR 901	Design rules and construction standards for ancillary structures of offshore installations
GS SAF 221	Safety rules for buildings

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
- Allow easy connection of components to the equipment on the support structure.

3.2 Materials

3.2.1 Main and secondary structures

- a) 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.

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 $\leq$ 255 Mpa. (4) Applicable to steel (and relevant welds) with MSYS $\leq$ 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) Z35 steel (i.e. steel with a mini specified reduction of area of 35% in the through thickness direction) shall be used for the through plate of any tee-butt weld assembly (full penetration weld) when the two following conditions are simultaneously met:

$$1.5 t + e > 55 \quad \text{with } t \geq 20$$

where: e = thickness of incoming plate in mm

t = thickness of the through plate in mm

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 STR 901](#).

3.3 Studies

Studies shall include:

- Overall design of the frame to provide the functions specified in section 3
- Preparation of detailed drawings
- 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).
- 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](#) basic allowable stresses.

3.3.1 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.

3.3.1.1 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).

The floor loads shall apply to clear floor surfaces and under no circumstances represent equipment loads:

- For walkways, uniformly distributed operating load to be used: 2.5 kN/m^2
- For other areas, unless otherwise indicated in a job specification, use 5.0 kN/m^2 .

Floor overload weighting (Ks) according to the item calculated.

Item calculated	Ks
Decking and beams of package	1
Main deck structure	0.5
Lowering of loads on the bearing structure/foundations	0.25

3.3.1.2 Climatic stresses

Wind loading: in the absence of any indication in the particular specification, the wind speed used for the calculation shall be 40 m/s, shape coefficient $C_s = 1.5$.

Snow/ice loading: Loads are indicated, where applicable, in the particular specification.

3.3.1.3 Dynamic and vibration analysis

By principle, the rotating equipment shall be mounted on a three point skid.

If anti-vibration mountings (A.V.M.) are implemented between the equipment skid and the supporting structure, multi supports (min. 4) shall be considered.

The dynamic effects of a "vibrating" equipment supported by the frame shall be taken into account. For rotating machines, the starting or short-circuit torque shall not induce rotation greater than 1/20 degree (1/1000 radian). The stiffness of the support structure shall be modeled when performing a "vibrating" equipment dynamic analysis.

Unless otherwise specified, mechanical vibration acceptance levels (displacement, speed and acceleration), specific to different types and classes of machine shall be based on [ISO 10816](#). They can be complemented by [ISO 7919](#).

The in-service configuration shall include equipment operating loads.

If a piping support beam is used as a handling support (rolling beam, lifting lug), the piping shall be considered as being full for the purposes of calculation and testing.

All main sources of vibration shall be considered in the design of the structure. The « vibrating » equipment list shall be defined taking into account the following parameters: type of rotating machine (centrifugal ,screw or reciprocating), electric power, excitation frequencies and dynamic forces, total mass, insulating systems with anti-vibration mountings (A.V.M.).

As a minimum the following shall be analysed for their effects on the structure:

- Operating mechanical equipment

In the frequency range of 5 to 80 hertz, a vibration analysis shall be carried out for "vibrating" equipment with the following acceptance criteria:

1. For equipment insulated with anti-vibration mountings (A.V.M.):
 - a) the six suspension modes shall be less than one half of the lowest excitation frequency of the equipment,
 - b) the supporting structure stiffness and the equipment skid stiffness (N/m) shall be twenty times higher than the A.V.M.'s stiffness.
2. In all cases, equipment skid and supporting structure first significant natural frequencies (i.e. mode shape involving equipment skid and surrounding supporting structure: estimated

participating mass, above 10 % of the total mass of the equipment skid and surrounding structure) shall be out of the frequency range of +/- 20% of the principal excitation frequencies less than 35 Hertz or +/- 10% of the principal excitation frequencies above 35 Hertz.

