

## GENERAL SPECIFICATION

### STRUCTURAL

#### GS EP STR 201

<b>Materials for offshore steel structures</b>
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## Contents

<b>1. Scope .....</b>	<b>6</b>
1.1 General.....	6
1.2 Structural materials.....	7
1.3 Non-structural materials.....	7
<b>2. Reference documents.....</b>	<b>7</b>
<b>3. Definitions.....</b>	<b>11</b>
<b>4. Member classification.....</b>	<b>11</b>
4.1 Structural members .....	11
4.2 Non-structural members (NS).....	12
4.3 Indication of member categories on documents .....	12
<b>5. General characteristics of structural steels.....</b>	<b>14</b>
5.1 Steel groups.....	14
5.2 Selection and designation of steel grades .....	14
5.3 Selection and designation of steel qualities .....	15
5.4 Complete designation of a steel .....	25
<b>6. General requirements for structural steels.....</b>	<b>25</b>
6.1 Steel designation .....	25
6.2 Sourcing of materials .....	25
6.3 Traceability of materials.....	26
6.4 Substitution of Materials .....	26
6.5 Manufacturing Procedure Specification (MPS).....	27
6.6 Quality assurance/quality control.....	27
6.7 Technical queries/non-conformance reports .....	27
<b>7. Steel plates .....</b>	<b>28</b>
7.1 General.....	28
7.2 Usable steel grades .....	28
7.3 Steel making process .....	28
7.4 Plate manufacturing/Delivery condition .....	29

General Specification		GS EP STR 201
Materials for offshore steel structures		
Rev.: 12	Effective date: 10/2013	Page: 3 of 90

7.5	Mechanical properties.....	29
7.6	Chemical composition.....	30
7.7	Ladle analysis .....	31
7.8	Destructive testings .....	33
7.9	Dimensional tolerances .....	33
7.10	Surface finish .....	34
7.11	Ultrasonic testing .....	35
7.12	Coated plates (when required in requisition) .....	35
<b>8.</b>	<b>Rolled sections.....</b>	<b>35</b>
8.1	General.....	35
8.2	Usable steel grades .....	36
8.3	Steel making process .....	36
8.4	Manufacturing process/Delivery condition .....	36
8.5	Mechanical properties.....	36
8.6	Chemical composition.....	36
8.7	Ladle analysis .....	36
8.8	Destructive testings .....	37
8.9	Dimensions and dimensional tolerances .....	37
8.10	Surface finish .....	38
8.11	Ultrasonic testing .....	38
<b>9.</b>	<b>Hollow sections.....</b>	<b>38</b>
9.1	General.....	38
9.2	Usable steel grades .....	39
9.3	Mechanical properties.....	39
9.4	Chemical composition.....	39
9.5	Ladle analysis .....	39
9.6	Destructive testing .....	39
9.7	Dimensions and tolerances .....	40
9.8	Surface condition .....	40
9.9	Non-destructive testing of welds.....	40
<b>10.</b>	<b>Welded tubulars .....</b>	<b>40</b>
10.1	General.....	40

**Materials for offshore steel structures**

Rev.: 12

Effective date: 10/2013

Page: 4 of 90

10.2	Usable steel grades .....	40
10.3	Steel making process .....	41
10.4	Plate and tubular manufacturing process .....	41
10.5	Welding.....	41
10.6	Mechanical properties.....	47
10.7	Chemical composition.....	53
10.8	Ladle analysis .....	53
10.9	Destructive testing/Production tests .....	53
10.10	Visual inspection.....	54
10.11	Non-destructive testings and repairs .....	54
10.12	Dimensions and dimensional tolerances .....	56
<b>11.</b>	<b>Seamless tubulars.....</b>	<b>58</b>
11.1	General.....	58
11.2	Usable steel grades .....	58
11.3	Steel making process .....	58
11.4	Manufacturing process/Delivery condition .....	59
11.5	Mechanical properties.....	59
11.6	Chemical composition.....	59
11.7	Ladle analysis .....	60
11.8	Destructive testing/Production tests .....	61
11.9	Dimensions and dimensional tolerances .....	61
11.10	Non-destructive testings .....	62
<b>12.</b>	<b>Pins and axles .....</b>	<b>63</b>
12.1	General.....	63
12.2	Chemical composition.....	63
12.3	Mechanical properties.....	63
12.4	Visual and MP inspections.....	64
12.5	Ultrasonic Testing (UT).....	64
12.6	Machining .....	64
<b>13.</b>	<b>Bolting.....</b>	<b>64</b>
<b>14.</b>	<b>Marking of structural materials .....</b>	<b>66</b>

General Specification		GS EP STR 201
Materials for offshore steel structures		
Rev.: 12	Effective date: 10/2013	Page: 5 of 90

14.1	Paint stencilling .....	66
14.2	Color coding.....	67
14.3	Die stamping.....	70
14.4	Marking of small products.....	70
<b>15.</b>	<b>Mill certificates .....</b>	<b>70</b>
<b>16.</b>	<b>Inspection .....</b>	<b>71</b>
16.1	General.....	71
16.2	Inspection by the Supplier/Manufacturer .....	71
16.3	Inspection by Supplier's Third Party Inspection agency (Supplier's TPI).....	71
16.4	Inspection by the Company (Company's TPI) .....	74
<b>17.</b>	<b>Documentation .....</b>	<b>74</b>
17.1	When the bids are submitted .....	74
17.2	Upon completion of materials production .....	74
17.3	Schedule.....	75
<b>18.</b>	<b>Other references .....</b>	<b>75</b>
Appendix 1	Material equivalences between GS EP STR 201 and ASTM/API/JIS Stds (Non-mandatory information).....	76
Appendix 2	Flux dryness .....	89

General Specification		GS EP STR 201
Materials for offshore steel structures		
Rev.: 12	Effective date: 10/2013	Page: 6 of 90

## 1. Scope

### 1.1 General

1. This specification defines the Company's general requirements for the manufacture and supply of structural materials to be used in the construction of offshore steel structures (such as jackets, decks, module support frames, flare booms, bridges, vent booms, quarters and modules, etc.) or parts of thereof.

For offshore steel structures, this specification shall be read in conjunction with [GS EP STR 101](#) and [GS EP STR 102](#)

For floating support hull, this specification shall be read in conjunction with [GS EP STR 653](#) and [GS EP STR 631](#).

For subsea structures, this specification shall be read in conjunction with [GS EP STR 653](#) and [GS EP STR 204](#).

For other structures (suction anchors, riser towers, etc.), this specification shall be read in conjunction with relevant specification or PPS.

This specification shall be read in conjunction with [GS EP STR 301](#), unless otherwise specified.

2. This specification discriminates "structural materials" from "non-structural materials" as per whether or not they are included into the composition of resisting members of the structure (refer to para. 1.2, 1.3 and 4).

It does not cover the following:

- Finishing materials such as roofing, cladding, partitions, flooring, etc.
- Cast or forged products (other than lifting pins and axles) see [GS EP STR 202](#) & [GS EP STR 203](#).

3. Where required, this specification shall be used in conjunction with a Project Particular Specification (PPS) detailing the additional tests and requirements or the possible modifications to the present specification, based on the particular design conditions or the local legislation of the structural project.
4. No deviations from the requirements stated in the present specification shall be permitted unless prior written approval has been obtained from the Company. Refer to para. 6.7 of this specification.
5. Attention is drawn on certain materials that shall be subject to inspection and approval by a Third Party Inspection (TPI), as referred to in para. 16.3 of this specification.
6. Attention is drawn too on certain materials that shall be subject to comply with requirements of Classification Society or any particular state regulation. In that case, material shall comply with the most severe requirement. In the event of conflict between this specification and any other contractual document, the Contractor shall inform the Company in writing and receive written clarification or approval from the Company.

General Specification		GS EP STR 201
Materials for offshore steel structures		
Rev.: 12	Effective date: 10/2013	Page: 7 of 90

## 1.2 Structural materials

1. This specification covers exclusively carbon steel materials.

It applies to plates, rolled sections, hollow sections, welded tubulars (including welded reducers) and seamless tubulars, having a max. Specified Yield Strength of 500 N/mm<sup>2</sup>. Steels with min. Specified YS above 355 N/mm<sup>2</sup> shall be subject to special Company's approval (refer to para. 5.2). It also applies to structural bolting (nuts and bolts) and forged pins or axles.

2. When it is deemed more convenient, this specification can also be used for the fabrication of cold formed tubulars and reducers/cones made by the Roll Bending process or the Press Bending process, although those products are normally covered by the specification **GS EP STR 301**.
3. The materials of following structures shall be defined in separate specifications:
  - Skid structures (skid mounted equipment)
  - Crane pedestal structures
  - Welded Plate Girders (WPG): either as per **GS EP STR 301** or **GS EP STR 304**, with prior agreement with the Company.
4. Cast materials and forged materials (other than pins or axles) shall be covered by specifications to be issued separately.

## 1.3 Non-structural materials

They are finishing materials and materials of annex structures (such as standard non-alloyed steels, stainless steels, semi-hard or hard steels, galvanized steels, etc.), as well as materials of structural accessories (such as false flooring, grating, stairs, handrails, wire mesh, etc.), which does not jeopardize the overall integrity of the platform.

These materials shall be steel group I, II or III (as defined in Table 5.1) unless otherwise noted.

## 2. Reference documents

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

The order of precedence of the applicable documents shall be:

- The Purchase Order (PO)
- The Project Particular Specification (PPS)
- The present General Specification
- The codes and standards in reference.

**Materials for offshore steel structures**

Rev.: 12

Effective date: 10/2013

Page: 8 of 90

Applicable Codes and Standards which are to be used in conjunction with this specification are stated in paragraphs hereafter.

Unless otherwise specifically indicated in writing by the Company, the Supplier shall work in accordance with the requirements specified herein and the applicable requirements of the latest editions at date of Contract award of the referenced Codes and Standards, whenever asked in the present specification.

Where this specification states no overriding requirements, the referenced Codes and Standards shall apply in full.

Standards equivalent to those referred to herein shall not be substituted without written approval of the Company. Approval of equivalent standards will not, in any way, remove responsibility of the Supplier to meet the requirements of the standards referred to and amended herein, in the event of conflict.

The Supplier shall equip himself with copies of all the reference specifications referred to in this specification and shall make them readily available to all fabrication, testing and inspection personnel involved on the work.

Reference	Title
API 2W	Specification for Steel Plates for Offshore Structures, Produced by Thermo-Mechanical Control Processing (TMCP)
API Q1	Specification for Quality Programs for the Petroleum, Petrochemical and Natural Gas Industry
API RP 2Z	Recommended Practice for Preproduction Qualification for Steel Plates for Offshore Structures
API SPEC 2B	Specification for the Fabrication of Structural Steel Pipe
API SPEC 5L	Specification for Line Pipe
ASTM A307	Carbon Steel Externally Threaded Standard Fasteners
ASTM A325	Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
ASTM A388	Ultrasonic Examination of Heavy Steel Forgings
ASTM A490	Structural Bolts, Alloy Steel, Heat Treated, 150 ksi Minimum Tensile Strength
ASTM A578	Straight-beam ultrasonic examination of plain and clad steel plates of special application
ASTM A6	General requirements for rolled steel plates, shapes, sheet piling, and bars for structural use
ASTM E112	Estimating the Average Grain size of Metals
ASTM E23	Notched Bar Impact Testing of Metallic Materials
ASTM E709	Standard Guide for Magnetic Particle Testing
AWS D1.1/D1.1M	Structural Welding Code – Steel



**Materials for offshore steel structures**

Rev.: 12

Effective date: 10/2013

Page: 9 of 90

Reference	Title
EN 10210-2	Hot finished structural hollow sections of non-alloy and fine grain steels - Part 2: Tolerances, dimensions and sectional properties
CSWIP	Requirements for the certification of personnel engaged in NDT
ISO 6892-1	Metallic materials - Tensile testing - Part 1: Method of test at room temperature
EN 10029	Hot rolled steel plates, 3 mm thick or above - Tolerances on dimensions, shape and mass.
ISO 148-1	Metallic materials - Charpy pendulum impact test - Part 1: Test method
EN 10025-1 (Parts 1; 2; 3; 4; 6)	Hot rolled products of structural steels – Parts 1; 2; 3; 4; 6
EN 10056-1	Structural Steel. Equal and unequal leg angles.
EN 10160	Ultrasonic testing of steel flat product of thickness equal to greater than 6 mm (reflection method)
EN 10163 (Parts 1; 2; 3)	Delivery requirements for surface condition of hot rolled steel plates, wide flats and sections - Parts 1; 2; 3
EN 10164	Steel products with improved deformation properties perpendicular to the surface of product
EN 10204	Metallic products - Types of inspection documents
EN 10210 (Parts 1; 2)	Hot finished structural hollow sections of non-alloy and fine grain structural steels - Parts 1; 2
EN 10225 (All parts)	Weldable structural steels for fixed offshore structures - Technical delivery conditions - All parts
EN 10306	Ultrasonic testing of H beams with parallel flanges and IPE beams
EN 1435	Non-destructive examination of welds. Radiographic examination of welded joints
EN 462	Non-destructive testing. Image quality of radiographs
EN 462-1	Image quality of radiographs - Part 1: Concept, Image Quality Indicators (wire type), determination of image quality value
ISO 11699-1	Non-destructive testing - Industrial radiographic film - Part 1: Classification of film systems for industrial radiography
ISO 10893-6	Non-destructive testing of steel tubes - Part 6: Radiographic testing of the weld seam of welded steel tubes for the detection of imperfections
ISO 1302	Geometrical Product Specification (GPS) - Indication of surface texture in technical product documentation
ISO 14344:2010	Welding consumables - Procurement of filler materials and fluxes

**Materials for offshore steel structures**

Rev.: 12

Effective date: 10/2013

Page: 10 of 90

Reference	Title
ISO 148-1	Metallic materials - Charpy pendulum impact test - Part 1: Test method
ISO 6507 (All parts)	Metallic materials - Vickers hardness test - All parts
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 9001	Quality management systems - Requirements
ISO 9712	Non-destructive testing - Qualification and certification of NDT personnel
SIS 05-59-00	Pictorial surface preparation standards for painting steel surfaces

**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.

Reference	Title
GS EP COR 350	External protection of offshore and coastal structures and equipment by painting
GS EP SPS 009	Corrosion protection of subsea stations
GS EP STR 100	Offshore steel structures - General
GS EP STR 101	Design of offshore jacket and subsea structures
GS EP STR 102	Design of offshore topside structure
GS EP STR 202	Cast materials for steel structures
GS EP STR 203	Forged materials for steel structures
GS EP STR 204	Subsea structures: Carbon Steel Material and Fabrication
GS EP STR 301	Fabrication of offshore steel structures
GS EP STR 304	Fabrication of welded plate girders (W.P.G.)
GS EP STR 631	CALM buoy terminals
GS EP STR 653	F(P)SO - Hull fabrication requirements

General Specification		GS EP STR 201
Materials for offshore steel structures		
Rev.: 12	Effective date: 10/2013	Page: 11 of 90

### 3. Definitions

Throughout this specification, the following definitions shall apply:

- **Supplier** Means the company designated on the Purchase Order form or Contract as being the selected supplier of the said materials.
- **Manufacturer** Means the company or its sub-contractors selected by the Company or the Supplier (as applicable) as the Manufacturer of the said materials.
- **Purchaser** Means the Company or the Supplier (as applicable) which have placed the Purchase Order to the Manufacturer.
- **Inspector** Means the Company's or Supplier's representative(s), (as applicable), or member(s) from an Inspection Agency duly appointed by the Company or the Supplier (as applicable) to act as its representative(s) for the purpose of the contract.
- **PPS** Designates the Project Particular Specification as defined in para. 1.1 above.
- **Approval** Means the authorization in writing given by the Company to the Supplier on a procedure or to proceed with the performance of a specific part of the work without releasing in any way the Supplier from any of his obligations to conform with the technical specifications, requisitions, etc. The words "Approve", "Approved" and "Approval" shall be construed accordingly.

### 4. Member classification

The following is a reminder of the provisions contained in General Specification **GS EP STR 100** on that matter.

#### 4.1 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.).

##### (1) Special category members (S)

Failure of any of these members either would cause total or partial destruction of the platform during its production or destruction of parts of the platform during their installation, or they are members that cannot be repaired.

##### (2) First category members (1)

Failure of any of these members would cause total or partial platform shutdown, but no total or partial destruction of the platform. Repair of these members would only be made if production or installation of the platform is stopped.

##### (3) Second category members (2)

They are members other than those classified in Special Category or First Category.

**Materials for offshore steel structures**

Rev.: 12

Effective date: 10/2013

Page: 12 of 90

This distribution of Structural Members into categories of importance shall be submitted to the Company for prior approval.

When exceptionally, and subject to Company approval, local cans are substituted by a constant thickness member to avoid multiple joints, the member shall be upgraded to Special Category.

As referenced in other specifications, primary structure addresses Special and First category structures as defined above. Secondary structures addresses Second category structures. Tertiary structures addresses non-structural items.

Table 4.1 provides the distribution of Structural Members into categories of importance.

## 4.2 Non-structural members (NS)

Accessory and finishing elements, i.e. not participating in the overall strength of the platform structures (e.g. cladding, hand-rails, stairs, ladders, grating, false flooring, etc.) constitute a class separate from that of Structural Members defined in the para. 4.1 above.

## 4.3 Indication of member categories on documents

Materials shall be identified as "S", "1", "2" and "NS" (as shown in para. 4.1 above) on drawings and materials requisitions.

**Table 4.1 - Classification of structural members into categories of importance**

Category Type of structure	Special category <sup>(3)</sup> <sup>(4)</sup>	First category	Second category
<b>Jacket and piles</b>	<ul style="list-style-type: none"> <li>- Pad eyes</li> <li>- Piles</li> <li>- Jacket legs <sup>(1)</sup> and part of them (ex. cans, bottles, etc.)</li> <li>- Cans of bracings</li> <li>- Buoyancy tanks</li> <li>- Conductor pipes</li> <li>- Crown rings (if any)</li> </ul>	<ul style="list-style-type: none"> <li>- Jacket bracings</li> <li>- Support structure of boat-landings, risers, riser protector (clamps, stub pieces, etc.)</li> <li>- Conductor guides (funnels and supporting plates)</li> </ul>	<ul style="list-style-type: none"> <li>- Boat landings</li> <li>- Bumpers</li> <li>- Riser protector</li> <li>- Mudmats</li> <li>- Shock cells</li> </ul>
<b>Deck</b>	<ul style="list-style-type: none"> <li>- Pad eyes and nodes to which they are connected</li> <li>- Deck legs and cans</li> <li>- Main girders with depths <math>\geq 800</math> mm</li> <li>- Critical nodes (based on design)</li> <li>- Transition pieces between deck and piles</li> <li>- Skidding beams</li> <li>- Bearing nodes (bridges, flares, turbines, etc.)</li> </ul>	<ul style="list-style-type: none"> <li>- Other members of the main structure</li> <li>- Rolled sections and WPG with <math>400 \leq</math> depths <math>&lt; 800</math> mm</li> <li>- Bracings of trusses</li> <li>- Gussets (thk <math>\geq 15</math> mm) welded on First Category members</li> <li>- Crane boom rests</li> </ul>	<ul style="list-style-type: none"> <li>- Secondary girders with depths <math>&lt; 400</math> mm</li> <li>- Joisting</li> <li>- Stiffening elements of the secondary structure</li> <li>- Hatch covers</li> <li>- Plating</li> </ul>
<b>Modules</b>	<ul style="list-style-type: none"> <li>- Pad eyes and nodes to which they are connected</li> <li>- Structural members that are critical during lifting</li> </ul>	<ul style="list-style-type: none"> <li>- Main girders, columns and bracings of trusses</li> <li>- Gantry structures</li> </ul>	<ul style="list-style-type: none"> <li>- Secondary members of the support structure</li> </ul>

**Materials for offshore steel structures**

Rev.: 12

Effective date: 10/2013

Page: 13 of 90

Category Type of structure	Special category <sup>(3)</sup> <sup>(4)</sup>	First category	Second category
<b>Helideck</b>	- Pad eyes	- Deck legs (for helideck landing pad not integrated to the superstructures) - Main girders columns and bracings	- Secondary members of the support structure
<b>Lifting appliances and accessories</b>	- All components subjected to concentrated stresses during lifting, such as pad eyes, etc. - Spreader beams - Crane pedestals up to and including the slewing ring	- Elements submitted to heavy stresses (dynamic loads among other stresses)	- Other structural members - Guides and bumpers of lifting aids
<b>Other structures <sup>(2)</sup> <sup>(5)</sup></b>	- Pad eyes and nodes to which they are connected - Bearing nodes, cans of vent booms and bridges	- Primary members of the main structure Main lattice girders of vent booms and bridges - Skidways, transition beams, sub-structures - Barge grillage - Main components (bracings) of sea fastening - Doubler plates on Special and First Category members - Stressed skin structures (walls and floors) including associated openings and reinforcements <sup>(6)</sup> - Blast & Fire walls <sup>(6)</sup>	- Secondary members of the support structure - Rigging platforms

(1) Jackets legs (except cans) with inner leg piles may be of First Category only when so approved by Company.