3. If the requirements of above paragraph 2 are not verified or achievable, a dynamic response shall be performed. The computed vibration levels shall verify the machinery acceptance criteria. For the calculation, the modal damping factor η ($\eta = 2 C / C_r$) shall be less or equal to 0.04 with C = viscous damping and C_r = critical viscous damping. In complement, the general topsides cartography shall be computed regarding human exposures to vibrations that shall not exceed the allowable limits as defined in **GS SAF 221**.

For four stroke diesel engines, the first excitation frequency is given by half the rotating speed.

3.3.1.4 Blast and fire design

The blast and fire loads to be considered shall be defined in the particular specification

The design shall be based on plastic/dynamic methods in order to justify the blast energy absorption.

3.3.1.5 Skidding stresses

This section applies mainly to equipment on skids which can be displaced by longitudinal skidding.

The frame shall be considered on supports in the extreme position (maximum span permitted by length of frame members).

Unless otherwise indicated, the minimum friction coefficient shall be 0.5.

3.3.1.6 Transportation stresses

The package can be transported by road and/or sea, installed in a structure or not.

In the absence of data in the job specification, the following acceleration transmitted to the package during sea transportation shall be combined:

- Roll and pitch: ± 0.9 g (horizontal acceleration)
- Heave: ± 0.4 g (vertical acceleration).

For this above, the securing of the equipment must be allowed for.

No one-third increase of the **AISC/API** Basic Allowable Stresses is allowed.

The sea fastening definition shall be supported by a transportation procedure and associated drawings and calculation note.

Lashing is subject to COMPANY approval for cargo weighing less than 50 T and prohibited for heavier. Use of chain and turnbuckle is subject to prior COMPANY approval. Turnbuckles with open hook are prohibited.

3.3.1.7 Lifting stresses

Verification methods shall be clearly described and shall have prior approval of the COMPANY.

Refer to section 5 of this specification.

3.3.2 Load combinations

The following load combinations shall be applicable for verifying the overall structure:

Load cases	In place, no service	In place, in service	In place, under test	Skidding	Lifting	Installation onto offshore structures	Transport
Gravity loads: structure	x	x	x	x	x	x	x
Gravity loads: equipment	Empty	In service	Full load	Empty	Empty	Empty	Empty
Operating loads	x	x					
Environment		x	x				x
Dynamic and static indeterminant coefficient (lifting)					x		
Roll $\pm$ heave or Pitch $\pm$ heave							x
Impact (Placement)						x	
Skidding horizontal force				x			
Cable horizontal force					x		

3.3.3 Verifications

Unless otherwise indicated in the Project particular specification and in the equipment manufacturer's recommendations, deflections shall not exceed the values below:

Type of structure	Deflection as 1/nth span			
	Structure for static equipment		Structure for dynamic equipment	
	In service	Handling & Transport	In service	Handling & Transport
Skid longitudinal beams	1/500	1/375	1/1500	1/1000
Floor main beams	1/500	1/375	1/1500	1/1000
Equipment supporting points	1/500	1/375	1/1500	1/1000
Floor joists	1/250	1/200	1/250	1/200
Rolling beam	1/500	-	1/500	-

3.4 Weight monitoring

Weight monitoring shall be carried out in compliance with specification **GS STR 001**. Derogations to the **GS STR 001** are subject to COMPANY approval on a case to case basis.

4. Fabrication

4.1 General

Unless otherwise stated, the fabrication shall be in accordance with [AWS D1.1 Code](#).

4.2 Manufacturing Procedure Specification (MPS)

A MPS including materials, fabrication sequence (pre-fabrication of elements, assembly sequence, welding sequence), welding and inspection (as stated hereafter) shall be submitted to COMPANY and approved before fabrication starts.

4.3 Welding

4.3.1 Welding process

Only SAW and SMAW process shall be normally used for welding. GMAW process is not acceptable. FCAW process shall be submitted to COMPANY approval.

4.3.2 Welding consumables

Welding consumables shall comply with an European standard or [AWS D1.1 Code](#).