(2) Any other structures which are not mentioned in this table, including inter-platform catwalks, superstructures of living quarters, vent booms, technical rooms or similar, etc.

(3) All pins, axles, castings and forgings shall be classified as Special Category (as for all pad-eyes).

(4) When multiple cans on the same member are replaced by a single element, this element is classified as Special Category. Conical transitions to cans are also classified as Special Category.

(5) For other structures such as FPU, FPSO, Subsea structures, Suction Anchors..., see relevant GS or PPS for Category definition.

(6) See note (13) Table 10.2 of the **GS EP STR 301** for particular NDT requirements.

## 5. General characteristics of structural steels

### 5.1 Steel groups

In this specification, steels are conventionally divided into 4 steel groups, according to their Minimum Specified Yield Strength, as shown in Table 5.1. These 4 steel groups are different from the AWS ones and shall not be considered for the Welding Qualification.

**Table 5.1 - Conventional Definition of steel Groups**

Steel group	Conventional steel designation	Min. Specified Yield Strength (MSYS)
I	Low Strength steels (LS steels)	$YS \leq 262 \text{ N/mm}^2$ (38,000 psi)
II	Medium Strength steels (MS steels)	$262 < YS \leq 295 \text{ N/mm}^2$ (42,800 psi)
III	High Strength steels (HS steels)	$295 < YS \leq 355 \text{ N/mm}^2$ (51,500 psi)
IV	Extra High Strength steels (EHS steels)	$355 < YS \leq 500 \text{ N/mm}^2$ (72,540 psi)

**Note:**  $1 \text{ N/mm}^2 = 1 \text{ MPa} = 145.079 \text{ psi}$

### 5.2 Selection and designation of steel grades

The conventional designation of steel grades is based on the Specified Mini. Yield Strength in  $\text{N/mm}^2$  for the smallest thickness range.

The usable grades as regard to steel product types are given in Table 5.2.

The steel grades indicated between brackets in Table 5.2 should be avoided. The use of EHS steel grades shall have prior approval of Company for each Project Development phase and application. S 460 steel grade and above are forbidden for driven piles, driven conductor pipes and jacket nodes (cans and incoming stubs). EHS steels shall not be used for 2<sup>nd</sup> Category materials.

The tensile properties to be satisfied for each steel grade are defined in the sections pertaining to each steel product in this specification.

As a general rule, steel grades, qualities, mills and delivery conditions shall be minimized by an intelligent grouping as much as possible (refer section 8.7.4 of the **GS EP STR 301**). It is reminded that such grouping may reduce significantly the amount of welding qualifications.

**Table 5.2 - Usable steel grades according to products types**

Steel group	Steel grade designation	Plates	Rolled sections and hollow sections	Welded tubulars	Seamless tubulars
<b>I</b> Low Strength steels (LS)	S 235	X	X	X	X
	(S 255)	X			
<b>II</b> Medium Strength steels (MS)	S 275	X	X	X	X
	(S 295)	X			
<b>III</b> High Strength steels (HS)	(S 315)			X	X
	S 355	X	X	X	X
<b>IV</b> Extra High Strength steels (EHS)	S 420 (1)	X	X (2)	X	
	S 460 (1)	X	X (2)	X	
	(S 500) (1)	X	X (2)	X	
<b>Notes:</b> <ul style="list-style-type: none"> <li>The symbol "S" is allocated to "Structural Steels".</li> <li>Steel grades between brackets should be avoided.</li> </ul>					
(1) These steel grades shall have prior approval of the Company.					
(2) EHS steel grades shall not be permitted for hollow sections.					

## 5.3 Selection and designation of steel qualities

### 5.3.1 General

Steel qualities are defined by:

- Notch impact toughness
- Carbon Equivalent (CE) and Pcm

and, in special cases, by:

- The reduction of area at tensile test in the through thickness direction
- The physical properties after stress relieving heat treatment (PWHT)
- The notch impact toughness after accelerated strained ageing (in case of steel to be cold or warm formed without subsequent heat treatment in the fabrication/construction which is to take place later on).

Selection of steel quality shall be subject to the Company's prior approval.

General Specification		GS EP STR 201
Materials for offshore steel structures		
Rev.: 12	Effective date: 10/2013	Page: 16 of 90

### 5.3.2 Notch impact toughness

a) All products shall have an impact toughness guaranteed by the producing mill. The impact test shall be actually carried out only if the thickness is equal to or more than the following ones:

- 26 mm for KL + 20 quality
- 12.5 mm for all other qualities.

The impact test shall be of the CHARPY V-notch type complying with Standard [ISO 148-1](#) or [ASTM E23](#). Depending on thickness, it consists of one or two sets of three impact test specimens as follows:

- One set below the surface for  $t \leq 50$  mm
- One set below the surface and one set at mid-thickness for  $t > 50$  mm.

b) Impact toughness is symbolized by the letter K followed by:

- The letter T or the letter L as per whether the longitudinal axis of specimen is transverse or parallel to the main rolling direction of steel
- The impact test temperature stated in Celsius degrees.

**Example:** KT - 20 means that impact test specimens shall be cut in the transverse direction as regard to main rolling direction and tested at -20°C.

c) For each usable steel grade, the impact test procedure and the required absorbed energies shall be as stated in Table 5.3 for full size specimens, according to structure Member Category in the construction and geographical zone where the structure will be located.

As far as possible, full size specimens shall be used. If for practical reasons sub-size specimens are deemed necessary, then they shall be of the largest possible size considering, on the one hand the product thickness and configuration, and on the other hand, the specimen dimensions stated in Table 5.4. For sub-size specimens, the absorbed energy requirements shall be those for full size specimens (see Table 5.3) multiplied by the corresponding factors given in the Table 5.4 hereafter.

d) For Special Category products (i.e. with KT impact test) the requirements for KL impact test shown in Table 5.3 must be guaranteed by the steel-producing mill.

The Company reserves the right to carry out tests, at any time, for checking the longitudinal impact toughness of these steels.



**Table 5.3 - Required absorbed energies at CHARPY V-notch test  
(full size 10 x 10 mm specimens)**

Steel grade	CHARPY-V Energy (Joules) (Mini. Average/Mini. Single)	
	Transverse (KT)	Longitudinal (KL)
	Special category	1 <sup>st</sup> and 2 <sup>nd</sup> categories
S 235 and (S 255)	Average: 28 Single: 21	Average: 28 Single: 21
S 275 (S 295) and (S 315)	Average: 32 Single: 24	Average: 32 Single: 24
S 355	Average: 40 Single: 30	Average: 40 Single: 30
S 420 (1) S 460 (1) (S 500) (1)	Average: 50 Single: 37	Average: 50 Single: 37
Transverse (KT): Specimens cut transverse to main rolling direction. Longitudinal (KL): Specimens cut parallel to main rolling direction.		
(1) These steel grades shall have prior approval of the Company.		

**Table 5.4 - CHARPY V-notch test. Sub-size specimens**

Specimen size (mm)	Multiplying factor
10 x 10	1
10 x 7.5	5/6
10 x 6.7	7/9
10 x 5	2/3

- e) Where one specimen fails to conform to the specified requirements, a retest may be accepted by the Inspector pending further investigation of the failure is made by the Supplier. Where it is thought that the failure can be an isolated case, then the Inspector may accept the testing of three additional specimens. The average value of the six specimens shall be at least equal to the minimum average value required, and each of the three additional samples shall satisfy the minimum individual requirement.
- f) The selection of steel quality regarding impact toughness shall be determined based on the following:
- The geographical location of structures and construction site (as per Table 5.5) (the most severe shall govern)
  - The Member Category (as per para. 4.1)

General Specification		GS EP STR 201
Materials for offshore steel structures		
Rev.: 12	Effective date: 10/2013	Page: 18 of 90

- The thickness of the structural component. Thickness is defined hereafter.
  - Table 5.6 gives the steel qualities required under these conditions.
  - For Special Category products, when it is practically impossible to perform the notch impact test with a transverse specimen, even with a sub-size specimen, the test shall then be performed using a longitudinal specimen, the test temperature being unchanged (Note that Table 5.3 gives identical requirements for absorbed energy, whatever the specimens are longitudinal or transverse). The Company shall be informed prior to this change.
  - In the present paragraph, “thickness” means a Reference Thickness defined as follows:  
In a butt connection, the Reference Thickness is the thickness of the steel plate. For butt welds at blended transitions between plates or tubulars of different thicknesses, the Reference Thickness is that of the thinner part. For welds not of straight butt configuration (e.g. stub to can welds or ring stiffener to can welds) the thickness of the abutting members (e.g. stub thickness or ring stiffener thickness) shall be the Reference Thickness. In the particular case of crown shims, the Reference Thickness shall be that of the related platform piles. In case of rolled sections, the thickness to take into account is that of flanges.

**g) Note:** Within the scope of this specification, defining a steel quality regarding impact toughness (examples: KT - 20, KL 0 quality, etc.), automatically implies particular requirements about chemical composition for the said material. These requirements on chemical composition shall be as defined in the sections pertaining to each product in this specification.

**Materials for offshore steel structures**

Rev.: 12

Effective date: 10/2013

Page: 19 of 90

**Table 5.5 - Definition of geographical zones**

<b>Geographical zone</b>	<b>Design temperatures <sup>(1)</sup></b>	<b>Examples of sites</b>
0 (Very Cold seas) <sup>(2)</sup>	$T_c < -15^{\circ}\text{C}$	Barents Sea - Caspian Sea
1 (Cold seas)	$-15^{\circ}\text{C} \leq T_c \leq 0^{\circ}\text{C}$	- North Sea - Baltic Sea - Irish Sea - Tierra del Fuego
2 (Temperate seas)	$0^{\circ}\text{C} < T_c \leq +15^{\circ}\text{C}$	- English Channel - Bay of Biscay - Western Mediterranean - Any subsea structure below -15m from Mean Sea Level and no icing considered.
3 (Warm seas)	$T_c > +15^{\circ}\text{C}$	- Gulf of Guinea - Arabian/Persian Gulf - Indonesian Sea - Red Sea - Eastern Mediterranean
<p>(1) Average temperature of coldest month minus 5°C at final location of the structure. For structure critical during construction or transportation, then the design <math>T_c</math> shall be based on those conditions (lifting/pulling points, sea-fastening, crane test, etc). The 5°C derating is not considered for subsea structures below -15m from Mean Sea Level without icing.</p> <p>(2) Very Cold Seas cases are not treated in this specification. A Particular Project Specification shall be issued for steel definition, subject to Company approval.</p>		

**Table 5.6 - Definition of steel qualities as regard to impact toughness**

Geographical zone	Thickness t (mm)	Member category		
		Special	First	Second
1 (Cold seas)	$t \leq 20$	KT-20/KT-40 (3)	KL 0 <sup>(2)</sup>	KL + 20
	$20 < t \leq 40$	KT-40	KL-20/KL-40 (3)	KL 0
	$40 < t \leq 55$		KL - 40	KL-20/KL-40 (3)
	$55 < t \leq 80$	KT – 50 (4)	KL - 50	KL - 40
	$80 < t \leq 105$		KL - 50	KL - 40
2 (Temperate seas)	$t \leq 12.7$	KT 0 <sup>(1) (2)</sup>	KL + 20 <sup>(2)</sup>	KL + 20
	$12.7 < t \leq 19.5$		KL 0 <sup>(2)</sup>	
	$19.5 < t \leq 25.4$	KT-20/KT-40 (3)	KL-20/KL-40 (3)	KL 0
	$25.4 < t \leq 38.1$			
	$38.1 < t \leq 65$	KT - 40	KL - 40	KL-20/KL-40 (3)
	$65 < t \leq 105$	KT - 50	KL - 40	KL-20/KL-40 (3)
3 (Warm seas)	$t \leq 20$	KT 0 <sup>(1) (2)</sup>	KL + 20 <sup>(2)</sup>	KL + 20
	$20 < t \leq 25.4$		KL 0 <sup>(2)</sup>	
	$25.4 < t \leq 40$	KT-20/KT-40 (3)	KL-20/KL-40 (3)	KL 0
	$40 < t \leq 45$			
	$45 < t \leq 83$	KT - 40	KL - 40	KL-20/KL-40 (3)
	$83 < t \leq 110$	KT – 50 (4)	KL - 40	KL-20/KL-40 (3)
	$110 < t \leq 150$			
KT: Test specimens cut perpendicularly to main rolling direction KL: Test specimens cut parallel to main rolling direction (1) Impact toughness KL instead of KT, only for rolled sections with flange thickness $\leq 20$ mm, test temperature remaining unchanged. (2) Minimum testing temperature shall be -20°C for QT steel plates and rolled sections, unless otherwise agreed. (3) Only rolled sections can be supplied with Charpy tested @ -20°C. Other products are tested @ -40°C. (4) For Pile material, crown shims and driving shoes, testing may be -40°C, subject to Company approval.				

### 5.3.3 Carbon Equivalent (CE) and Pcm

The Carbon Equivalent calculated on ladle using the International Institute of Welding (IIS) formula shall meet the requirements stipulated in Table 5.7 depending on material thickness.

For TMCP steel and all steels with  $C \leq 0.12\%$ , the requirements of Pcm contained in Table 5.7 shall apply in addition to requirements of CE.

The CE and Pcm computed on product shall not exceed the CE and Pcm computed on ladle by more than 0.02% and 0.01% respectively.

$$CE = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15} \%$$

$$P_{cm} = C + \frac{Si}{30} + \frac{Mn}{20} + \frac{Cu}{20} + \frac{Ni}{60} + \frac{Cr}{20} + \frac{Mo}{15} + \frac{V}{10} + 5B$$

Note that ladle CE and Pcm of Quenched and Tempered (QT) steels and Extra High Strength (EHS) steels shall not exceed 0.41% and 0.22% respectively (refer to Table 5.7).

**Table 5.7 - Carbon Equivalent and Pcm on ladle for structural steels**

Thickness of product	Pcm All products with C ≤ 0.12% <sup>(2)</sup>	CE <sub>IIIS</sub> max. ladle All steels whatever C contents <sup>(2)</sup>		
		Seamless tubulars	Rolled sections, hollow sections <sup>(1)</sup>	Plates, welded tubulars
t ≤ 20 mm	0.22	0.42	0.41	0.40
20 < t ≤ 30 mm	0.23	0.43	0.42	0.41
30 < t ≤ 51 mm	0.23	0.44	0.43	0.42
51 < t ≤ 70 mm	0.23	NA*	NA*	0.43
t > 70 mm	0.24	NA*	NA*	0.44
*NA: Not Acceptable				
(1) The Reference Thickness shall be the flange thickness.				
(2) For QT steels and EHS steels, max. CE and Pcm shall be 0.41% and 0.22% respectively.				

### 5.3.4 Steels with specified reduction of area in the through thickness direction (Z 35 quality)

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](#).

Z 35 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 plate (see definition of mother plate in para. 7.1.3 of this specification) whatever the sulphur content. When traceability (regarding rolled plate) of

General Specification		GS EP STR 201
Materials for offshore steel structures		
Rev.: 12	Effective date: 10/2013	Page: 22 of 90

individual plates is not ensured, then three tensile specimens shall be cut at each end of individual plate. For rolled sections, the location of sampling and test units shall be as indicated in para. 8.5.4 and 8.8 of this specification.

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  $\geq 16$  mm, the sulphur and the phosphorus contents in the ladle analysis shall not exceed 0.005% and 0.020% respectively.

Delivery condition for Z 35 steels shall be Normalized or TMCP.

### 5.3.5 Steels with specified physical properties after stress relieving heat treatment (PWHT)

Where the thickness, complexity or high level of stresses of the welded assemblies will require or, at least, indicate the probable requirement of stress relieving heat treatment after welding, the corresponding steels shall be ordered with tests on their physical properties (at least for tensile and impact properties, exception is made of reduction of area in the through thickness direction) after such a heat treatment.

As a rule, this heat treatment shall be defined by the steel producing mill and transmitted to the Company and Purchaser for information. The holding temperature should not be lower than  $580^{\circ}\text{C} \pm 15^{\circ}\text{C}$  for controlled rolled steels,  $30^{\circ}\text{C}$  below the tempering temperature for QT steels and  $600^{\circ}\text{C} \pm 15^{\circ}\text{C}$  for other steel processing methods, for a holding time of 2 minutes per mm of thickness.

Acceptance tests shall then be performed on samples having undergone the heat treatment under simulated conditions. The results obtained shall comply with requirements stated in this specification concerning steel qualities and grades.

Steels of this quality shall be symbolized by the letter "P" (for "Post Weld Heat treatment").

The "P" quality steel shall be required for materials that will be submitted to PWHT (Ref. **GS EP STR 301** § 9). The "P" quality is not required for crown shim materials.

Under Contractor responsibility and subject to Company approval the requirement for heat treatment may be avoided/modified pending on the actual fabrication sequence (can without girth weld, reference thickness less than above figure, no PWHT, CTOD).

### 5.3.6 Steel for forming

Steel materials that are to be subject to a cold or warm forming process (including forming of welded tubular) without the intent of performing a subsequent heat treatment, shall be ordered with impact toughness test made after a strain ageing test when the percentage strain (PS) which is anticipated at fabrication stage is more than the values indicated in Table 5.8. If the PS is more than 6%, hot forming and/or heat treatment are mandatory.

General Specification		GS EP STR 201
Materials for offshore steel structures		
Rev.: 12	Effective date: 10/2013	Page: 23 of 90

**Table 5.8 - Limits of Percentage Strain for cold forming without strain ageing test (see 5.3.6.1)**

Geographical zone	Max. acceptable Percentage Strain (PS)
Temperate seas and warm seas	5%
Cold seas	4%

**Note:** To clarify the following requirements, it is reminded that the plate capability of plastic elongation (uniform elongation) is limited to 10% approx.