The use of welding consumables that provide a weld deposit with low diffusible hydrogen content (i.e. consumables specified for less than 10 cm³ per 100 g of weld deposited metal) shall be mandatory if one of the following conditions is satisfied:

- Thickness of one of the elements to be assembled is > 15 mm
- Minimum Specified Yield Strength (MSYS) of one of the elements to be assembled is > 300 MPa.

4.3.3 Welding specification

Before starting work, the CONTRACTOR shall prepare a detailed welding specification for the entire construction. This shall be kept available on the sites at which the welding work is carried out.

The specification shall include:

- A weld map showing identification of welds and applicable WPS and NDT
- For each type of weld, applicable WPS and relevant WPQR, according to [AWS D 1.1](#) or [EN 288 Std](#)
- Extent of non-destructive testing, together with NDT procedures
- Mill acceptance certificates of the welding consumables to be used.

4.3.4 Approval of welding procedures

a) All WPS applicable to welds and repair welds shall comply with [AWS D1.1 Code](#) or [EN 288 Std](#) and shall include a VICKERS hardness test (under 5 or 10 kg load) and a CHARPY V-notch test (WM, FL and 2 mm from FL).

Impact test requirements for welds shall be those of relevant base material: refer to Table 1.

Hardness test shall not show any value exceeding 325 HV5 or 10.

WPS limitations shall be those of the applicable standard or Code.

- b) All WPS shall have the prior approval of COMPANY.
- c) Qualified welding procedures from previous orders may be accepted without further qualification tests, provided that the following conditions are satisfied for Special and Primary structures:
- The qualification records proposed by CONTRACTOR are fully documented as regard to the requirements of present specification (for example, brand name and designation of consumables shall be clearly indicated in WPS and WPQR, and Mill Certificate of base material used for qualification tests shall be included in WPQR).
 - The Carbon Equivalent (ladle), Pcm (ladle) and Carbon content (ladle), whichever the greater, of the job do not exceed those of the test piece (as shown on WPQR) by no more than 0.02%.
 - The WPS/WPQR has been qualified by an internationally recognized inspection agency.

All the above conditions shall always be subject to prior acceptance of the COMPANY.

4.3.5 Approval of welders

All welders shall be qualified in compliance with [EN 287.1Std](#) or [AWS D1.1 Code](#).

4.3.6 Constructional provisions

a) Welds subject to fatigue stresses

Due consideration shall be paid to welds subject to cyclic/fatigue stresses during service.

Supporting structure for rotating machinery of power in excess of 100 kW (unless otherwise agreed), or for vibration inducing machinery such as diesel engines or reciprocating compressors irrespective of their power shall be considered as fatigue sensitive structure with respect to weld design, performance and inspection. Weld profiling by grinding may be deemed necessary.

b) Continuous welds

All welds shall be continuous to avoid any risk of corrosion.

c) Proximity of welds

The distance between the toes of two consecutive full penetration welds shall be greater of 6 times the material thickness or 100 mm.

d) Climatic conditions

Welding operations shall be interrupted when the metal temperature is below -10°C.

Between -10° and 0°C, minimum preheating shall be 50°C.

e) Preheating

The preheating and interpass temperatures shall comply, as a minimum, with the recommendations of [AWS D1.1](#), unless higher temperatures are required in WPS. Control of preheating shall always include the welding start.

4.3.7 Non-Destructive Testing (NDT)

The CONTRACTOR shall prepare non-destructive testing procedures. These procedures shall form part of the Manufacturing Procedure Specification defined above.

a) Qualification of NDT personnel

NDT operators shall have the level 2 qualification ([CSWIP/PCN](#), [EN 473](#) or equivalent).

b) Type and extent of NDT on welds

- All weld preparations shall be 100 % visually inspected before welding
- All finished welds shall be 100% visually inspected before any NDT is made
- NDT shall be carried out not earlier than 24 hours after welding has been completed in accordance with Table 2.