Forming process which results in a percentage strain exceeding 6% shall meet the following conditions:

- Either forming shall be carried out at a temperature  $\geq 550^{\circ}\text{C}$
- Or forming shall be carried out at a temperature  $\geq 880^{\circ}\text{C}$
- Or forming is to be carried out in cold condition then, it shall be subject to subsequent normalization or quench tempering or stress relieving. A Magnetic Particle Inspection (MPI) shall be performed before and after heat treatment. When stress relieve heat treatment is applied, either as post forming heat treatment or as post welding heat treatment, in addition to the other specified tests, micrographic examination shall be carried out as described here below (\*).

#### 5.3.6.1 Steel with specified impact toughness after strain ageing

- a) A verification of impact toughness after accelerated ageing shall also be made in the case of welded tubulars made from cold formed plates (press bending, roll bending, etc.) where the PS is over the limits stipulated in Table 5.8. Refer to para. 10.6.1.b of this specification. Heat treatment shall be mandatory for any cold forming resulting in a permanent straining exceeding 10% for steels with  $\text{SMYS} \leq 355 \text{ MPa}$  or 8% for steels with  $\text{SMYS} > 355 \text{ MPa}$ .
- b) The Percentage Strain (PS) due to forming is defined as follows by the max. permanent straining percentage obtained over the stretched plate surface.

$$\text{PS} \% = \frac{t}{D} \times 100$$

- $$\left\{ \begin{array}{l} t = \text{material thickness} \\ D = \text{forming diameter at mid - thickness of material} \end{array} \right.$$

- c) The strain ageing test shall be carried out under the following conditions on a steel sample:
- Tensioning of the sample so as to obtain the same permanent elongation as that anticipated for the final product
  - Then artificial ageing by heat treatment at  $250^{\circ}\text{C}$  during one hour.

General Specification		GS EP STR 201
Materials for offshore steel structures		
Rev.: 12	Effective date: 10/2013	Page: 24 of 90

Charpy V-notch impact test shall be carried out on the steel sample in the strained condition and in the strained plus ageing condition.

Impact test specimens shall be cut from the sample according to the same direction, as regard to the main rolling direction, as that prescribed for the steel quality in question.

Location of impact test specimens through the material thickness shall be as per para. 5.3.2 of this specification.

The test results shall meet the related requirements stated in this specification for steel grades and qualities (refer to Table 5.3).

**d)** Steels of this quality shall be symbolized by the letter "A" (for "Ageing").

#### **5.3.6.2 Materials for cold or warm forming with or without subsequent heat treatment**

The Purchaser shall obtain from the steel producing mill all the necessary instructions and recommendations to perform the said forming and heat treatment, so as to obtain the required steel characteristics at fabrication stage.

The information relating to heat treatment shall be made known to the Company.

Tensile tests and impact tests as per this specification shall be required on material further to simulated forming and subsequent heat treatment, if any.

(\*) In the case of cold forming with subsequent stress relieve heat treatment; the micro structure from the base metal of test sample before forming and after forming/stress relieve shall be examined for comparison, to ensure that steel structure does not vary. After etching, the through thickness section from the extrados to the intrados shall be examined with a suitable magnification. At any location in the through thickness, an increase of grain size, i.e. a decrease of grain size N°, by more than one point to [ASTM E112](#), between the structure before forming and after forming/stress relieve, shall not be acceptable. Steel/plate producing mill shall guarantee the plate against the grain size increasing sensitivity. Testing by producing mill is not required. The test shall apply at the forming production stage.

#### **5.3.6.3 Materials for hot forming**

All materials to be used in hot forming shall be of the normalized type, according to [EN 10025-3 Std.](#)

The Purchaser shall obtain from the steel producing mill all the necessary instructions and recommendations to perform the said hot forming and, when necessary, the heat treatment to be made after forming, so as to obtain the required steel characteristics at fabrication stage.

Those informations shall be communicated to the Company.

Tensile tests and impact tests as per this specification shall be required on material further to simulated hot forming, and subsequent heat treatment, if any.



General Specification		GS EP STR 201
Materials for offshore steel structures		
Rev.: 12	Effective date: 10/2013	Page: 25 of 90

## 5.4 Complete designation of a steel

Within this specification, the complete designation of a steel (i.e. its symbolic designation) shall consist of:

- The letter "S" (for "Structural") followed in all cases and in order by
- The designation of its grade (see para. 5.2)
- The designation related to impact toughness (see para. 5.3.2).

Then, when applicable, the above designation is completed in order by:

- The letter "P" for steels with specified physical properties after stress relieving heat treatment (see para. 5.3.5)
- The letter "A" for steels with specified impact toughness after Strain Ageing test (see para. 5.3.6). However, the product shall be marked with this letter only when so explicitly required in the Project Particular Specification
- The designation "Z 35" for steels with specified reduction of area in the through thickness direction (see para. 5.3.4).

Examples:

- S 355. KT - 20.Z 35
- S 355. KT - 20.P. Z 35
- S 355. KT - 20.A. Z 35.

**Note:** Carbon Equivalent (or Pcm) is not indicated in the symbolic steel designation. This characteristic is implicitly related to material thickness (see para. 5.3.3).

## 6. General requirements for structural steels

### 6.1 Steel designation

Steels shall be designated as stated in para. 5.4 of this specification.

Steels shall be referenced as such on all engineering documents (drawings, specifications, requisitions, etc.) with reference to this specification.

### 6.2 Sourcing of materials

**6.2.1** All materials shall be new. The list of Manufacturers shall be submitted to the Company for approval prior to order.

**6.2.2** When it is agreed with the Company that materials can be supplied from stocks, then the following shall be met:

- The list of potential stockists/stock holders shall have prior approval of the Company
- The original Mill certificates of materials shall be made available to the Inspector for review. The certificates made by dealers or stockists shall not be acceptable. Certified true copy of a Mill certificate made by an international and Company recognized

General Specification		GS EP STR 201
Materials for offshore steel structures		
Rev.: 12	Effective date: 10/2013	Page: 26 of 90

certification authority may be accepted provided that the original Mill certificate can be shown to the Inspector for review

- The original markings shall be easily visible on products.

In addition, the Company or Purchaser reserves the right to require additional or confirmatory tests (chemical analysis, mechanical tests, thickness measurements, etc.) from the stockist and to undertake a visit at stockist's storage area to check the said products as regard to corrosion, surface condition, storage condition, markings, etc.

### 6.3 Traceability of materials

The Manufacturer (or stock holder) shall ensure full traceability of the supplied materials. The in-house traceability procedure shall be made available to the Inspector on request.

### 6.4 Substitution of Materials

**6.4.1** The use of steel grades, qualities and dimensions other than those required by this specification shall not be made unless a written approval from the Company is obtained.

**6.4.2** Substitution of a steel for another (from this specification or a different standard) shall not in any manner modify the requirements of this specification regarding acceptance tests and inspections to be made (with related criteria), marking to be applied on products and documentation to be supplied.

Appendix 1 to this specification shows, for information, some equivalent steels in ASTM and API Stds provided that, in some cases, certain of the steel characteristics are to be further checked or measured for full compliance to this specification.

Any substituted steel from another Company approved Std (e.g. BS, DIN, NF, ASTM, API, etc.) shall, in addition, fully comply with the requirements of the said Std.

**6.4.3** Steel quality KL + 20 may be replaced by a steel of an equivalent quality defined in any Company approved Std provided that this steel is totally in accordance with the said Std and also that tensile and CE/Pcm properties, as a minimum, remain in accordance with this specification.

**6.4.4** For convenience, grouping of steel qualities can be proposed by the Manufacturer/Supplier, e.g. by up-grading steels in a higher quality and grade (e.g. KL-20 quality in lieu of KL0 quality, KT0 in lieu of KL0, etc.) as far as all other requirements of this specification are fulfilled. The substitution of materials shall be clearly stated in a matrix. For shock absorbers (riser protector, ...) or any structural component for which stress-strain curves is part of the design data, upgrading in grade shall be preliminarily approved by Company.

General Specification		GS EP STR 201
Materials for offshore steel structures		
Rev.: 12	Effective date: 10/2013	Page: 27 of 90

## 6.5 Manufacturing Procedure Specification (MPS)

The Manufacturer shall establish a detailed specification (called MPS herein) for the manufacture and inspection of proposed materials, giving full details of the characteristics of the materials, describing all proposed manufacturing and inspection operations in their correct sequence together with their parameters of execution. The proposed specification shall include, but not be limited to, all information concerning the following:

- Steel making process
- Deoxidization method
- Special treatment(s)
- Aimed chemical analysis, minimum and maximum working limits (ladle and product) selected by the Manufacturer for the order
- Manufacturing process/delivery condition of steel products (e.g. normalizing, etc.)
- Proposed Welding Procedure Specifications (WPS) for welded products
- Visual inspection procedure
- Dimensional procedures
- Non-Destructive Testing (NDT) procedures
- Qualification of welders (for welded products) and NDT Inspectors.

This detailed MPS shall be submitted to the Company four (4) weeks mini. before commencement of production.

## 6.6 Quality assurance/quality control

**6.6.1** The Manufacturer (or stock holder) shall operate a Quality Assurance system approved by a recognized authority. The quality Assurance Manual shall be submitted to the Company.

**6.6.2** Four (4) weeks prior to the commencement of the materials manufacture, the Manufacturer shall prepare and submit to the Company a written Quality Control Plan which describes the inspections to be performed at all stages of manufacture of materials. The Quality Control Plan shall set forth "witness", "hold", "review" and "monitor" stages.

## 6.7 Technical queries/non-conformance reports

**6.7.1** All Supplier's requests for clarifications or deviations to the Company specifications shall be submitted to the 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 as long as it has not been submitted to and accepted by the Company through a Technical Query.

**6.7.2** Approval given by the Company to any Supplier's work procedures, specifications, requisitions, etc. shall not release in any way the Supplier from its obligation to meet the Company specifications.

**6.7.3** Any work performance or any test result which is found, at a later date, not in conformance with the Company specifications or agreed procedure shall be subject to a

General Specification		GS EP STR 201
Materials for offshore steel structures		
Rev.: 12	Effective date: 10/2013	Page: 28 of 90

Non-Conformance Report (NCR) to be issued by the Supplier for submission to the Company. NCR report shall indicate corrective action intended by the Supplier.

## 7. Steel plates

### 7.1 General

**7.1.1** This section specifies requirements for steel plates. The use of wide flats shall not be permitted.

**7.1.2** Steel plates shall fully comply (including testing and inspection methods and procedures) with the following relevant standards for the steel grades and qualities which meet the requirements of this specification, including the requirements stated in section 5, unless otherwise stated in the following:

- [EN 10025-4 Std](#) or [API 2W](#): Parts 1, 2 and 3 for S 235 steel grade and any steel (except S 420, S 460 and S 500) with impact testing temperature of -20°C and above
- [EN 10225 Std](#) or [API 2W](#) for S 420, S 460 and S 500 steel grades and any steel with impact testing temperature below -20°C.

**7.1.3** 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.

### 7.2 Usable steel grades

As per Table 5.2, the usable grades shall be:

- S 235, S 275 and S 355  
However, as mentioned in para. 5.2, the supplementary grades S 255 and S 295 may also be used, but only if so previously agreed with the Company.
- S 420 and S 460 (subject to prior approval of the Company for each Project development phase and application).

### 7.3 Steel making process

**7.3.1** Steel making process shall be the Basic Oxygen Converter or the Basic Electric Furnace. In all cases rimming steel (i.e. equivalent to deoxidization method "FU" of [EN 10025 Std](#)) shall not be permitted.

**7.3.2** Steel shall be as follows:

- For steel qualities K + 20 and K 0, steel shall be semi-killed as a minimum
- For steel qualities K - 20, K - 40 and K - 50, steel shall be fully killed (i.e. equivalent to deoxidization method "FF" of [EN 10025 Std](#)) and shall have a fine grain structure containing nitrogen binding elements in amount sufficient to bind the free nitrogen
- All Z 35 steels shall be fully killed and silico-calcium treated.

**7.3.3** Steel making process, deoxidization method, as well as special treatments, when applicable, (such as desulphurization treatment, silico-calcium treatment, degassing, etc.)

along with casting method (ingot or continuous casting) shall be stated to the Company when the bids are submitted.

## 7.4 Plate manufacturing/Delivery condition

The delivery condition of steel plates of Special and First Category shall meet the following requirements:

### 7.4.1 Steel plate in Special Category with thickness:

- $\geq 40$  mm for cold sea
- $\geq 50$  mm for intermediate sea
- $\geq 60$  mm for warm sea

shall be qualified according to [API RP 22](#) or [EN 10225](#) option 18 witnessed by a TPI. Temperature of CTOD tests (performed during qualification) shall be lower than the minimum service temperature.

### 7.4.2 Validity of qualification stated in 7.4.1 shall be according § 5 of [API RP 22](#). In addition, the following changes shall be considered as MAJOR and shall request a full requalification:

- Specific plate-rolling mill and steel product facility.
- Specific steel-making method or melting practice (EAF-VD, BOF-LRF-VD, etc.), nominal proportions of scrap (by designated scrap grade) and hot-metal charge, nominal weight or heat, and any hot-metal treatment (degassing, desulfurization, injection, refining, etc.).
- Method of inclusion shape control and procedure for verifying metallurgical effectiveness.
- Casting method (top poured ingot, bottom-poured ingot, or continuous), usage of argon shrouding, and implementation of strand-cast soft reduction.
- Segregation-control procedures (electromagnetic stirring, electromagnetic braking, etc.) and segregation quality-control procedures (sulfur and phosphorous prints of slab cross sections and testing frequency) for continuous-cast product.
- Continuous cast slab thickness or ingot size and weight and relationship to plate thickness.
- Cross rolling ratio.

### 7.4.3 Steel plates of Special and First Category with thickness Between 15 mm and 100 mm shall be in TMCP-AcC Delivery Condition (Thermo mechanically rolled + Accelerated Cooling).

## 7.5 Mechanical properties

### 7.5.1 The tensile properties of finished plates shall meet the requirements of Table 7.1.

### 7.5.2 Tensile tests shall be carried out in transverse direction in accordance with provisions of [EN 10025-1 Std](#) and [ISO 6892-1 Std](#). The upper yield strength ( $R_{eH}$ ) shall be determined.

If a yield phenomenon is not present, then the 0.2% proof strength ( $R_{p0.2}$ ) shall be determined.

**7.5.3** Impact tests shall comply with the provisions of para. 5.3.2 of this specification.

**7.5.4** For Z 35 quality plates, the tensile tests in the through thickness direction shall conform to [EN 10164 Std.](#) One set of three test specimens shall be cut at each end of mother plate at midway between plate edges. When traceability (regarding rolled plate) of individual plates is not ensured, then 3 tensile specimens shall be cut at each end of individual plate. Refer also to the requirements contained in para. 5.3.4 of this specification.

**Table 7.1 - Tensile properties of steel plates, rolled sections and hollow sections**

Steel grade	Steel Quality KT or KL (°C)	Minimum Yield Strength (YS) (N/mm²) (3)						Minimum tensile strength (N/mm²)		El. min (%)	YS TS max (1)
		Nominal thickness in mm									
		≤ 16	> 16 ≤ 40	> 40 ≤ 63	> 63 ≤ 80	> 80 ≤ 100	> 100 ≤ 150	≤ 100	> 100 ≤ 150		
S 235	+ 20 up to - 50	235	225	215	215	215	195	340-470	340-470	24	0.85
(S 255)		255	245	235	225	225	205	400-540	390-530	23	0.85
S 275		275	265	255	245	235	225	410-560	400-540	22	0.85 (2)
(S 295)		295	285	275	265	255	245	430-610	450-610	22	0.85 (2)
S 355		355	345	335	325	315	295	470-630	460-620	22	0.85 (2)
S 420	- 20 up to - 50	420	400	390	380	380	360	500-690	NA	19	0.90
S 460		460	430	420	410	400	NA	530-720	NA	18	0.90
(S 500)		500	460	450	440	420	NA	560-750	NA	17	0.90

**Notes:**

(1) Requirement applicable only to K - 20, K - 40 and K - 50 qualities.

(2) For thermo mechanical plates, YS to TS ratio is extended as follows:

- $t \leq 16$  mm : 0.91
- $16 < t \leq 40$  mm : 0.90
- $40 < t \leq 63$  mm : 0.88
- $63 < t \leq 100$  mm : 0.86

(3) Constant grades (i.e. steel with constant SMYS whatever is the thickness) may be accepted providing preliminary approval of Company at the design stage

## 7.6 Chemical composition

**7.6.1** The chemical composition as determined by ladle analysis shall comply with the provisions of Table 7.2. Deliberate addition of Boron shall not be permitted.

**7.6.2** Each steel shall also comply with the Carbon Equivalent and Pcm requirements on ladle and product stated in para. 5.3.3 of this specification.

General Specification		GS EP STR 201
Materials for offshore steel structures		
Rev.: 12	Effective date: 10/2013	Page: 31 of 90

**7.6.3** The product chemical analysis shall meet the values of Table 7.2 including the plus tolerances stated hereafter (in% weight):

- |  |              |
|--|--------------|
| • C: + 0.02  | • Nb: + 0.01 |
| • Mn: + 0.10   | • V: + 0.01  |
| • Si: + 0.05   | • Cr: + 0.05 |
| • S: $\begin{cases} + 0.005 \\ + 0.002 \text{ for Z 35 steel} \end{cases}$ | • Ni: + 0.05 |
| • P: $\begin{cases} + 0.005 \\ + 0.002 \text{ for Z 35 steel} \end{cases}$ | • Cu: + 0.05 |
| • Al: + 0.000  | • Mo: + 0.02 |
| • Ti: + 0.01   | • N: + 0.001 |

**7.6.4** Tests methods for chemical analysis shall be according to corresponding standards.

Location of sampling for Z 35 steels shall be according to [EN 10164](#), except that samples shall be cut on the longitudinal axis for plates.

## 7.7 Ladle analysis

Each cast of steel shall be chemically analysed as per para. 7.6 of this specification for the following elements:

- C, Mn, S, P and all elements for CE and Pcm calculation
- Deoxidizing and special treatments elements (Si, Al, Ce, Ca, as applicable)
- Any other intentionally added elements
- N only for K - 20, K - 40 and K - 50 qualities.

Carbon Equivalent (CE) and Pcm (see para. 5.3.3) shall be reported.

**Materials for offshore steel structures**

Rev.: 12

Effective date: 10/2013

Page: 32 of 90

**Table 7.2 - Chemical composition on ladle for steel plates, rolled sections and hollow sections (% weight)**

Grade	Quality KT or KL (°C)	C max.	Mn max.	Si max.	S max. (1)		P max. (1)		Other elements
S 235	+ 20	0.21	1.35	0.40	0.045	0.005	0.045	0.020	(3)
	0	0.18	1.35	0.35	0.045	0.005	0.045	0.020	
	- 20	0.17	1.35	0.35	0.040	0.005	0.040	0.020	
	- 40	0.17	1.35	0.35	0.035	0.005	0.035	0.020	
	- 50	0.17	1.35	0.35	0.030	0.005	0.030	0.020	
(S 255)	+ 20	0.21	1.35	0.40	0.045	0.005	0.045	0.020	(3)
	0	0.19	1.35	0.35	0.045	0.005	0.045	0.020	
	- 20	0.18	1.35	0.35	0.040	0.005	0.040	0.020	
	- 40	0.18	1.35	0.35	0.035	0.005	0.035	0.020	
	- 50	0.18	1.35	0.35	0.030	0.005	0.030	0.020	
S 275	+ 20	0.21	1.45	0.40	0.045	0.005	0.045	0.020	(3)
	0	0.19	1.45	0.35	0.045	0.005	0.045	0.020	
	- 20	0.18	1.45	0.35	0.040	0.005	0.040	0.020	
	- 40	0.18	1.45	0.35	0.035	0.005	0.035	0.020	
	- 50	0.18	1.45	0.35	0.030	0.005	0.030	0.020	
(S 295)	+ 20	0.22	1.60	0.50	0.045	0.005	0.045	0.020	(3)
	0	0.20 (2)	1.60	0.35	0.045	0.005	0.045	0.020	
	- 20	0.18 (2)	1.60	0.35	0.040	0.005	0.040	0.020	
	- 40	0.18 (2)	1.60	0.35	0.035	0.005	0.035	0.020	
	- 50	0.18 (2)	1.60	0.35	0.030	0.005	0.030	0.020	
S 355	+ 20	0.22	1.60	0.50	0.045	0.005	0.045	0.020	(3)
	0	0.20 (2)	1.60	0.35	0.040	0.005	0.040	0.020	
	- 20	0.18 (2)	1.60	0.35	0.035	0.005	0.035	0.020	
	- 40	0.18 (2)	1.60	0.35	0.035	0.005	0.035	0.020	
	- 50	0.18 (2)	1.60	0.35	0.030	0.005	0.030	0.020	
S 420	-20	0.16 (4)	1.70	0.35	0.030	0.005	0.035	0.020	(3)
S 460	up to	0.18 (4)	1.70	0.35	0.030	0.005	0.035	0.020	
(S 500)	-50	0.18 (4)	1.70	0.35	0.030	0.005	0.035	0.020	

- (1) For Z 35 steels or for any wall thickness  $\geq 16$  mm in special and first category: S = 0.005% max. and P = 0.020% max.
- (2) 0.22% for non-QT products with thickness exceeding 30 mm
- (3) Nb max. = 0.05%
- V max. = 0.08% (0.12% for QT steels)
- Al (total) max. = 0.060%
- Cu max. = 0.40%
- Mo max. = 0.08% (0.25% for QT steels)
- Ni max. = 0.50% (1.00% for QT steels)



General Specification		GS EP STR 201
Materials for offshore steel structures		
Rev.: 12	Effective date: 10/2013	Page: 33 of 90

Cr max. = 0.20% (0.25% for QT steels)

Ti max. = 0.03% (0.05% for QT steels)

(V+Nb) max. = 0.10% (0.15% for QT steels)

B = addition not permitted (0.0005% max.)

N = 0.009% max. However this max. value is extended to 0.014% if chemical composition shows a minimum total Al content of 0.020% or if sufficient other N binding elements are present. The N binding elements shall be highlighted in MPS and on Mill certificates.

(4) 0.12% for QT steels.

## 7.8 Destructive testings

### 7.8.1 Definition of the test unit

The test unit is defined as follows:

- For Special Category steels and Z 35 steels: by each mother plate for mechanical tests.
- For First and Second Category steels (other than Z 35 steels): by each fraction of 40 metric tonnes, or part thereof, in each cast of steel (and per heat treatment batch for QT plates).

In addition, the test unit shall contain products of the same form and grade and of the same thickness range as specified in Table 7.1 of this specification, and shall show a thickness variation of not more than 10 mm. Tests shall always be carried out on the thickest product of the test unit.

### 7.8.2 Type and frequency of tests

Each test unit as defined above shall be subject to a series of tests comprising:

- One prismatic (i.e. strip) specimen for transverse tensile test
- One set ( $t \leq 50$  mm) or two sets ( $t > 50$  mm) of three CHARPY V-notch impact test specimens cut in the longitudinal or transverse direction (according to steel quality KL or KT)
- A chemical analysis on one plate per each cast and steel quality in Special and First Category, except KL + 20 and KL0 (otherwise, no product chemical analysis)
- One set of three tensile specimens cut in the through thickness direction at each end of mother plate, as described in para. 5.3.4 and 7.5.4 of this specification (for Z 35 steels only).

Locations of sampling shall be as indicated in para. 7.5 and 7.6 of this specification.

## 7.9 Dimensional tolerances

**7.9.1** Plate nominal dimensions (length, width, thickness) shall be as stated in the Purchaser's requisition.

General Specification		GS EP STR 201
Materials for offshore steel structures		
Rev.: 12	Effective date: 10/2013	Page: 34 of 90

**7.9.2** All dimensional tolerances shall conform to [EN 10029 Std](#), except otherwise stated in the following:

- a) Thickness:** At any location of an individual plate, the thickness shall not exceed the minimum and maximum tolerances indicated in Table 7.3 below.

**Table 7.3 - Tolerances on plate thickness**

Nominal thickness (mm)	Tolerances (mm)
$3 \leq t < 5$	-0.3/+0.8
$5 \leq t < 8$	-0.3/+1.0
$8 \leq t < 15$	-0.3/+1.1
$15 \leq t < 25$	-0.3/+1.3
$25 \leq t < 40$	-0.3/+1.5
$40 \leq t < 80$	-0.3/+2.1
$80 \leq t \leq 150$	-0.3/+2.4

- b)** Length and width where dimensions of plates are defined in the requisition by their width and length, the tolerances on these dimensions shall be as per [EN 10029 Std](#).

Where plates are defined by their area, the minimum plate width shall be 3.500 mm.

- c)** Flatness according to class S of [EN 10029 Std](#).

## 7.10 Surface finish

**7.10.1** Requirements for surface quality and repair conditions shall be as per [EN 10163 Std](#), Parts 1 and 2, and the following.

For reference, the minimum permissible thickness shall be those defined in para. 7.9 above.

**7.10.2** Requirements for repairs shall be as follows:

- a)** Special Category steels: Class B/Subclass 3

All repairs shall be made by grinding only (welding is not allowed) and thickness at ground areas shall not be reduced below the minimum specified thickness.

- b)** First Category steels: Class B/Subclass 2. The depth of any welding repair shall not exceed 25% of thickness or 5 mm, whichever the less.

- c)** Second Category steels: Class A/Subclass 2. Welding repairs shall be as stated above for First Category steels.

General Specification		GS EP STR 201
Materials for offshore steel structures		
Rev.: 12	Effective date: 10/2013	Page: 35 of 90

**7.10.3** Welding repairs shall not be permitted. However, in specific cases when welding repairs are permitted by the Company, the repair procedures shall have prior approval of the Company and shall be properly qualified by tests. Qualification tests shall include the following:

- In all cases, whatever the depth of repair: performance of side bend tests and of a VICKERS hardness survey on Weld Metal and Heat Affected Zone using a 5 kg load. No hardness value shall exceed 325 HV5
- In all cases, except for K + 20 quality, when the weld repair depth exceeds 5 mm (if exceptionally permitted): performance of CHARPY V-notch test on Weld Metal and 2 mm from Fusion Line. The requirements shall be identical to those of the said repaired materials in terms of testing temperature and required absorbed energy.

All weld repaired areas shall be inspected by MPI and ultrasonic testing according to requirements of [EN 10163-1 Std.](#)

The Manufacturer shall provide reports for every welding repair as per [EN 10163-1 Std.](#)

## 7.11 Ultrasonic testing

**7.11.1** Plates shall be ultrasonically inspected in accordance with procedure and acceptance criteria of [EN 10160 Std](#) and the following.

UT scanning shall be carried out on edges and body of plate.

The Manufacturer's UT procedure shall be submitted to the Company for prior approval.

**7.11.2** Each plate of Z 35 quality more than 12 mm thick shall be inspected as per "Class S<sub>3</sub>/E<sub>4</sub>" of [EN 10160 Std.](#)

Plates of quality other than Z 35 quality (i.e. non-Z steels) shall be inspected as per "Class S<sub>1</sub>/E<sub>2</sub>" of [EN 10160 Std](#) in the following cases:

- For steel qualities K - 20, K - 40 and K - 50: when  $t \geq 12$  mm
- For steel qualities K 0: when  $t \geq 20$  mm.

**7.11.3** The Manufacturer shall supply the Company with ultrasonic testing reports giving full details of testing procedure and testing results.

## 7.12 Coated plates (when required in requisition)

Coated plates shall be used only with prior approval of the Company.

Refer to [GS EP COR 350](#).

## 8. Rolled sections

### 8.1 General

**8.1.1** This section specifies requirements for rolled sections.

Requirements particular to hot finished hollow sections are stated in section 9 of this specification.

General Specification		GS EP STR 201
Materials for offshore steel structures		
Rev.: 12	Effective date: 10/2013	Page: 36 of 90

**8.1.2** Rolled sections shall fully comply (including testing and inspection methods and procedures) with the following relevant standards for the steel grades and qualities which meet the requirements of this specification, including requirements stated in section 5, unless otherwise indicated hereafter:

- [EN 10025 Std Parts 1; 2; 3; 4; 6](#) for S 235 steel grade and any steel (except S 420, S 460 and S 500) with impact testing temperature of -20°C and above.
- [EN 10225 Std](#) for S 420, S 460 and S 500 steel grades and any steel with impact testing temperature below -20°C.

## 8.2 Usable steel grades

As per Table 5.2, the usable grades shall be:

- S 235, S 275 and S 355.
- S 420 and S 460 (with prior approval of the Company).

## 8.3 Steel making process

Provisions of para. 7.3 of this specification shall apply.

## 8.4 Manufacturing process/Delivery condition

Manufacturing process and delivery condition of rolled sections is at the Manufacturer's option. However, sections of all grades in thickness above 25 mm and Z 35 sections shall be normalized or processed by the TMCP.

## 8.5 Mechanical properties

**8.5.1** The tensile properties of finished rolled sections shall meet the requirements of Table 7.1.

**8.5.2** Tensile tests shall be carried out in longitudinal direction in accordance with provisions of para. 8.6.2.1 of [EN 10025-1 Std](#) and [ISO 6892-1 Std](#). The upper yield strength ( $R_{eH}$ ) shall be determined. If a yield phenomenon is not present, the 0.2% proof strength ( $R_{p0.2}$ ) shall be determined.

**8.5.3** Impact tests shall comply with the provisions of para. 5.3.2 of this specification.

**8.5.4** For Z 35 quality rolled sections, the tensile test in the through thickness direction shall conform to [EN 10164 Std](#). Two sets of three test specimens shall be cut from one end of the product at locations stated in above mentioned Std: one from the flange and one from the web. Refer also to the requirements contained in para. 5.3.4 of this specification.

## 8.6 Chemical composition

Provisions of para. 7.6 and Table 7.2 of this specification shall apply.

## 8.7 Ladle analysis

Provisions of para. 7.7 of this specification shall apply.

## 8.8 Destructive testings

### 8.8.1 Definition of the test unit

The test unit is defined as follows:

- a) For Special Category steels and Z 35 steels: by each rolled section when its weight exceeds 220 kg/metre. Otherwise, the test unit shall be each lot of five rolled sections per size, cast and heat treatment batch or each fraction of 10 metric tonnes of sections per size and per cast, or part thereof, whichever the greater.
- b) For First and Second Category steels (other than Z 35): by each fraction of 40 metric tonnes (20 metric tonnes for EHS steels), or part thereof, in each cast of steel. In addition, the test unit shall contain sections of the same steel source form, grade and heat treatment, and of the same thickness range as specified in Table 7.1 of this specification, but shall include rolled sections whose thickness do not vary by more than 10 mm.

Tests shall always be carried out on the thickest product of the test unit.

### 8.8.2 Type and frequency of tests

Each test unit as defined above shall be subject to a series of tests comprising:

- One prismatic specimen for longitudinal tensile test
- One set ( $t \leq 50$  mm) of three CHARPY V-notch impact test specimens cut in the longitudinal direction or transverse direction as per Table 5.6
- A chemical analysis on two products of the test unit, for all steel qualities in Special and First Category, except KL + 20 and KL 0
- Two sets of three tensile specimens cut in the through thickness direction at one end of product, as described in para. 5.3.4 and 8.5.4 of this specification (for Z 35 steels only).

Locations of sampling shall be as indicated in para. 8.5 and 8.6 of this specification.

## 8.9 Dimensions and dimensional tolerances

**8.9.1** Depth of rolled H and I shaped sections shall be limited to 600 mm in the following cases:

- a) When there is possibility of lamellar tearing due to large anticipated welding stresses or service loads perpendicular to their surface.
- b) When it is proven that delivery of these rolled sections cannot be guaranteed within an acceptable schedule.

In both above cases, rolled sections shall be replaced by Welded Plate Girders (WPG). For cases a) above, WPG shall be fabricated in whole or in part, from Z 35 quality steels.

In all cases, the use of rolled sections with depths of more than 600 mm shall be subject to the Company prior approval.

**8.9.2** The type of rolled sections as regard to European or American dimensions Stds shall be as defined in the PPS or on the Purchaser's requisition.

**8.9.3** Dimensional tolerances shall then comply with the following:

- Unit/specific length: as per requisition (typically 9 to 12 m long) with -0, +100 mm
- Rolling tolerances:
  - For European type rolled sections (e.g. HEA, HEB, IPE, etc.): as per [EN 10025 Std](#) and relevant EN and Euronorm Stds referenced herein, or alternatively as per [EN 10056-1](#), as applicable.
  - For American type rolled sections (e.g. W, UB, UC, HP, etc.): as per [ASTM A6](#). However permissible camber and sweep variations shall not exceed L/1000 (L = length of rolled section).

## 8.10 Surface finish

As per [EN 10163 Std](#): Part 1 and 3, and the following:

- For Special and First Category Steels: class D/Subclass three. However, the minimum thickness as specified in applicable product Stds (e.g. Euronorms, etc.) shall be met on 100% of product surface
- For Second Category steels: class D/ Subclass three.

## 8.11 Ultrasonic testing

Rolled sections of H and I shaped type (or equivalent) shall be ultrasonically tested over 100% of webs and flanges according [EN 10306](#) with the scanning plans A, B, C, D:

- For Special Category steels when web thickness is greater than 12 mm and for First Category steels when web thickness is greater than 20 mm. Quality class shall be 1.2 for scanning plan A & B and 2.3 for scanning plan C & D
- For Z 35 steels Quality class shall be 1.2 for scanning plan A & B and 2.4 for scanning plan C & D.

The Manufacturer shall supply the Company with ultrasonic testing reports.

# 9. Hollow sections

## 9.1 General

**9.1.1** This section specifies the technical delivery requirements for hot finished hollow sections of square or rectangular shape, fabricated by a seamless or welded process. The use of hollow sections for Special and First Category shall be subject to the prior approval of the Company.

**9.1.2** This section does not consider hollow sections in Z 35 steel.

**9.1.3** Electric resistance welded (ERW and HFI) hollow sections shall not be permitted for Special category members. They are acceptable for First and Second category and Non Structural members when wall thickness is less than 16 mm. In all cases, longitudinal weld shall be located at a distance of minimum 15 mm from the beginning of the corner.

**Materials for offshore steel structures**

Rev.: 12

Effective date: 10/2013

Page: 39 of 90

**9.1.4** Hollow sections shall fully comply (including testing and inspection methods and procedures) with [EN 10210-1](#) and [EN 10210-2 Stds](#) (and EN Stds or Euronorm Stds referenced herein) for the steel grades and qualities which meet the requirements of this specification, including the requirements stated in section 5 (when applicable), unless otherwise specified hereafter.

**9.1.5 Note:** Cold formed hollow sections are not considered in this section. However, these products can be used for Second Category and Non Structural members if not used in seawater with cathodic protection and, then, their supply shall be in accordance with a standard to be agreed with the Company.

## **9.2 Usable steel grades**

As per Table 5.2, the usable grades shall be:

- S 235, S 275, S 355, S420.

## **9.3 Mechanical properties**

**9.3.1** The tensile properties of finished hollow sections shall meet the requirements of Table 7.1 for base metal (longitudinal) and weld (transverse ultimate tensile strength).

**9.3.2** Impact test shall comply with the provisions of para. 5.3.2 of this specification. Impact tests shall apply for base metal (longitudinal) and weld (Weld Metal axis and 2 mm from Fusion Line): refer to para. 9.6.2.

## **9.4 Chemical composition**

Provisions of para. 7.6 and Table 7.2 of this specification shall apply including requirements for Carbon Equivalent.

## **9.5 Ladle analysis**

Provisions of para. 7.7 of this specification shall apply.

## **9.6 Destructive testing**

### **9.6.1 Definition of the test unit**

As per rolled sections in para. 8.8.1 of this specification.

### **9.6.2 Type and frequency of tests:**

From each test unit, one sample shall be cut for the preparation of the following test pieces:

- One longitudinal tensile test
- Three sets of three impact tests specimens (one in Base Metal, one in Weld Metal axis and one at 2 mm from Fusion Line)
- A chemical analysis on two products of the test unit, for all steel qualities in Special and First Category, except KL + 20 and KL 0.

Location of sampling and test methods shall be as specified in [EN 10210 Std](#).



## 9.7 Dimensions and tolerances

- Unit/specific length: as per requisition with following tolerances: -0, +100 mm.
- Dimensional tolerances shall comply with [EN 10210-2](#).

## 9.8 Surface condition

As per para. 7.8 of [EN 10210-1 Std](#). However, repair by welding on the body of hollow sections shall not be permitted.

## 9.9 Non-destructive testing of welds

Welds shall be inspected on their full length using a method and a calibration which allow for a full weld thickness inspection.

For Special Category hollow sections, when authorized by Company, ERW or HFI welds shall be inspected by RT (Once per heat) or a macro-section shall be performed on weld as an alternate. No planar defect shall be allowed.

## 10. Welded tubulars

### 10.1 General

**10.1.1** This section applies to structural tubulars manufactured by specialised pipe mills or tubular workshops which are qualified to produce tubulars according to API specifications. It does not apply to construction yards (fabrications at construction yards are covered by General Specification [GS EP STR 301](#)).

**10.1.2** Tubulars shall be manufactured from cold formed plates and shall be welded longitudinally using Submerged Arc Welding (SAW). The longitudinal weld shall have at least one inside pass and one outside pass. Use of spiral-welded tubulars shall be limited to certain piling, with prior approval of the Company. Use of Electric Welded tubulars (ERW/HFIW tubulars) shall not be permitted.

For hot formed or heat treated tubulars or cones (if any), reference shall be made to para. 6.4 of [GS EP STR 301](#) for base material requirements and testing.

**10.1.3** Tubulars shall be fabricated and tested/inspected in full compliance with [API SPEC 5L](#) (pipe mills) or [API SPEC 2B](#) (tubular workshops), where applicable, and the requirements stated in the present specification.

**10.1.4** In this section, the so-called “cans” are defined as critical tubulars (such as tubular joints) which must resist impact, plastic fatigue loading and lamellar tearing. Cans are usually required with a fixed unit length (typically of 3 to 6 m long) specified in the requisition.

### 10.2 Usable steel grades

As per Table 5.2, the usable grades shall be:

- S 235, S 275 and S 355.

However, as mentioned in para. 5.2, the supplementary grade S 315 may also be used, but only if so previously agreed with the Company.



General Specification		GS EP STR 201
Materials for offshore steel structures		
Rev.: 12	Effective date: 10/2013	Page: 41 of 90

- S 420 and S 460 (subject to prior approval of the Company).

### 10.3 Steel making process

Provisions of para. 7.3 of this specification shall apply.

### 10.4 Plate and tubular manufacturing process

**10.4.1** Provisions of para. 7.4 of this specification shall apply. No welding repairs shall be permitted on plates.

**10.4.2** Delivery condition of mother plates for tubular shall be TMCP for First and Special Category members. Tubular fabrication process (e.g. UOE process, roll bending process, press bending process) is left at the Manufacturer's discretion, unless otherwise mentioned in the PPS.