Table 2 - Extent of Non-Destructive Testing (NDT)

Structural Member or Weld	Type of Weld	NDT Extent	NDT Method
Lifting pad-eyes (1) / padears / trunions welds and connecting welds to incoming members	Full penetration weld	100%	UT + MPI
	Fillet and Partial Penetration welds	100%	MPI
Main beams / girders / tubular braces and connection welds	Full penetration weld	100%	UT + MPI
	Fillet and Partial Penetration welds	20%	MPI
Girders web to flange welds	Full penetration weld	20% (2)	UT
	Fillet and Partial Penetration welds	20%	MPI
Girders flanges / Tubular braces	Butt weld	100%	UT or RT (3)
Girders webs	Butt weld	20%	RT
Notes: (1) This also applies to pad-eyes of lifting spreader bars (2) To be 100% at node location (3) For butt welds: UT for WT ≥ 25 mm and RT for WT < 25 mm			

c) Acceptance criteria

Acceptance criteria shall be as defined in [AWS D 1 1](#).

Lack of fusion, incomplete penetration and undercut shall not be acceptable in welds of pad eyes or components subject to concentrated lifting loads (e.g. hooking parts of lifting devices and accessories).

All repairs shall be stated on the NDT record.

4.4 Bolted connections

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

Mechanical / locking devices of nuts shall be provided for bolted connections between structural members pertaining to special or first category, to masts, to equipment superstructures, to vibrating equipment, etc.

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.

Reference shall also be made to the [GS STR 201](#).

4.5 Corrosion protection

Protection by painting shall be carried out in accordance with [GS COR 350](#) and the Project specification where applicable.

4.6 Dimensional tolerances

Dimensional tolerances shall be as per [AISC](#) Std and [AWS D1.1 Code](#).

In all critical assembly (excluding mechanical fixing), no point shall deviate from theoretical by more than 10 mm in the two planar directions and 6 mm perpendicularly.

For equipment supports on the structure, more restrictive value dictated by rotating machine operating conditions or the pressure vessel design code shall require adjustment and/or machining of the support.

Guard rails and hand rails: after installation on site, the top rail shall be straight and leveled to the eye.

Landings and stairways: after installation on site, levels and horizontal positions shall not be more than 25 mm from the theoretical positions.

5. Installation methods

Lifting equipment shall be sized in compliance with the agreed rules (international standards, professional recommendations, national regulations, etc.).

Verification methods shall be clearly described and shall have prior approval of the COMPANY.

To facilitate offshore lifting operations, shackle ears or cable securing devices sized to take a horizontal force of 10 % of the weight of the package shall be required.

Spreader frame, sling and shackle certificates shall be submitted.

This section defines the minimum requirements to be fulfilled to analyse the structure of any package to be installed offshore.

5.1 Lifting studies

5.1.1 General

The purpose of the lifting studies is to check the structural behaviour of the packages to be lifted, and to calculate and design all the relevant lifting devices such as pad eyes, pad ears, trunnions, shackles, spreader bars or spreader frames, slings, bumpers and guides, etc.

This section defines the minimum requirements for any package lifting studies. Depending of the destination of the platform, or of the selected installation CONTRACTOR, different methods and/or different acceptance criteria may be required by the Particular Specification.

Depending of the context of the study (basic engineering, detailed engineering, construction), the CONTRACTOR shall consider a more or less stringent contingency for the position of the center of gravity of the package to be approved by COMPANY.

This section covers the lifting operations performed with single or double hook lifting systems, single or double crane vessel lifting system. Other systems shall be covered by the Particular Specification.

Unbalanced prongs loads on the hook shall be addressed and approved by the crane manufacturer.

5.1.2 Lifting analysis

5.1.2.1 Computer model

The computer model used to verify the package structure at lift shall reflect the exact location of the application point of the sling force on the structure considering the eccentricity of pad eyes and slings.

The model shall be such that the center of gravity of the package and the hook point are in perfect static equilibrium.