However, these information shall be made known to the Purchaser when the bids are submitted and then stated on Mill certificates of tubulars.

**10.4.3** Unless otherwise agreed with the Company, the tubulars shall be formed with their generators parallel to the main rolling direction of plates.

However, for instructive purposes, this section also specifies test sampling and acceptance criteria for tubulars formed with their generators perpendicular to the main rolling direction of plates (refer to para. 10.6.2).

**10.4.4** Unless otherwise agreed by Company, welded tubulars or cans shall not include any circular welds. When this is necessary, tubulars shall include only one circular weld per unit length taking into account the prohibited areas defined in § 7.10 of [GS EP STR 301](#). Prior any mother plate purchasing, location of circular welds shall be submitted to Company acceptance. Longitudinal welds shall then be radially offset by a minimum angle between 30° and 90° with a minimum of 250 mm.

### 10.5 Welding

#### 10.5.1 Applicable Standard

Welding shall be carried in compliance with requirements of [AWS D1.1/D1.1M](#) Code and the requirements of this specification.

#### 10.5.2 Welding processes

The welding process for longitudinal seams and circular welds (if any) shall be confined to the automatic Submerged Arc Welding (SAW) process.

Gas Metal Arc Welding (GMAW) process may be used for tack-welding only provided that the weld is completely remolded by the Submerged Arc Welding process. This shall be proved on macro-sections during PQR and production tests.

Weld repair shall be carried out by SAW process or manual Shielded Metal Arc Welding (SMAW) process using extra-low hydrogen electrodes (i.e. max. specified diffusible hydrogen content of 5 ml per 100 g of weld metal).

Each welding procedure shall be fully detailed in a Welding Procedure Specification (WPS) form previously approved by the Company.

Welding Energy shall be limited to a maximum of 4.5 kJ/mm.

### 10.5.3 Welding consumables

#### 10.5.3.1 Selection of consumables

- a) Consumables shall conform to [AWS D1.1/D1.1M](#) code and shall have been approved by an international recognized certification body (e.g. DNV, LLOYD's, etc.).
- b) If classification of the structure is required, welding consumables shall conform to rules of the Classification Society.
- c) Cellulosic electrodes are strictly forbidden for structural use.
- d) Welds forming connections between steels of different grades of material shall develop the minimum specified tensile properties of the lower steel grades being joined, unless otherwise previously approved by the Company.

Welds forming connections between steels of different grades of material shall develop the minimum specified notch impact properties at the lowest temperature of steel grades being joined, unless otherwise previously approved by the Company.

- e) For repair welding or multiple repairs, "extra low hydrogen" electrodes are required (i.e. maximum specified hydrogen content of 5 ml per 100 gram of weld metal).
- f) For welding castings or forgings, "extra low hydrogen" electrodes are required (i.e. maximum specified hydrogen content of 5 ml per 100 gram of weld metal).
- g) For SMAW process, coated electrodes shall have a minimum diameter of 3.15 mm on Structural Steels.
- h) The number of different consumables shall be minimized.
- i) All consumable batches (lots) used in production shall be tested (for SAW, all flux batches as well as wire batches are to be tested). Consumable batches shall be qualified at the very early stage (welding qualification or advanced production test) in order to make sure of their quality at the very beginning of the production. The test shall be carried out on butt weld on the highest grade steel used for which the lots are used in production. One tensile test transverse to the weld and a set of three Charpy V notch in weld metal at the lowest temperature for which the lots are used in production shall be carried out. Results shall meet the value of the highest grade steel for tensile test and the minimum requirement for the highest grade steel at test temperature for the Charpy test, according [GS EP STR 201](#).

#### 10.5.3.2 Supply, storage of welding consumables

Low hydrogen electrodes and fluxes shall be supplied in sealed moisture proof containers. The unopened containers shall be stored in a dry location where a temperature of 20°C approx. is maintained at all times.

Each heat, lot (or so called batch herein) of consumables shall be subject to inspection and approval by the Inspector. 3.1 Mill test certificates from consumables manufacturers showing test results actually obtained on the said lot shall be submitted to the Inspector.

**Materials for offshore steel structures**

Rev.: 12

Effective date: 10/2013

Page: 43 of 90

The lot and the level of testing are specified as per [ISO 14344](#) as follows:

- Covered electrodes: class C5 or alternatively C3 provided it is limited to one heat number and when the chemical composition of wet mixes is controlled by raw material analysis and computerized weighing
- Bare solid electrodes and rods: class S3
- Flux cored electrodes and metal cored electrodes and rods: class T3
- Flux for submerged arc welding: class F2.

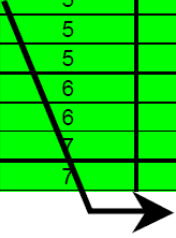
The level of testing shall be as per [ISO 14344 – Schedule 4](#) as a minimum.

Certificates of conformance are not acceptable. Batch testing of welding consumables is required from Contractor in combination with production test plan.

For steel grades above 440 MPa, SAW flux procurement, packing, storage and use shall conform to requirements of Appendix 2.

For steel grades less than 440 MPa, SAW flux shall be stored in metallic drums or double polyethylene bags with aluminum layer. If not, in addition of a sealed packaging, storage room shall guaranty an atmosphere with absolute water content less than 11 g per kg of dry air. Table of correspondence between T°C and relative humidity is given in the following Table. Paper bag is not considered as a sealed packaging.

g of water vapor / kg of dry air		Temperature							
Relative humidity %		5	10	15	20	25	27	30	35
	40	2	3	4	6	8	9	11	14
	45	2	3	5	7	9	10	12	16
	50	3	4	5	7	10	11	13	18
	55	3	4	6	8	11	12	15	20
	60	3	5	6	9	12	13	16	21
	65	4	5	7	10	13	15	17	23
	70	4	5	7	10	14	16	19	25
	75	4	6	8	11	15	17	20	27
	80	4	6	9	12	16	18	22	29
	85	5	7	9	13	17	19	23	31
	90	5	7	10	13	18	20	24	33



**Acceptable**

FCAW wires shall be permanently protected from moisture.

### 10.5.3.3 Drying procedures and use of welding consumables

As a general rule, welding electrodes shall be treated and used in accordance with recommendations of their manufacturers. In the absence of written recommendations from the manufacturers of consumables, the requirements of [AWS D1.1/D1.1M](#) shall apply.

The permissible atmospheric exposure of low hydrogen electrodes shall be two hours max., unless shorter a time is required in [AWS D1.1/D1.1M](#).

Low hydrogen electrodes which have been in direct contact with water shall be definitely rejected and removed from the Site.

**Materials for offshore steel structures**

Rev.: 12

Effective date: 10/2013

Page: 44 of 90

Welders shall be provided with individual portable ovens (heating quivers) for electrode conservation during the work on site.

Flux for SAW process shall be dried according Vendor's written recommendation with a minimum of 300°C during 2 hours. Waiver of this drying may be granted by Company provided packaging of flux is done with metallic drums or double polyethylene bags with aluminium layer and that Vendor certify by written a diffusible hydrogen in sealed pack less than 5 ml/100 g of deposited metal. This certification may be based on correlation curves between hydrogen content in flux and diffusible hydrogen in deposited metal.

When necessary, drying of flux shall be performed on layers of 5 cm maxi. Drying in drums is considered as inefficient.

Holding T°C of flux shall be over 100°C.

Transportation and storage of flux before use shall be done in closed container and flux always protected from moisture contamination. Duration at a T°C of less than 100°C shall be limited to 2 hours maximum. A special care to flux shall be implemented at the end of the working shifts.

Recycling of flux may be accepted after filtration (with size of filters mesh according Vendor's written recommendation) and a complete re-drying cycle.

Percentage of recycled flux in used flux shall be limited to 25% (75% of new flux). This percentage can be upgraded to 50% if a magnetic filtration is added to the size filtration.

If compressed air is used for flux propulsion air shall be free of oil and moisture (moisture and oil removal system after compressor).

At the end of the working shift, FCAW wires shall be stored in a dedicated area protected from moisture.

The Contractor's consumable management procedure for storing, handling, drying, flux recycling and traceability including Vendor's written recommendation shall be approved by the Inspector before fabrication commences.

#### 10.5.4 Welding procedure qualifications

- a) Welding procedure for longitudinal welds, circular welds (if any) and repair welds shall be qualified as per [AWS D1.1/D1.1M](#) code by means of visual examination (100%), non-destructive testing (100%) and mechanical tests.
- b) Qualified welding procedures from previous orders approved by an international and Company recognized inspection agency may be accepted without further tests provided that acceptable documentation is supplied 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 the WPQR) and subject to prior approval of the Company. However, production tests where required (see para. 10.9 hereafter) shall always be maintained. In that case, the main weld of first tubular produced shall be subject to a full set of production tests as per para. 10.9.2.b of this specification.

General Specification		GS EP STR 201
Materials for offshore steel structures		
Rev.: 12	Effective date: 10/2013	Page: 45 of 90

c) Grouping of material qualities and pipe sizes may be made for certain welding conditions (e.g. minimum, maximum heat input) subject to prior approval of the Company. In such a case, the following conditions shall apply to base materials:

1 - Material grades with SMYS (Specified minimum yield Strength) greater than 355 MPa

Any steel with a minimum specified YS in excess of 355 MPa, i.e. S 420, S 460 and S 500 steel grades as defined by **GS EP STR 201** shall require separate welding procedure qualification test on the production material:

- Per delivering mill
- Per as-delivery condition
- Per each steel grade
- Per each steel quality (impact test requirements).

**Note:** Qualification done with Charpy test performed at a temperature qualifies production with Charpy test requested at a higher temperature.

The validity of such a welding procedure qualification is moreover limited to materials of the same grade as defined above considering the further restriction:

- Carbon, Carbon Equivalent and Pcm of the test material is not less than 0.02%, 0.03% and 0.02% respectively, in comparison with the materials of the order
- Welding consumables are considered as still acceptable in Company's opinion.

2 - Material grades with SMYS less than or equal to 355 MPa

Welding procedure qualification tests is required for steels corresponding to group I as defined by **AWS D1.1/D1.1M**, or any steels group II as defined by **AWS D1.1/D1.1M**, with SMYS less or equal to 355 MPa, or any steel combination as defined by **AWS D1.1/D1.1M**.

The validity of such a welding procedure qualification is limited to materials of the same group or steel group combination as defined above, considering the further restriction:

- Per delivering mill (group II only)
- Per as-delivery condition (group II only)
- Per each steel quality (impact test requirements).

**Note:** Qualification done with Charpy test performed at a temperature qualifies production with Charpy test requested at a higher temperature.

In addition, any welding procedure qualified as per above, will cover materials of the said group provided that:

- Minimum Specified YS does not exceed the SMYS of the qualified material by more than 60 MPa
- Carbon Content, Carbon Equivalent and Pcm of the test material is not less than 0.02%, 0.03% and 0.02% respectively, in comparison with the materials of the order
- Welding consumables are considered as still acceptable in Company's opinion.

General Specification		GS EP STR 201
Materials for offshore steel structures		
Rev.: 12	Effective date: 10/2013	Page: 46 of 90

d) Unless otherwise agreed with the Company, two weld repair types shall be qualified by tests:

- One partial repair (minimum of 2/3 thickness repair) simulating a defect located on Fusion Line, and
- One shallow cap repair with two weld passes minimum simulating a defect located at weld toe (e.g. undercut repair).

Where welding from inside of pipe is not intended by the Manufacturer, nor practicable, nor accepted by the Company, then a through thickness repair simulating a defect centered in Weld Metal axis shall also be required.

e) The following mechanical tests shall be carried out on each qualification test weld:

- Two tensile tests transverse to the weld. The ultimate tensile strength shall meet the values shown in Table 10.1
- Two guided bend tests: one face-bend and one root-bend test, with weld reinforcement removed from both faces, shall be carried out for wall thickness of 12.7 mm and less. For wall thickness above 12.7 mm, these tests shall be replaced by two side bend tests. Specimens to be full pipe wall thickness with a specimen width of 12.5 mm.

The mandrel diameter for bending shall be as follows:

- 2 t max. for grade S 235
- 3 t max. for grades S 275 and S 355

(t = thickness of test specimen).

- Three CHARPY V-notch impact test specimens transverse to weld cut on the outside pipe surface in accordance with Figure 10.1.a (notch in the Weld Metal axis, on the Fusion Line, at 2 mm from Fusion Line).

For tubulars in thickness above 50 mm, two additional sets shall be cut at weld root as shown on Figure 10.1.b.

Locations of CHARPY V-notch test specimens in weld repairs shall be as shown on Figure 10.2.

Impact tests shall be carried out at the same test temperature as that specified for the related base material quality.

Impact test results shall meet the required absorbed energies stated in Table 5.3 of this specification.

- One macrography/hardness test: a VICKERS hardness survey shall be conducted using a 5 kg load in accordance with figure 10.3.

The maximum acceptable single hardness value shall be 350 HV5 or HV10.

For welds located in sea water under cathodic protection, maximum acceptable single hardness value shall be 300 HV5 or HV10.

The value of 300HV5 or HV10 may be increased to 325 HV5 or HV10 for non critical welds without fatigue or welds with PWHT.



General Specification		GS EP STR 201
Materials for offshore steel structures		
Rev.: 12	Effective date: 10/2013	Page: 47 of 90

When unacceptable values of hardness are found, one retest after light machining or grinding (max 2 mm) and adequate polishing is accepted.

- Shallow cap repairs shall include only side bend tests and hardness test as detailed above.

## 10.6 Mechanical properties

### 10.6.1 On steel plates

- For tubulars made from Z 35 steel, the plates shall be tested before forming by tensile tests in the through thickness direction, per mother plate, under the conditions specified in para. 5.3.4 of this specification. Alternatively, those tests may be performed on tubulars (instead of on plates).
- Where the permanent deformation (straining) produced by cold forming is greater than the values given in Table 5.8 of this specification (i.e. when  $D < 20 t$ , with  $D$  and  $t$  as defined in para. 5.3.6.c of this specification), without any subsequent heat treatment, an accelerated ageing test shall be made in accordance with the provisions of para. 5.3.6 of this specification.

The impact test results obtained after tensioning and after ageing at the test temperature corresponding to the quality of the steel tested shall comply in all cases with the requirements of para. 5.3.2 of this specification.

This test shall be made once per steel source, grade and quality. Grouping of materials may be agreed with Company for the materials which are of similar chemical composition.

### 10.6.2 On finished tubulars (base metal and weld)

- Tensile properties of base metal of tubulars shall satisfy the requirements set in Table 10.1 of this specification with tensile procedure as per para. 7.5.2. In all cases (i.e. whether tubulars are formed parallelly or perpendicularly to main rolling direction of plates), the longitudinal axis of tensile test specimens shall be parallel to longitudinal axis of tubular.
- Impact tests on base metal of tubulars shall comply with para. 5.3.2 of this specification (specimens transverse to tubular axis for KT quality and longitudinal to tubular axis for KL quality).
- However, where plates are formed perpendicular to the main rolling direction, impact test is always longitudinal to tubular axis (i.e. tubular is always of KT quality, no matter what the component Category may be).

Welds shall comply with the requirements given in para. 10.5.3.1 and Table 5.3 of this specification.

**Materials for offshore steel structures**

Rev.: 12

Effective date: 10/2013

Page: 48 of 90

**Table 10.1 - Tensile properties of tubulars (welded and seamless tubulars)**

Steel grade	Steel quality KL or KT (°C)	Mini. YS (N/ mm <sup>2</sup> ) (1) (5)	TS (N/ mm <sup>2</sup> )	El% (2)	$\frac{YS}{TS}_{max}$ (3)
S 235	+ 20 up to - 50	235	370 – 520	22	0.85
S 275	+ 20 up to - 50	275	410 – 550	21	0.85 (4)
(S 315)	+ 20 up to - 50	315	430 – 560	21	0.85 (4)
S 355	+ 20 up to - 50	355	480 – 630	21	0.85 (4)
S 420	- 20 up to - 50	420	500 – 690	19	0.90
S 460		460	530 – 720	18	0.90
(S 500)		500	580 – 770	17	0.90

(1) Upper yield strength ( $R_{eH}$ ) or 0.2% proof strength ( $R_{p0.2}$ ) if a yield phenomenon is not present.

(2) Elongation measured with  $L_0 = 5.65\sqrt{S_0}$ .

(3) This requirement is applicable only to K - 20, K - 40 and K - 50 qualities.

(4) For pipes made with TMCP plates, max. YS to TS ratio shall be:

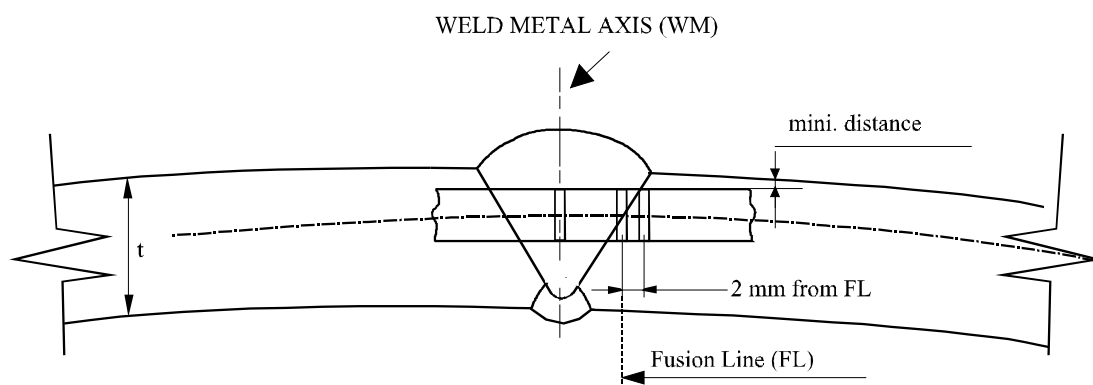
- $t \leq 16$  : 0.92
- $16 < t \leq 40$  : 0.91
- $40 < t \leq 63$  : 0.90

(5) For  $t > 40$  mm, YS shall comply with those YS stated in table 7.1 for plates.

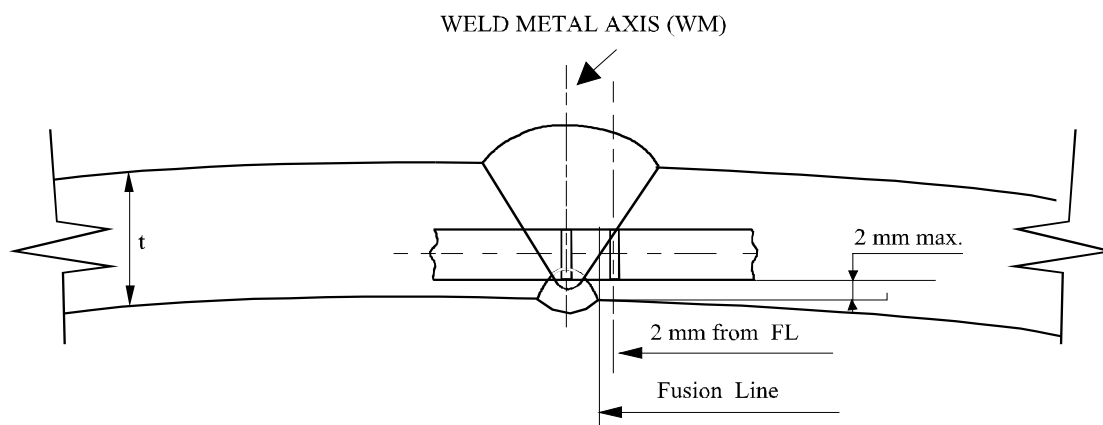


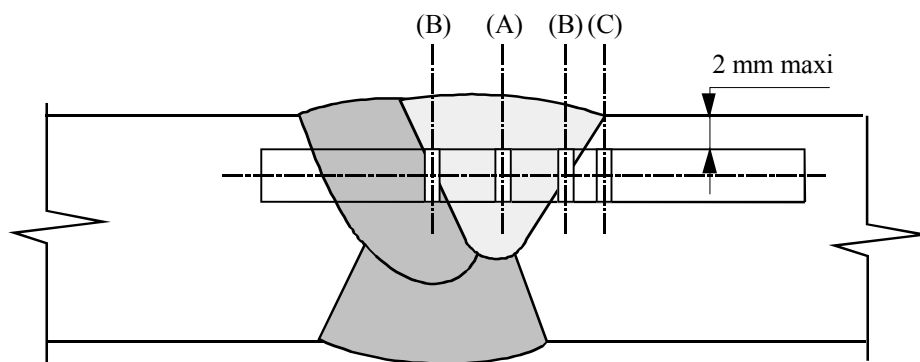
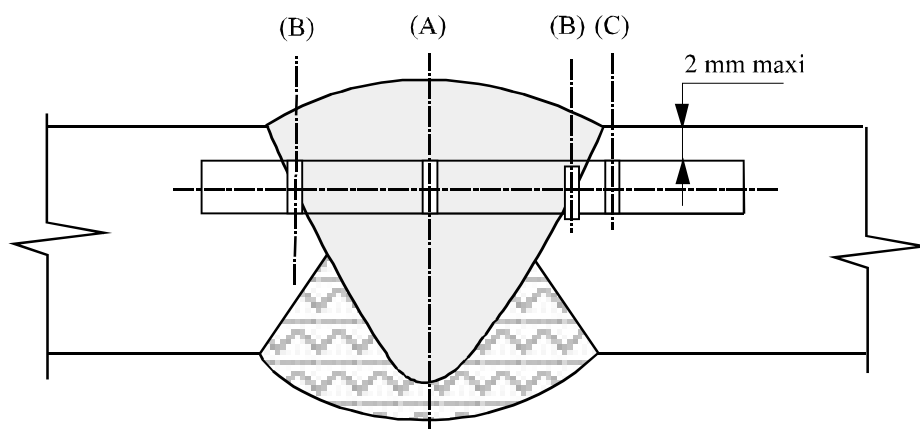
**Figure 10.1 - Charpy V-notch tests in main welds**
**a) All tubulars (whatever the thickness)**

(Impact tests at weld cap only)

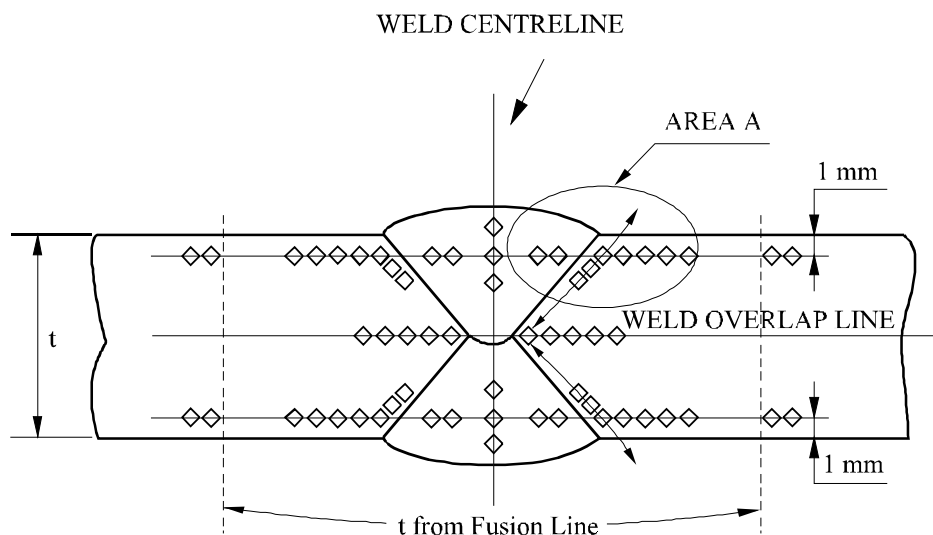
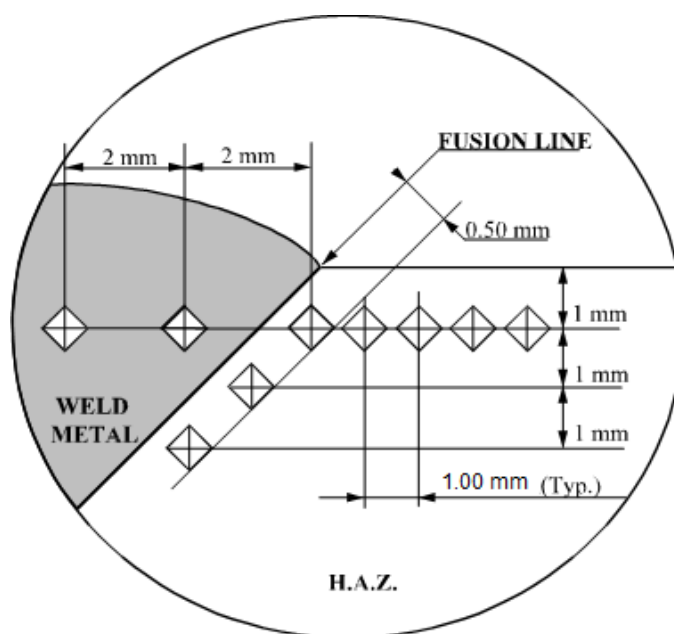

**b) Additional tests for tubulars where  $t > 50$  mm**

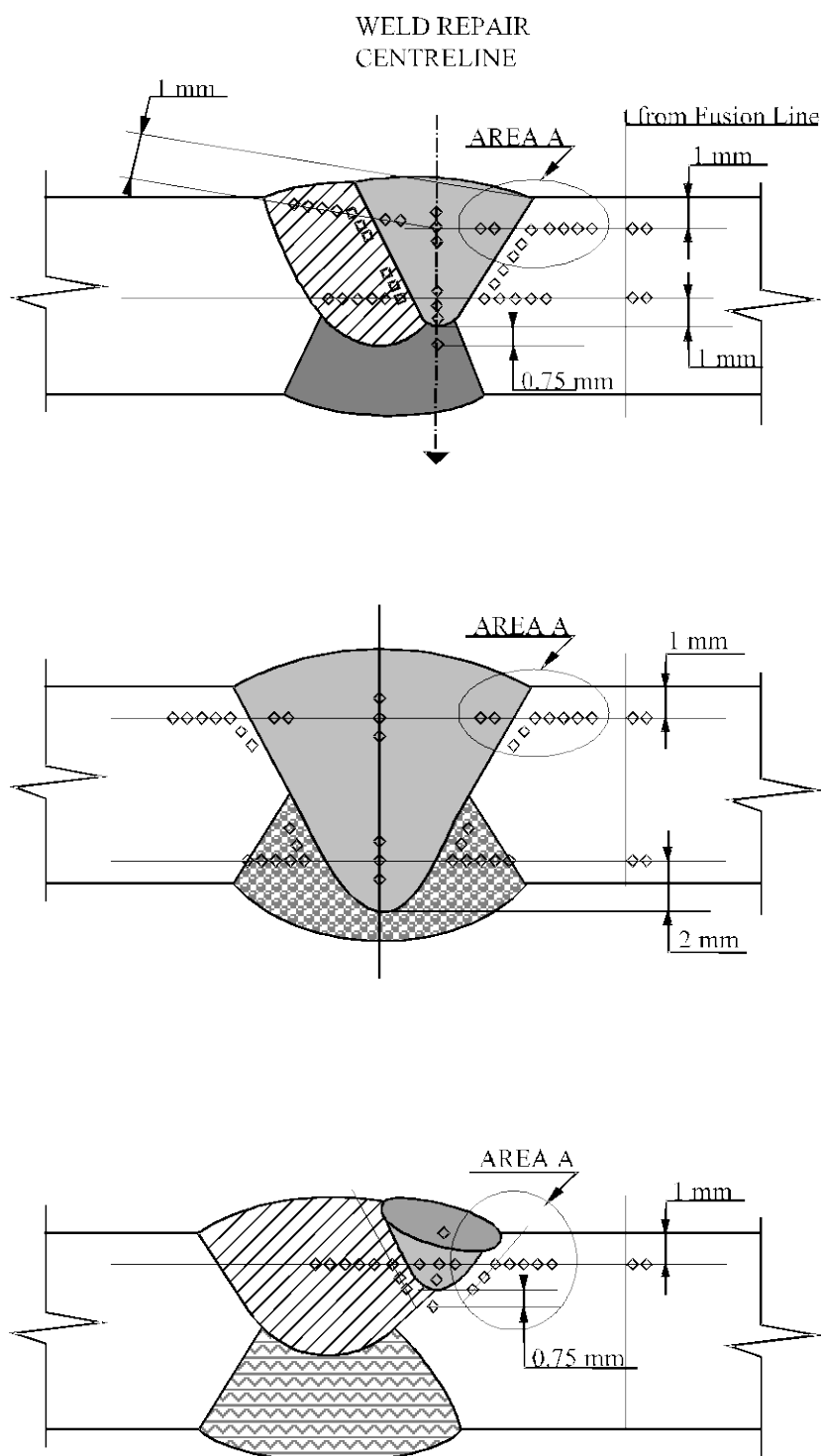
(Impact tests at weld root)



**Figure 10.2 - Charpy V-notch impact test in weld repairs**
**a) Partial-thickness repair**

**b) Through-thickness repair**

**Notch specimen location:**

- (A) Notch at centerline of repair weld
- (B) Center of notch located on fusion line
- (C) Center of notch located 2 mm from fusion line.

**Figure 10.3 - Vickers hardness survey in weld for procedure qualification tests**
**a) Longitudinal or circular seams**

**Enlargement of area A (typical)**


**Figure 10.3 - Vickers hardness survey in weld for procedure qualification tests (cont'd)**
**b) Repair welds**


## 10.7 Chemical composition

Provisions of para. 7.6 of this specification shall apply in full. Note that tubular grade S 315 (when its use is agreed) shall comply with the chemical composition required for grade S 295 in Table 7.2.

## 10.8 Ladle analysis

Provisions of para. 7.7 of this specification shall apply.

## 10.9 Destructive testing/Production tests

### 10.9.1 Definition of the test units

Tests units shall be defined separately as follows for base metal and welds:

#### a) For Special Category steels

- In base metal: by each fraction of 40 metric tonnes (80 metric tonnes for piles), or part thereof, in each cast of steel
- In weld
  - For 2-pass weld (one inside + one outside): by each lot of 25 tubulars (or cans) or 300 metres of tubulars (whichever the lesser) welded in sequence, per cast and WPS
  - For multipass weld (i.e. more than 2 passes): by each lot of 16 tubulars (or cans) or 200 metres of tubulars (whichever the lesser) welded in sequence, per cast and WPS.

#### b) For First and Second Category steels

- In base metal: by each fraction of 100 metric tonnes, or part thereof, in each cast of steel
- In weld/First Category steels:
  - For 2-pass weld (one inside + one outside): by each lot of 100 tubulars (or cans) or 1200 m of tubulars (whichever the lesser) welded in sequence, per cast and WPS
  - For multipass weld (i.e. more than 2 passes): by each lot of 50 tubulars (or cans) or 600 metres of tubulars (whichever the lesser) welded in sequence, per cast and WPS.
- In weld/Second Category steels:
 

The size of above lots are doubled.

c) For **Z 35 steel**, the test unit for the tensile tests in through thickness direction shall be each mother plate.

d) Production test shall be arranged in such a way that all consumable batches (lots) used in production are tested for the lowest temperature for which they are used in production. (for SAW, all flux batches as well as wire batches are to be tested). Consumable batches shall be qualified at the very early stage (welding qualification or advanced production test) in order to make sure of their quality at the very beginning of the production.

General Specification		GS EP STR 201
Materials for offshore steel structures		
Rev.: 12	Effective date: 10/2013	Page: 54 of 90

### 10.9.2 Type and frequency of tests

Each test unit as defined above shall be subject to the following tests:

#### a) On base metal

- One tensile test cut longitudinally to tubular axis as stated in para. 10.6.2.a
- One or two sets of impact test specimens (according to thickness) as stated in para. 10.6.2.b and 5.3.2
- A chemical analysis on two products of the test unit, for all steel qualities in Special and First Category, except KL + 20 and KL 0. Alternatively, chemical analysis may be made on plates.

#### b) On weld

All tests specified for the welding procedure qualification test weld: refer to para. 10.5.3.1.e. However, the hardness survey shall be carried out according to Figure 10.4 (simplified hardness survey).

### 10.10 Visual inspection

Visual inspection and MPI shall comply with [AWS D1.1/D1.1M](#), Table 6.1.

### 10.11 Non-destructive testings and repairs

**10.11.1** Steel plates shall be ultrasonically tested in accordance with the requirements of para. 7.11 of this specification.

No welding repairs shall be permitted on plates.

**10.11.2** Longitudinal welds and circular welds (if permitted) shall be 100% examined by NDT. NDT means radiography (for thickness less or equal than 25 mm) or ultrasonic testing (for thickness above 15 mm).

Radiographic inspection of weld extremities (over 200 mm min.) shall be made on longitudinal welds with thickness less than 25 mm or double checked with manual UT using a different operator than for the initial check for thicknesses over 15 mm.

The intersection of longitudinal and circumferential butt welds with thickness less than 25 mm shall be inspected by radiography (or double checked with manual UT using a different operator than for the initial check for thicknesses over 15 mm) for 200 mm in each direction from the intersection point. If the radiography or the double UT check indicates repair then the zone of inspection for the defect weld shall be extended 200 mm. This process shall be repeated if further unacceptable defect is found.

MPI of weld extremities (over 200 mm min.) for search of transversal defects shall be made internally and externally. Any planar indication shall be immediately reported to Company and investigations for determining the explanation and the cause of the transverse defect implemented.

100% MPI shall also be carried out on any welds when capping or back weld is made with a process other than Submerged Arc Welding.

**Materials for offshore steel structures**

Rev.: 12

Effective date: 10/2013

Page: 55 of 90

**10.11.3** Beveled ends (if any) shall be 100% inspected by MPI (square cut tubulars are not subject to MPI).

**10.11.4** Except otherwise stated in para. 10.11.5 and 10.11.6 hereafter, NDT procedures and acceptance criteria shall be according to [API SPEC 5L](#) for tubulars made at pipe mills with a 2-pass weld. For all other tubulars made at tubular workshops, NDT procedures and acceptance criteria shall comply with [AWS D1.1/D1.1M](#), except that acceptance criteria shall be Class R for UT. For automatic UT of weld, the number and arrangement of probes shall be in relation to WT, such that the whole weld volume is properly scanned. All NDT procedures shall have prior approval of the Company.

**10.11.5** The reference standard for UT testing of welds shall include N5 notches located on inside and outside weld surfaces (longitudinally at weld centreline + transverse to weld axis + longitudinally at weld toes, all on both sides of weld).

A hole of 3.0 mm dia. shall also be radially drilled in weld metal axis.

**10.11.6** Radiography shall comply with the following:

- Methodology shall conform to [EN 1435](#) Class A.
- Radiographic source shall be X only.
- Film systems shall comply with [ISO 11699-1](#) **Class C4**.
- Only lead screens.
- ISO or [EN 462-1](#) wire Image Quality Indicator (IQI).
- Sensitivity to be 1.8% max. for  $WT \leq 20$  mm and 1.6% for  $WT > 20$  mm.
- Image density to be 2.2 to 3.8.

Radioscopy or computed radiography (phosphoscreens or equivalent) could be carried out as a substitution of silver radiography provided that:

- Basic images (without any treatment) are stored in locked files accessible to Company
- The global NDT system is satisfactory audited by Company (including witnessed comparative tests, data storage process, skills of NDT operators, etc.).

**10.11.7** Repair rate

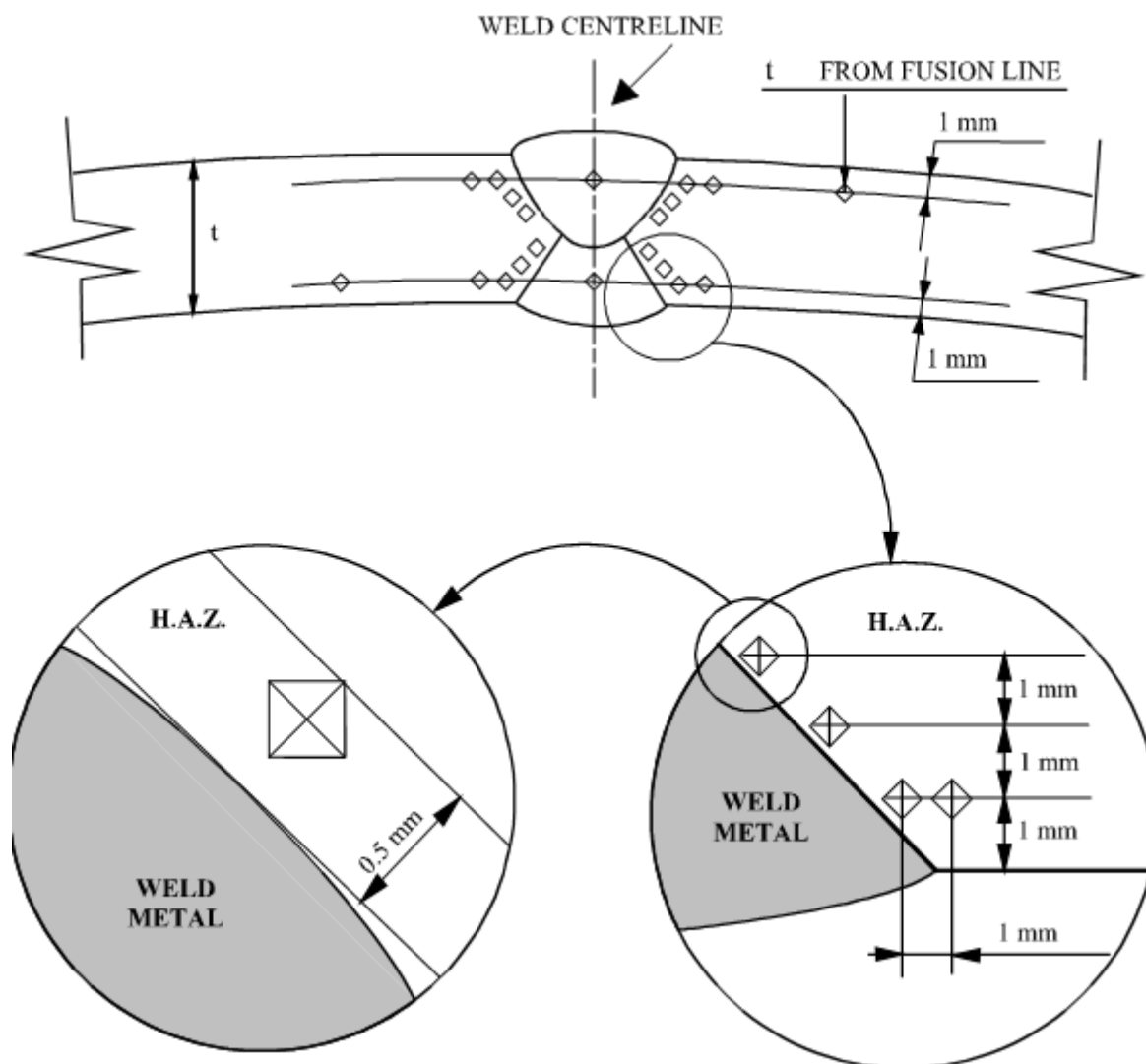
After 15% of production, if repair rate (\*) exceeds 15%, the production shall be stopped. Manufacturer shall assess the manufacturing/welding procedure. He shall issue a NCR (Non Conformance Report). The NCR shall indicate the found points of drift and the proposed corrective actions. The NCR shall be submitted to Company representative/inspector approval prior the restart of production.