5.1.2.2 Loads

For any lifting analysis, the calculations carried out shall combine and include the following loads and factors:

- For an unweighed structure, the calculations shall consider the maximum expected weight, which includes the contingencies defined in the weight report.
- For a weighed structure, the calculations shall consider the weighed weight plus a tolerance factor of 3 % due to weighing inaccuracy.
- When the maximum expected lift weight is above 90 % of the maximum lift capacity, the maximum lift capacity shall be considered for the lifting analysis.
- Whenever the results of a weighing (if any) would show a weighed weight greater than the maximum expected weight and/or an excessive COG shift, the lifting calculations shall be revised to consider the weighed weight plus 3 %, and the structure shall be reinforced accordingly if required.

5.1.2.3 Variation of COG

Lifting analyses during engineering phase shall consider:

- The variation of the calculated location of the centre of gravity within a rectangle whose sides are equal to 10 % of the overall width and length for a skid but not less than within a 1.0 m x 1.0 m square area for a package.
- The variation of the minimum sling angle of $60^\circ \pm 5^\circ$.

5.1.2.4 Dynamic Amplification Factor (DAF)

A dynamic amplification factor shall be applied for the design of the whole structure, the lifting points, the slings, the shackles and the spreader bars or frames, if any.

Weight of the lifted object	< 150 T	> 150 T
DAF offshore	1.30	1.20
DAF inshore	1.15	1.10

5.1.2.5 Skew load distribution (SKL) for single-hook lifts

In lieu of a more refined analysis taking into account the relative stiffness of the lifted object and slings, the lifted object and slings, the misfit and inaccurate sling lengths within the tolerances and other uncertainties with respect to the force distribution in the slinging arrangement, a skew load distribution shall be considered on any set of diagonally opposite slings.

The SKL distribution shall be applied for the design of the whole structure, the lifting points, the slings, the shackles and the spreader bar or frames.

- For statically indeterminate four points lifts with one of the following slinging arrangement:
 - Four slings directly from the four lifting points to the hook
 - Four slings to the hook with an intermediate spreader frame
 - Four slings to the hook with two intermediate rigid spreader beams.

It shall be considered:

Statically indeterminate four points lifts	Rigid object (truss)	Flexible object (pancake)
Skew load factor SKL	1.50	1.33
Skew load distribution in any set of diagonally opposite slings	75/25 %	67/33 %

- For statically determinate four points lifts with one of the following slinging arrangement:
 - Four slings to the hook with two intermediate loose spreader beams
 - Two slings to the hook with one intermediate spreader beams.

It shall be considered:

- SKL factor = 1.10 i.e. a skew load distribution in any set of diagonally opposite slings of 55/45 %.

5.1.2.6 Other load factors for multi-hook lifts

In addition to skew load factors calculated in accordance with above requirements for single-hook lifts, it shall be considered the yaw and tilt effects which may result from a deviation of the hooks from their ideal relative positions.

In the absence of significant wind loading or tugger line loads, a minimum Yaw Effect Factor (YEF) of 1.05 shall be used.

When cranes are on the same vessel, the Tilt Effect Factor (TEF) shall be calculated for a tilt of 3° and for a tilt of 5° when the cranes are on separate vessels.

These factors shall be applied for the design of the whole structure, the lifting points, the slings, the shackles and the spreader bar or frames.

5.1.2.7 Consequence factor

A consequence factor equal to 1.35 shall be applied to loads for the design of lifting points, spreader bars/frames, incoming structural members connected to lift points, including their both extremities.

A consequence factor equal to 1.15 shall be applied to the rest of the structure.

For selection of slings and shackles, the consequence factor is not to be considered for evaluating the minimum SWL as it is included in the sling or shackle safety factors.

5.1.2.8 Allowable stresses

No increase of basic allowable stresses is allowed for lifting analysis.

5.1.3 Lifting points and incoming members design

The lifting points and incoming members shall be considered as special category components.

Lifting points and incoming members shall be designed using the sling loads resulting from above plus an horizontal longitudinal and transversal load equal to 10 % of the sling load mentioned above and applied at centerline for the trunnion or at top of the pinhole for the pad eye.

In case of lifting with 2-fold slings or grommet arrangement, a 55/45 % sling force distribution shall be considered on each part of grommet or sling, in order to take into account the friction on the trunnion or on the hook.

The position of lifting points shall be such that easy and safe access is ensured for installation and removal of slings, shackles, pins, etc.

The lift points shall be located at strong points on the structure, as symmetrically as possible around the COG position. The location of the COG shall be within an elliptic area centered on the geometrical center of the lifting points with large & small diameters equal to one-third of the corresponding distances between the lifting points.

The distance between the lift points shall not be less than half the overall dimension of the total module length or width to avoid a significant sling force increase by a small offset of the center of gravity.

The design of the pad eye/trunnion and its connections to the incoming members of the lifted object shall be based upon shear connection details, whenever possible.

The design of the lift point based on the transfer of stress in the through thickness of plates is prohibited.

For fabricated lifting points, the main plate rolling direction shall be in line with the sling direction. Lifting points drawings shall show the plate rolling direction.

The main plate shall be Z 35 quality.

5.1.3.1 Pad eyes

When cheek plates are used, they shall be on both sides of the main plate. Only one pair of cheek plates shall be used. The thickness of the cheek plate must be smaller than or equal to 75% of the main plate thickness: cheek plates shall be welded to main plates by a peripheric fillet weld and also by a 12 mm minimum partial penetration weld inside the pinhole when pinhole diameters are larger than 100 mm. The welds inside the pinhole shall not be considered for the calculation. If centralising rings are used on each side of the padeye, they shall not be welded to the cheek plates.

The radius of the main plate of the pad eye shall not be less than the maximum value of:

- $1.50 \times D$
- $D/2 + 3"$

D being the diameter of the pinhole

The cheek plate should be circular with the largest possible diameter. The radius of the cheek plate should be the radius of the main plate minus cheek plate thickness. The top of the fillet weld shall be clear of the corner of the main plate by 5 mm minimum.

The pin hole diameter shall be maximum 5 mm larger than the diameter of the pin for shackles with SWL > 200 T and 3 mm for SWL < 200 T. Pin holes shall be machined to generally accepted fabrication tolerances.

The holes shall be line bored after the welding of the cheek plates to the main plate.

In addition to the diametral bearing pressure check, the Hertz pressure shall be checked for cylindrical bearing surfaces, and shall be limited to 2.5 Fy, Fy being the smaller yield strength value when parts in contact have different ones.

Centralizers plates shall be used to limit the gap between the pad eyes and shackle yaw to 5 mm both sides.

5.1.3.2 Trunnions

The trunnion central main plate (shear plate) shall be slotted through the main tubular or plate the trunnion is attached to, and shall be designed to transfer the total sling load into the main tubular or plate, not taking into account the trunnion.

The trunnion should only be regarded as a bent circumference for the sling eye.

Inside the trunnion, stiffener plates are to be provided to transfer the sling load into the main plate via bearing and shear respectively.

The main plate thickness shall be equal to or larger than the lifting stub stiffener plate.

As the sling will flatten out at the contact area during lifting, the width of the stub (groove) shall be 1.25 times the sling diameter plus 25 mm.

The keeper plate shall protrude approximately 100 % of the sling diameter at the bearing area pending on suitable retainer details and at least 100 mm above the bearing face of the trunnion.

For sling installation an overall clearance of 1.5 times the sling diameter is required between the keeper plate and the main tubular or plate stiffeners, chords and other projections.

To prevent movement of the slings a special locker sling retainer device shall be designed. This sling retainer shall be easy removable.

All sharp edges likely to damage the sling during handling and transportation shall have a minimum radius of 5 mm.

The minimum trunnion diameter shall be three times the sling diameter where the sling eye is on the trunnion and four times the sling diameter where the body of the sling is on the trunnion.

5.1.4 Slings and shackles

Slings and shackles shall be selected so that their MANUFACTURER's rated SWL is not less than the sling load calculated as per sections 5.1.2 and 5.1.3.