(\*) Repair rate is understood as the ratio of the number of repaired tubulars to the total number of welded tubulars with the same welding procedure.

**10.11.8** On tubulars, repairs of base metal imperfections shall be governed by requirements contained in para. 7.10 of this specification.

No welding repairs in base metal or weld shall be permitted within 200 mm from tubular end.

**Figure 10.4 - Vickers hardness survey in weld for production tests (longitudinal seam)**



## 10.12 Dimensions and dimensional tolerances

### 10.12.1 Joints

Reference shall be made to provisions of para. 10.4.4.

### 10.12.2 Unit length

Unit length of tubulars and cans shall be as mentioned in the Purchaser's requisition with the following tolerances:

- Tubulars = -500/+700 mm
- Cans = -0/+10 mm.



General Specification		GS EP STR 201
Materials for offshore steel structures		
Rev.: 12	Effective date: 10/2013	Page: 57 of 90

### 10.12.3 Diameters

- a) Outside Diameter of pipe body: the tolerance shall not exceed  $\pm 0.5\%$  of the specified nominal Outside Diameter, with a max. of  $\pm 4$  mm.
- b) Inside diameter of pipes ends: the tolerance on the Internal diameter within 100 mm (4") of the pipes ends shall not exceed  $\pm 1.6$  mm from the nominal Internal Diameter defined as follows:

$$\text{Nominal ID} = \text{nominal OD} - 2 \times \text{nominal WT}$$

### 10.12.4 Out of roundness

Tolerances shall be as per [API SPEC 2B](#), clause 6.2.

For commercial length (i.e. tubulars dedicated to be cut at length), 5 measurements shall be made: 2 at extremities, one in the middle, one at each quarter length.

### 10.12.5 Thickness

Tolerances shall be  $-5\%$ ;  $+10\%$  of the specified nominal wall thickness.

### 10.12.6 Straightness

Maximum allowable deviation shall be 1.2 mm per metre. Straightness shall be checked on two planes, as a minimum, displaced by  $90^\circ$ .

One of these planes shall include the longitudinal seam.

### 10.12.7 Offset of plate edges (longitudinal and circular welds)

Maximum radial offset shall be as follows:

- $t \leq 20$  mm: 2 mm
- $t > 20$  mm:  $t/10$ , max. 3 mm.

### 10.12.8 Height of weld beads

Inside and outside weld reinforcement height shall be as follows:

- Within  $+ 0.5$  mm;  $+ 3.0$  mm for WT less than 1"
- Within  $+ 0.5$  mm;  $+ 3.5$  mm for WT 1" and above.

### 10.12.9 Squareness of ends

Tubular and cans shall be cut perpendicular to their longitudinal axis within 1.6 mm across any diameter.

General Specification		GS EP STR 201
Materials for offshore steel structures		
Rev.: 12	Effective date: 10/2013	Page: 58 of 90

### 10.12.10 End preparation and protection

Unless otherwise stated in the PPS or the Purchaser's requisition the following applies:

- Can ends shall be beveled for welding with an angle of 30° -0°, + 5° and a root face of 1.6 mm ± 0.8 mm. Can ends shall be fitted with steel bevel protectors of a type approved by the Purchaser
- Ends of any other tubulars shall be square cut, without bevel protectors.
- Inside and outside weld reinforcements of cans shall be ground flush (to 0.0 mm, + 0.5 mm) with the inside contour of the can for a minimum distance of 100 mm from each end

Only inside weld reinforcements shall be ground flush as above for any other tubulars.

- To prevent distortion, large tubulars (as a minimum for OD above 60 x WT) shall be fitted either with metallic stiffeners or wooden stiffeners.

### 10.12.11 Bulges, dents and flats areas

On the tubular body, deviations from the original contour of the tubular shall not exceed 3 mm depth, nor shall they extend in any direction greater than 1/4 of the diameter of the tubular. Any sharp bottom deformations are unacceptable.

## 11. Seamless tubulars

### 11.1 General

11.1.1 This section specifies requirements for seamless tubulars manufactured by pipe mills which are qualified to produce tubulars according to API specifications.

11.1.2 Seamless tubulars shall fully comply (including testing and inspection methods and procedures) with [API SPEC 5L](#) for the steel grades which meet the requirements of this specification, including the requirements stated in section 5, unless otherwise indicated hereafter.

Hydrostatic testing of tubulars is not required.

### 11.2 Usable steel grades

As per Table 5.2, the usable grades shall be:

- S 235, S 275 and S 355.

However, as mentioned in para. 5.2, the supplementary grade S 315 may also be used, but only if so previously agreed with the Company.

### 11.3 Steel making process

11.3.1 Steel making process shall be the Basic Oxygen Converter or the Electric Furnace. In all cases rimming steel shall not be permitted.

**Materials for offshore steel structures**

Rev.: 12

Effective date: 10/2013

Page: 59 of 90

**11.3.2** Steel making process, deoxidization method, as well as special treatments, when applicable (such as degassing, etc.) along with casting method shall be stated to the Company when the bids are submitted.

#### **11.4 Manufacturing process/Delivery condition**

**11.4.1** Tubulars shall be manufactured by the hot finish process using the Plug Rolling Mill Process or the Mandrel Mill Process (the Pilger Mill process shall not be permitted).

**11.4.2** Tubular shall be supplied in the as-rolled condition (if reliable physical properties in accordance with this specification can be obtained) or in the normalized condition, or in the quenched-tempered condition. The as-rolled condition is not authorized for Special Category and Z 35 members.

Delivery condition of tubulars shall be made known to the Purchaser when the bids are submitted and then stated on Mill certificates of tubulars.

#### **11.5 Mechanical properties**

**11.5.1** The tensile properties in longitudinal direction of finished tubulars shall meet the requirements of Table 10.1 of this specification.

**11.5.2** Tensile tests shall be carried out in accordance with the provisions of para. 8.6.2.1 of [10025-1 Std](#) and [ISO 6892-1 Std](#). The upper yield strength ( $R_{eH}$ ) shall be determined. If a yield phenomenon is not present, the 0.2% proof strength ( $R_{p0.2}$ ) shall be determined.

**11.5.3** Impact tests shall comply with the provisions of para. 5.3.2 of this specification.

#### **11.6 Chemical composition**

**11.6.1** The chemical composition as determined by ladle analysis shall comply with the provisions of Table 11.1. Deliberate addition of Boron shall not be permitted.

**11.6.2** Each steel shall also comply with the Carbon Equivalent and Pcm requirements on ladle and product stated in para. 5.3.3 of this specification.

**11.6.3** The product chemical analysis shall meet the values of Table 11.1 including the plus tolerances stated hereafter (in% weight):

C: + 0.02	Nb: + 0.01
Mn: + 0.10	V: + 0.01
Si: + 0.05	Cr: + 0.05
S: + 0.005	Ni: + 0.05
P: + 0.005	Cu: + 0.05
Al: + 0.000	Mo: + 0.02
Ti: + 0.01	N: + 0.001

**11.6.4** Tests methods for chemical analysis shall be according to corresponding standards.

### 11.7 Ladle analysis

Each cast of steel shall be chemically analyzed as per para. 11.6 above for the following elements:

- C, Mn, S, P + all elements for CE and Pcm calculation
- Deoxidizing and special treatment elements (Si, Al, Ce, Ca, as applicable)
- Any other intentionally added elements
- N only for K - 20, K - 40 and K - 50 qualities.

Carbon Equivalent (CE) and Pcm (see para. 5.3.3) shall be reported on Mill certificates.

**Table 11.1 - Chemical composition on ladle of seamless tubulars (% weight)**

Grade	Quality KT ou KL (°C)	C max. (2)	Mn max.	Si max.	S max.	P max.	Other elements
S 235	+ 20	0.21	1.20	0.40	0.050	0.050	(1)
	0	0.20	1.20	0.40	0.045	0.045	
	- 20	0.18	1.20	0.40	0.040	0.040	
	- 40	0.17	1.20	0.40	0.035	0.035	
	- 50	0.17	1.20	0.40	0.030	0.030	
S 275	+ 20	0.21	1.35	0.40	0.050	0.050	(1)
	0	0.20	1.35	0.40	0.045	0.045	
	- 20	0.20	1.35	0.40	0.040	0.040	
	- 40	0.18	1.35	0.40	0.035	0.035	
	- 50	0.18	1.35	0.40	0.030	0.030	
(S 315)	+ 20	0.22	1.50	0.50	0.045	0.045	(1)
	0	0.21	1.50	0.50	0.045	0.045	
	- 20	0.20	1.50	0.50	0.040	0.040	
	- 40	0.18	1.50	0.50	0.035	0.035	
	- 50	0.18	1.50	0.50	0.030	0.030	
S 355	+ 20	0.22	1.60	0.50	0.045	0.045	(1)
	0	0.20	1.60	0.50	0.045	0.045	
	- 20	0.18	1.60	0.50	0.040	0.040	
	- 40	0.18	1.60	0.50	0.035	0.035	
	- 50	0.18	1.60	0.50	0.030	0.030	

- (1) Nb max. = 0.05%  
V max. = 0.08%  
Al (total) max. = 0.060%  
Cu max. = 0.30%  
Mo max. = 0.08%  
Ni max. = 0.50%  
Cr max. = 0.30%  
Ti max. = 0.03%  
N max. = 0.012%  
(V + Nb) max. = 0.10%  
B: addition not permitted (0.0005% max.)

- (2) C max to be 0.12% for QT tubulars.

General Specification		GS EP STR 201
Materials for offshore steel structures		
Rev.: 12	Effective date: 10/2013	Page: 61 of 90

## 11.8 Destructive testing/Production tests

### 11.8.1 Definition of the test unit

The test unit is defined as follows:

- a) For Special Category steels: by each tubular when its weight exceeds 150 kg/metre or its WT is above 25 mm. Otherwise, the test unit shall be each lot of 8 metric tonnes of pipes per size, cast and heat treatment batch, or part thereof, whichever the greater.
- b) For First and Second Category steels: by the quantity of tubulars having the same grade, quality and size, and coming from the same cast of steel. In addition, the test unit is limited to:
  - 200 tubulars for OD of 12<sup>3</sup>/<sub>4</sub> and below
  - 100 tubulars or 100 metric tonnes of steel (whichever the lesser in tonnage) for OD above 12<sup>3</sup>/<sub>4</sub>.

### 11.8.2 Type and frequency of tests

Each test unit as defined above shall be subject to the following tests:

- One tensile test cut longitudinally to tubular axis
- One set of three CHARPY V-notch impact test specimens cut in the longitudinal or transverse direction (according to quality KL or KT)
- A chemical analysis made on two tubulars of the test unit, for all steel qualities in Special and First Category, except KL + 20 and KL O.

## 11.9 Dimensions and dimensional tolerances

### 11.9.1 Unit length

All tubulars shall have a unit length of 11 m ± 1 m, unless otherwise stated in the Purchaser's requisition.

When any other fixed lengths are stated in the requisition, tolerances shall be ± 1 m.

Jointers shall not be permitted.

### 11.9.2 Outside diameters

- On pipe body = ± 0.65% of nominal OD
- At pipe ends over a distance of 100 mm:
  - ± 1.6 mm for OD ≤ 12<sup>3</sup>/<sub>4</sub>
  - ± 2.0 mm for OD > 12<sup>3</sup>/<sub>4</sub>, with WT ≤ 20 mm
  - ± 2.4 mm for OD > 12<sup>3</sup>/<sub>4</sub>, with WT > 20 mm.

### 11.9.3 Wall thickness

Tolerances shall be -10%, + 15% of the specified nominal wall thickness.

General Specification		GS EP STR 201
Materials for offshore steel structures		
Rev.: 12	Effective date: 10/2013	Page: 62 of 90

Wall thickness may be measured by automatic ultrasonic tester examining spirally the pipe with a minimum coverage of 20% of pipe body.

#### 11.9.4 Out-of-roundness

The difference between maximum outside diameter and minimum outside diameter shall not exceed the following:

- On pipe body: 1.5% of nominal OD
- At pipe ends over a distance of 100 mm: 1% of nominal OD.

#### 11.9.5 Straightness

Max. allowable deviation shall be 1.4 mm per metre of tubular length.

#### 11.9.6 Squareness of ends

Tubulars shall be cut perpendicular to the pipe longitudinal axis within 1.6 mm across any diameter.

#### 11.9.7 End preparation and protection

Unless otherwise stated in the PPS or the PURCHASER's requisition, seamless tubulars shall be supplied square cut, without bevel protectors.

Where beveled ends are required, angle shall be 30° -0°, + 5°, root face shall be 1.6 mm ± 0.8 mm and tubulars shall be fitted with bevel protectors.

#### 11.9.8 Bulges, dents and flat areas

Not acceptable.

#### 11.10 Non-destructive testings

**11.10.1** All tubulars shall be NDT tested over their full length. Ultrasonic testing and/or Electro Magnetic Inspection (EMI) shall apply.

All pipe ends not scanned by the full automatic technique may be cut out or otherwise may be inspected by manual ultrasonic examination (or by automatic electromagnetic testing technique).

**11.10.2** NDT procedures shall comply with [API SPEC 5L](#) whatever the Structural Category. For S and 1<sup>st</sup> category seamless tubular, the requirements stated below shall be applied too. All NDT procedures shall have prior approval of the Company.

**11.10.3** For NDT (EMI and/or UT), the reference standard pieces shall contain N5 notches oriented parallel, transverse and at 45° to pipe longitudinal axis, located on both inside and outside surface, and also a longitudinal flat bottomed groove 5 mm wide at mid thickness.

**11.10.4** Welding repairs shall not be permitted whatever the Structural Category.

## 12. Pins and axles

### 12.1 General

Lifting Pins and axles to be used in structures shall be classified as Special Category members. They shall be made of hot forged materials supplied in the quenched and tempered condition as defined below. Pins and axles for other services shall comply with the **GS EP STR 203**.

Steel shall be of the Chromium - Molybdenum type (e.g. 0.25% C - 1.00% Cr - 0.20% Mo) or of similar steel, developing a mini. specified YS of 460 MPa (see para. 12.3 here below). It shall be fully killed and produced to fine grain practice. Steel designation shall be S 460 KL - 20 for Warm Seas and Temperate Seas, and KL - 40 for Cold Seas, unless otherwise agreed with (or specified by) the Company.

The Supplier shall state at the bid stage the detailed characteristics of the material he proposes (in terms of material standard, brand name (if any), full chemistry, mechanical properties versus heat treatments, etc.) for prior approval of the Company.

No welding shall be permitted on pins and axles.

Material shall comply with testing and requirements stated in para. 12.2 and 12.3 hereafter.

### 12.2 Chemical composition

Each forging shall be analyzed for ladle and product analysis. Chemical analysis shall comply with the analysis previously approved by the Company.

### 12.3 Mechanical properties

Each forging shall be subject to tensile test and impact test.

All tests shall be made in a sufficient full size prolongation (or extension) that shall not be removed from the forging until final heat treatment is carried out.

Tests shall comprise the following per each forging.

- a) One longitudinal tensile test (i.e. specimen oriented in the direction of longitudinal axis of forging and principal grain flow) using round bar specimen.

Specimen shall be cut at mid-diameter of forging (i.e. at longitudinal axis) with the mid-length of specimen at least 50 mm from end of prolongation. For forging diameter D above 50 mm, the specimen shall be cut at mid-radius of forging and mid-length of specimen shall be at least one D from end of prolongation.

Tensile specimen to be as per **ISO 6892-1 Std.**

Results shall meet the following requirements:

- YS (0.2% Proof Strength) : 460-650 MPa
- YS to TS ratio : 0.85 max.
- Elongation : 18% mini
- Reduction of area : 40% mini

General Specification		GS EP STR 201
Materials for offshore steel structures		
Rev.: 12	Effective date: 10/2013	Page: 64 of 90

- b) 2 sets of 3 longitudinal CHARPY-V impact specimens, one located as per tensile specimen above and the other one located 2 mm below external surface of forging.

Specimen notch shall be cut parallel to external surface of forging (and close to external surface for the specimen located 2 mm below the forging surface).

Impact specimens to be as per [ISO 148-1 Std](#) or [ASTM E23 Std](#).

Following requirements shall be met at the test temperature (full size specimens):

- 50 joules mini average
- 37 joules mini single.

## 12.4 Visual and MP inspections

Each forging shall be subject to 100% visual and MPI.

MPI shall be conducted in accordance with [ASTM E709](#) or Article 7 of ASME V, and carried out so as to detect any possible flows oriented either in longitudinal or transverse direction as regard to longitudinal axis of forging.

No linear indications shall be accepted.

## 12.5 Ultrasonic Testing (UT)

The entire volume of the forging shall be subjected to UT (straight-beam and angle-beam examinations) according to [ASTM A388](#). The reference block calibration method shall be used. The reference block shall comprise flat-bottom holes of 3 mm dia. distributed through the thickness at different depths to develop a calibration reference curve and adjust the sensitivity.

All indications that exceed the DAC reference curve when examined with the gain setting used to produce the DAC reference curve shall be cause for rejection.

## 12.6 Machining

The forging shall be machined to the final dimensions shown on the Company approved structural drawing.

The machined surface of each forging shall have a maximum surface roughness of 125 CLA (12.5 µm) according to [ISO 1302](#).

## 13. Bolting

1. Bolted connections between structural members pertaining to special or first category shall be avoided as far as possible. Bolts in tension should not be used for lift points and bolted connections should not be located in splash zones or zones otherwise subject to intermittent wetting, or in other zones where inspection is difficult or impossible. If such connections are unavoidable their use and detailing shall be subject to Company Approval.
2. Mechanical/locking devices of nuts shall be provided for bolted connections between structural members pertaining to special or first category, to masts, to equipment superstructures, to vibrating equipment, etc.



**Materials for offshore steel structures**

Rev.: 12

Effective date: 10/2013

Page: 65 of 90

3. In case bolted connections have to be implemented, they shall be designed according to [AISC Steel construction manual](#) (latest edition):
  - Part 7: Design considerations for bolts
  - Part 9: Design of connecting elements
  - Part 10: Design of simple shear connections
  - Part 11: Design of flexible moment connections
  - Part 12: Design of fully restrained moment connections
  - Part 13: Design of bracing connections and truss connections
  - Part 14: Design of beam bearing plates, column base plates, anchor rods and column splices
  - Part 15: Design of hanger connections, bracket connections, and crane rail connections
  - Part 16: Specifications and Codes:
    - [AISC](#) Specification for structural steel buildings, chapter J: connections, joints and fasteners
    - RCSC Specification for structural joints using [ASTM A325](#) or [ASTM A490](#) bolts for High Strength (HS) bolting.
4. Bolting shall generally be in carbon steel to [ASTM A307](#), [ASTM A325](#) or to [ISO 898-1](#). [ASTM A490](#) bolting can be used where it is confirmed that bolt materials are limited to have an actual yield strength no higher than 950 MPa and hardness no higher than HRC 34.
5. The use of High Strength bolts shall be subject to prior approval of the Company.
 