Due attention shall be paid to the use of bent slings around trunnion or hook. In such a condition, the breaking load of the sling shall be multiplied by a bending efficiency factor C_b equal to:

$$C_b = 1 - 0.5 \times (d_2/d_1)^{1/2}$$

Where:

d_1 = diameter of trunnion

d_2 = diameter of the sling

Bent slings around shackle are not acceptable for heavy lifts (> 1000 T).

Multi-shackle pin-pin arrangements are forbidden.

In case of multi-shackle pin-bow arrangement, spacers shall be provided as required so as to align the rigging system.

Any sling which has been previously bent shall not be used for direct tension without fold.

5.1.5 Installation aids

5.1.5.1 Rigging aids

Auxiliary lifting aids have to be prepared and installed:

- Cradles, lifting, and/or push-pull devices in such a position to ensure easy installation/removal of the pins, shackles, sheaves, etc., when the SWL of the shackle is greater than 200 T.
- Access platforms for an easy and safe access to each area where this is necessary.
- Rigging platforms for supporting the rigging arrangement during the transportation phase and to ensure an easy access of the crane hook for lifting operation.

- Temporary handrails around rigging platform and safe guard lines along legs and braces shall be provided for safety of access.
- The rigging platform shall be designed to support the weight of the rigging (slings, shackles, spreader bar, etc.) plus an uniform distributed load equal to 5.00 KN/m^2 .
- The connection of the rigging platform on the object shall be performed using fast release bolted clamps to allow for an easy removal in one piece. The rigging platform shall be self bearing when clamps are released.

5.1.5.2 Bumpers and guides

A guide system shall be designed to ensure a placement of the package within a final tolerance of max $\pm 25 \text{ mm}$ out of the required designed position.

The following criteria shall be considered, W being the lifted weight of the package:

When approaching the required position, the limitations of movements of the module should be:

- Vertical: $\pm 0.75 \text{ m}$
- Horizontal: $\pm 1.50 \text{ m}$ in any direction
- Tilt: 2 degrees
- Plan rotation: 3 degrees (when package is close to its final location).

When designing the guidance system (bumpers, guides, installation lugs, pins and buckets), the following structural requirements have to be taken into consideration:

- The position of each element of guidance system will depend upon acceptable support points on the module, nodes being obvious locations.
- Doubler plates shall be used for the connections of the guides on the receiving structure and on the module. unless written approval by COMPANY.
- The guidance system should be designed so that the guide elements fail prior to permanent deformation of any part of the module. For integrated guidance system any deflection must be within the elastic limit of the material.
- The connection into the object and the object members framing at the bumper or guide location, should be at least as strong as the bumper or guide.
- The stiffness of bumper and guide members should be as low as possible in order that they may deflect appreciably without yielding.
- Design of bumpers and guides should cope with easy sliding motion of bumper in contact with guide. Slopping members should be at an acute angle to the vertical. Edges and sharp corners should be avoided on areas of possible contact, and weld beads should be ground flush.

The design of the guide system shall be based on the following load criteria (W = object lifted weight):

- Vertical sliding bumpers
 - Horizontal force in plane of bumper (F_h): $0.10 \times W$
 - Horizontal force out of plane of bumper (friction) (F_t): $0.05 \times W$
 - Vertical force (friction) (F_v): $0.01 \times W$

Forces in all three directions will be combined to establish the worst design case.

- Pin/bucket guides

- Horizontal force on cone/end of pin (F_h): $0.05 \times W$
- Vertical force on cone/end of pin (F_v): $0.10 \times W$ for secondary guides
 $0.20 \times W$ for primary guides

Horizontal force in any direction will be combined with vertical force to establish the worst design case.

- "Cow-horn" type bumpers with vertical guide

- Horizontal force in any direction (F_h): $0.10 \times W$
- Vertical (friction) force (F_v): $0.01 \times W$

Horizontal force in any direction will be combined with vertical force to establish the worst design case.

- "Cow-horn" type guide with horizontal bumper

- Horizontal force in any direction (F_h): $0.05 \times W$
- Vertical force on inclined guide-face (F_v): $0.10 \times W$

Horizontal force in any direction will be combined with vertical force to establish the worst design case.

Note: Basic allowable stresses without one-third increase shall be considered for integrated guide design and module checks. One-third increase shall be considered for non integrated guide design.

Placement forces on final supports : in absence of more specific study, a vertical impact factor of 1.5g shall be considered without the one-third increase of the Basic Allowable Stresses.

6. Quality

6.1 Quality plan

Before starting the design and construction operations, a Quality Plan shall be prepared detailing in sequence all the activities involved in design, study, procurement, fabrication and testing. These operations shall be further described in detailed procedures.

These operations shall include (non-exhaustive list):

- Preparation and monitoring of the detailed design and construction schedule
- Preparation of design premises drawings, calculations justifying the sizing of lifting equipment, the structure, floors and all details providing a clear understanding of the structure
- Co-ordination of the design studies and the different stages of the work
- Supply the copies of CONTRACTOR's orders (unpriced) with requisitions
- All work as defined in this specification
- Supply of all elements, materials and equipment needed to carry out the work

- Supply of conformity and test certificates issued by an approved authority
- All tests for controlling the correct execution and operation of CONTRACTOR's plant, including necessary labour force, equipment and consumables
- Preparation for transportation, including loading, and securing
- Updating drawings to "as built" drawings.

All these operations shall be supported by documentation to be later on included in the project close-out report.

The Quality Plan shall cover all the operations required for the satisfactory completion of the structure, under the responsibility of the CONTRACTOR and also of his SUBCONTRACTORS and SUPPLIERS. It shall be consistent with the work completion schedule and shall specify agreed lead times. The COMPANY shall add the activities that he considers under his responsibility (document review, inspection points and hold points) to the Quality Plan.

6.2 COMPANY Supervision

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

- **Engineering: (pre-service and in-service conditions)**
 - Design premises: Hold point
 - Calculation notes: Review
 - AFC drawings: Review
 - Weight report: Review
 - Material Take Off: Review
- **Fabrication studies:**
 - Calculation notes: Review
 - Shop drawings: Review
- **Fabrication:**
 - Material certificates: Review
 - Welding procedures/qualifications: Hold Point
 - Welding consumables certificates: Review
 - Welders qualification: Review
 - NDT procedures and reports: Review
 - Dimensional control procedure: Review
 - Dimensional reports: Review
 - Weighing procedure: Review
 - Weighing report: Review
 - Final technical acceptance and Release Certificate: Hold Point

7. Technical Queries/Non-Conformance Reports

1. Any CONTRACTOR's requests for clarifications or deviations to COMPANY specifications shall be submitted to COMPANY only through Technical Queries (TQ), the format of which shall have prior approval of the COMPANY.

A deviation to specifications shall not be considered as accepted if it has not been submitted to and accepted by COMPANY through a Technical Query.

2. Approval given by the COMPANY to any CONTRACTOR's work procedures, specifications, equipment, etc., shall not release in any way the CONTRACTOR from his obligation to meet the COMPANY's specifications.
3. Any work performance or test result which is found, at a later date, not in conformance with COMPANY specifications or agreed procedure shall be subject to a Non-Conformance Report (NCR) to be issued by the CONTRACTOR for submission to COMPANY. NCR report shall indicate the corrective action intended by the CONTRACTOR.

Appendix 1 Percentages of contingency + tolerances

Phases	Basic engineering	Detailed engineering		Construction	
Disciplines	IFD	IFD	AFC	As-built	Weighed weight
Structural	20 %	12 %	7 %	5 %	3 %
Mechanical	20 %	12 %	7 %	5 %	3 %
Piping	20 %	12 %	7 %	5 %	3 %
Electrical	25 %	15 %	10 %	5 %	3 %
Instrumentation	25 %	15 %	10 %	5 %	3 %
Architecturals	25 %	15 %	10 %	5 %	3 %
HVAC	25 %	15 %	10 %	5 %	3 %
Safety	25 %	15 %	10 %	5 %	3 %

IFD = Issue For Design

AFC = Approved For Construction