High Strength bolts shall be in full compliance with the requirements of [ASTM A325](#) or [ASTM A490](#). The mechanical properties shall be subject to sample inspections using the "shipping lot method" and a copy of the inspection test report for each shipping lot shall be furnished to the Purchaser and Company.

Use of HS bolts subject to shearing stresses shall not be permitted in non-sheltered areas opened to projections or dripping of liquids. Utmost care shall be taken to ensure assembly resistance to corrosion.
6. Where components in materials other than carbon steel are joined with bolts then the bolting material should match so far as possible. Company approval for such bolts shall be gained.
7. Connections shall be classed as "pretensioned joints" or "slip critical joints" where so required by section J.1-10 of the AISC Specification for structural steel buildings and/or section 4.3 of RCSC Specification for structural joints using [ASTM A325](#) or [ASTM A490](#) bolts. Drawings of bolt connections shall in all cases identify the joint type as "snug-tightened", "pretensioned" or "slip-critical" as applicable, and shall define associated requirements.
8. Fabrication procedures for Company Approval shall be developed accordingly, to define procedures for bolt handling, coating provisions and joint assembly.

9. Anti-corrosion measures shall follow the following requirements unless noted otherwise:

- For areas in and above of the splash zone, the bolting shall be galvanized and then painted. All threaded components of the fastener assembly must be galvanized by the same process.
- For areas in the splash zone and below, all contact surfaces shall be painted even for slip resistant joints with a reduced friction coefficient.
- For immersed zones, the bolting shall be painted at least for corrosion protection during fabrication, and painted or oiled during storage. Electrical continuity shall be provided with serrated washers or similar to be approved by Company.
- Zinc plated bolts shall be avoided due to QA/QC problems (hydrogen embrittlement).

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

10. For joints with controlled tightening bolts,

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

**Note:** The friction coefficient is defined as follows:

- $K = 1000 C / (d \times P \times 0.88)$ , where
- K is the friction coefficient
- C (in N.m) is the torque to be applied to obtain a pre-load P (in N) in the bolt
- d (in mm) is the nominal bolt diameter.

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

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

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

## 14. Marking of structural materials

Except for the case mentioned in para. 14.4 (products in small sizes) materials shall be identified by markings (namely, paint stencilling, colour coding and die stamping) as detailed in the following.

### 14.1 Paint stencilling

14.1.1 Paint stencilling of materials shall be made with white paint and shall include, as a minimum, the following:

- Company's name
- Project name

General Specification		GS EP STR 201
Materials for offshore steel structures		
Rev.: 12	Effective date: 10/2013	Page: 67 of 90

- Purchase Order no.
- Heat/cast no.
- Steel designation (e.g. S 355. KT - 20)
- Requisition no./Items no.
- Dimensions (e.g. OD x WT)
- Manufacturer's mark/logo.

#### 14.1.2 Arrangement of paint stenciling

- For plates, paint stenciling shall be arranged at right angle to the principal rolling direction and located at top or bottom of plate. This does not apply to mother plates for tubulars where paint stenciling may be according to Mill's standard approved by the Company.
- For tubulars, paint stenciling shall be made at one tubular end as follows:
  - $OD \geq 18''$  = on inside
  - $OD \leq 16''$  = on outside.

c) For rolled sections and hollow sections, paint stenciling shall be made at one end of product.

#### 14.1.3 Letters and figures shall be as follows:

- At least 40 mm high for steel plates and welded tubulars
- At Manufacturer's standard for other products.

14.1.4 Paint stenciling shall start at 200 mm minimum from end of product.

14.1.5 A protective coating of clear varnish shall be applied on stencilled area.

### 14.2 Color coding

Color coding shall apply to Special and First Category materials to identify steel grades and steels qualities. This shall be carried out as follows.

#### 14.2.1 Steel qualities

- Color coding shall be made by 50 mm wide painted bands or stripes using the following color coding:
  - K + 20 = unpainted
  - K 0 = white
  - K - 20 = blue
  - K - 30 = yellow
  - K - 40 = red
  - K - 50 = purple
  - Z 35 (whatever the impact test temperature) = green (as an additional band or stripe).

General Specification		GS EP STR 201
Materials for offshore steel structures		
Rev.: 12	Effective date: 10/2013	Page: 68 of 90

**b) Arrangement of color coding shall be as follows: see sketches of Figure 12.1.**

- For plates:
  - Special category: paint on one longitudinal plate edge (full length)
  - First Category: paint on both edges of two opposite corners (over 300 mm in length, each side of corner).

For Z 35 steel, an additional green paint on one transverse plate edge (full length) for Special Category and on both edges of the two other opposite corners (over 300 mm min. in length, each side of corner) for First Category.
- For cans, reducers, crown shims:
  - Special Category: a longitudinal stripe (full length of product).

For Z 35 steel, an additional longitudinal green stripe full length.
- For any other tubulars:
  - Special and first category: a circumferential band at 300 mm approximately from one pipe end.

For Z 35 steel, an additional circumferential green band at the same end of product.

Color bands shall be located on outside surface of tubulars for  $OD < 24"$  and on inside surface for  $OD \geq 24"$ .
- For rolled sections and hollow sections:
  - Special Category: a longitudinal stripe full length (on web for rolled sections).

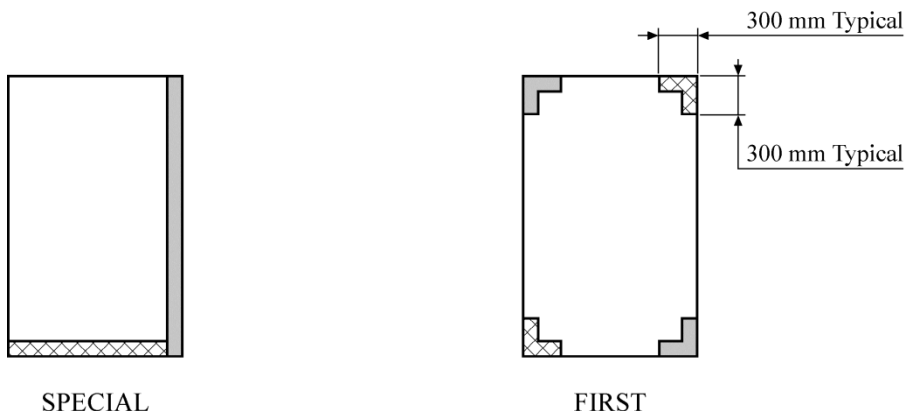
For Z 35 steel, an additional longitudinal green stripe full length of product.

  - First Category: a longitudinal stripe (400 mm long minimum) at one end of product.

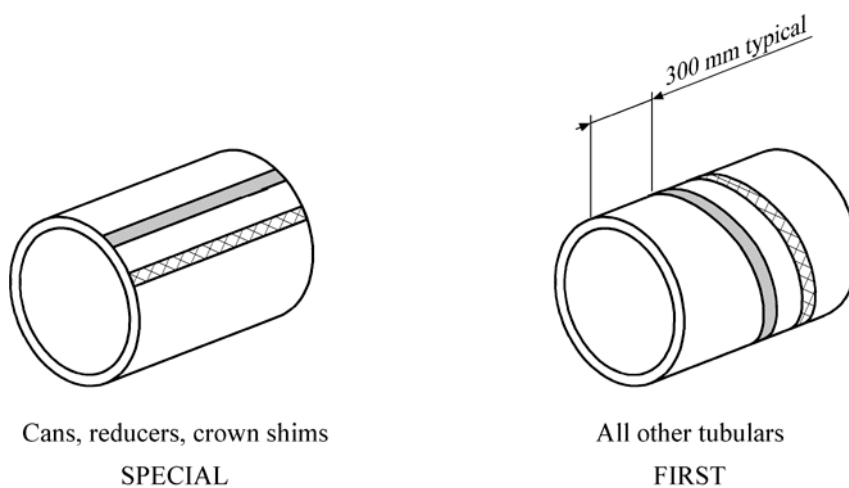
For Z 35 steel, an additional longitudinal stripe (400 mm long minimum) at the same end of product.

**Figure 12.1 - Color coding arrangement for steel qualities**

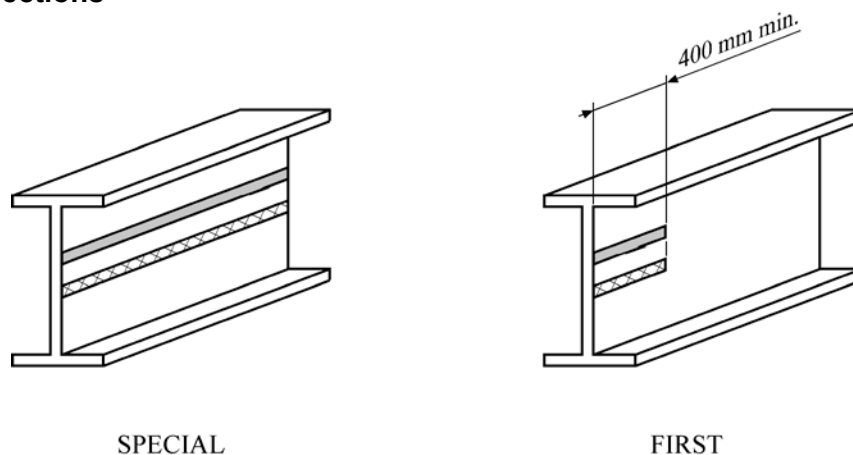
- Plates**





- Tubulars**



- Rolled sections**



Key :  Colour band / stripe (impact properties)

 Colour band / stripe (Green) for Z35 steel

### 14.2.2 Steel grades

In addition to the above quality coding, colour coding for steel grades shall be made by a painted stripe (50 mm wide x 400 mm long) located below the stencilling as above in para. 14.1.2 (i.e. at both ends) using the following code:

- S 235 = unpainted
- S 275 = white
- S 355 = blue
- S 420 = yellow
- S 460 = red
- S 500 = purple

### 14.3 Die stamping

**14.3.1** Die stamping shall apply to plates, welded tubulars, rolled sections, cans and cones (if any) in Special and First Category steels.

**14.3.2** Die stamping shall include heat/cast number (and plate No. for plates) as a minimum. It shall be located at 300 mm approx. from one end of product and located below paint stencilling. For tubulars, it shall be made on inside surface for  $OD \geq 18"$  and outside surface for  $OD \leq 16"$ .

Die stamping shall be circled with white paint.

**14.3.3** The rolling direction of plates shall be die stamped (and circled with white paint) and also paint marked by an arrow.

**14.3.4** Die stamping shall be made using round nosed dies and digits shall be at least 8 mm high.

### 14.4 Marking of small products

Rolled sections and hollow sections of small sizes (size 200 mm and below) in Secondary steels may be delivered in bundles. In this case the marking will be using metal labels fixed to bundles (at least two metal labels per bundle).

## 15. Mill certificates

1. Structural materials shall be supplied with Mill inspection certificates in accordance with [EN 10204](#) standard and the following.

- 3.2 Mill certificate for Special and First Category steels. Mill certificates shall be established by the Manufacturer but approved, signed and stamped by the Inspector
- 3.1 Mill certificate for Second Category steels.

2. Mill certificate shall make reference to the present General Specification and applicable PPS, if any.

3. Mill certificates shall indicate, as a minimum, the following:

- Rolling technique/delivery condition of base material (e.g. as rolled, normalized rolling, normalized heat treated, TMCP, etc.) and temperature of heat treatment
- Type of tubular (e.g. seamless, welded) together with manufacturing process (e.g. UOE, Bending Roll, Press Bending)

- Ladle analysis including Carbon Equivalent (CE) and Pcm
- Mechanical test results and product chemical analysis (including CE and Pcm) with reference to product No.
- Non-Destructive Tests performed with acceptance
- Any supplementary tests and inspections carried out
- Certificate No. and date of issue.

## 16. Inspection

### 16.1 General

- Inspection of materials shall be carried out in accordance with the requirements stated in the present General Specification and applicable PPS, if any.
- The Supplier shall notify the Inspector sufficiently in advance to enable him to be present at qualification tests and at all other tests or stages of manufacture subject to acceptance in accordance with this specification and approved Quality Control Plan.
- The Supplier shall ensure that the Inspector has full and free access to all parts of the plants mill, workshops, laboratories or other locations where the fabrication, inspection and testing of materials are performed complete or in part.

### 16.2 Inspection by the Supplier/Manufacturer

The Supplier/Manufacturer shall bear full responsibility of the conformity of its supply to all requirements of this specification and referenced specifications.

He shall, for this purpose, take all necessary measures, making use of suitable means, devices and qualified personnel, enabling him to ensure permanent and effective control at each stage of steel production.

All NDT operators shall be qualified to level 2 of [CSWIP](#) or EN schemes.

All inspections carried out by the Supplier/Manufacturer during steel production shall form the subject of reports kept up-dated at any time. These reports shall be made available for consultation at any time by the PURCHASER's and inspection agency's representatives as defined below in para. 16.3 and 16.4.

In addition, the Supplier shall provide the services of a Third Party Inspection as stated in para. 16.3 hereafter.

### 16.3 Inspection by Supplier's Third Party Inspection agency (Supplier's TPI)

**16.3.1** All Special and First Category materials shall be subject to inspection and approval by a recognized and independent inspection body, such as Bureau Veritas, DNV, Germanischer Lloyd's and/or the like approved by the Company. Such inspection shall be provided by the Supplier on its behalf as part of its scope of work.

**16.3.2** The third party shall sign and stamp all 3.2 certificates. The date of stamping and signature shall be mentioned on certificates.

General Specification		GS EP STR 201
Materials for offshore steel structures		
Rev.: 12	Effective date: 10/2013	Page: 72 of 90

**16.3.3** Unless otherwise agreed with the Company, the minimum scope of work of this third party agency shall be as follows (the TPI may have a more extensive scope of work to fulfill their own obligations of material acceptance).

**(1) For steel plates**

- Witness sampling, review chemical analyses (cast and product)
- Review and sign heat treatment records/charts
- Witness and marking test samples and test specimens
- Witness mechanical tests
- Witness/monitoring visual examination and dimensional inspection
- Checking markings (stenciling, color coding, die stamping, shipping mark)
- Witness calibration of ultrasonic equipment
- Review, approval, sign and stamp of Mill certificates, laboratory tests and NDT records
- Hard stamping of third party inspection's mark.

**(2) For welded tubulars (including cans)**

- Witness calibration of ultrasonic equipment at plate inspection
- Review chemical analysis records (cast and product)
- Review/approval of steel plate Mill certificates and NDT records
- Visual inspection of plates (on receipt at pipe mill)
- Witness tubular manufacturing procedure qualification (forming, welding, testing)
- Review and approval of WPS, PQR and qualification of welders
- Monitoring welding work and witness repair welding
- Witness calibration of UT equipment (welded seams and tubulars ends)
- Monitoring UT, radiography and MPI
- Review radiographic films and records
- Witness and marking test samples and test specimens
- Witness mechanical tests
- Witness visual and dimensional inspection (including bevels) of tubulars
- Monitoring the measuring of tubulars length
- Checking markings (stenciling, color coding, die stamping, shipping mark)
- Checking bevel protectors, if any
- Review, approval, sign and stamp of Mill certificates, laboratory test records and NDT records
- Hard stamping of third party inspection's mark.



General Specification		GS EP STR 201
Materials for offshore steel structures		
Rev.: 12	Effective date: 10/2013	Page: 73 of 90

### (3) For seamless tubulars

- Checking raw materials
- Witness tubular manufacturing procedure qualification
- Review chemical analysis records (cast and product)
- Review approve and sign heat treatment records.
- Witness calibration of NDT equipment (UT, EMI, MPI)
- Monitoring NDT performance
- Witness and marking test samples and test specimens
- Witness mechanical tests
- Witness/monitoring visual and dimensional inspection (including bevels)
- Monitoring the measuring of tubular length
- Checking markings (stenciling, color coding, shipping mark)
- Checking bevel protectors, if any
- Review, approval, sign and stamp of Mill certificates, laboratory test records and NDT records
- Hard stamping of third party inspection's mark (when required).

### (4) For rolled sections and hollow sections

- Review of chemical and mechanical test records
- Monitoring NDT performance, if any
- Witness visual inspection
- Monitoring dimensional inspection
- Witness mechanical tests
- Monitoring length measurements
- Checking markings (stenciling, color coding, shipping mark)
- Review, approval, sign and stamp of Mill certificates, laboratory tests and NDT records
- Hard stamping of third party inspection's mark (when required).

**Note:** In addition to the above, the scope of work of the Supplier's TPI shall always include the following:

- Review and approval of Manufacturing Procedure Specification (MPS), Quality Control procedures and material traceability, including product tracking system (e.g. for plates, tubulars, etc.)
- Issue of Release Certificates for product dispatches
- Review and approval of the Supplier's close-out production dossiers.

General Specification		GS EP STR 201
Materials for offshore steel structures		
Rev.: 12	Effective date: 10/2013	Page: 74 of 90

## 16.4 Inspection by the Company (Company's TPI)

**16.4.1** The Company may elect an independent inspection agency, so-called the Company's Third Party Inspection, to carry out inspections on supplied materials on behalf of the Company.

The nominated agency will be notified to the Supplier in due time, with related scope of work.

**16.4.2** The Company reserves to the right to re-check tests carried out by the Supplier. For this purpose, the Company may request the delivery of samples or specimens for analyze in an independent laboratory chosen by the Company.

## 17. Documentation

The following minimum documentation shall be supplied by the Supplier.

### 17.1 When the bids are submitted

- Name of Manufacturers and mills. Name of sub-contractors
- A simplified Manufacturing Procedure Specification (including welding procedures and inspection procedures) based on provisions of para. 6.5
- Full technical features of the proposed materials/products. This shall include as-delivery condition (e.g. normalizing, TMCP, etc.) of product, as well as aimed chemical composition (ladle mini./max.), and max. CE and Pcm
- Mill certificates from Manufacturers (this applies to stockists): refer to para. 6.2.2
- Marking of materials (where different from that specified)
- Deviations to present specification. Any material substitution shall be fully detailed
- Quality Assurance certification ([ISO 9001:2000](#), [API Q1](#), etc.).

### 17.2 Upon completion of materials production

**17.2.1** A production report shall be supplied by the Supplier. It shall include, but not be limited to, the information and documents stated hereafter:

- Manufacturing Procedure Specification (finalized)
- Mill certificates (as per para. 15)
- Welding procedure specifications, records and production test reports
- Visual and NDT reports
- Dimensional inspection reports
- Quality Control Plan
- Compilation of concession/deviations, if any, granted by the Company during material manufacture.

**Materials for offshore steel structures**

Rev.: 12

Effective date: 10/2013

Page: 75 of 90

**17.2.2** The PPS shall state the number of originals and copies of the Mill certificates and of production report which are to be supplied to the Company.

**17.2.3** The inspection agency (whatever it acts on behalf of the Supplier or the Company) shall stamp (rubber-stamp) and sign these documents for the acceptance of materials with 3.2 certificates meeting all the requirements of this specification.

**17.3 Schedule**

**17.3.1** Materials with 3.2 certificates shall be dispatched only after a Release Certificate has been issued by the nominated Supplier's TPI inspection agency.

**17.3.2** All Mill certificates shall be supplied at the time of dispatch of the materials.

**17.3.3** The full production report as above in para. 17.2.1 shall be transmitted to the Purchaser without delay after completion of materials production. The latest date of submission of this report shall be three weeks max. after materials dispatch. Whenever possible, the production report will be supplied on a CD-ROM, as well.

**18. Other references**

Following external documents are applicable: [ASTM A578](#), [ISO 9712](#), [EN 462](#), [ISO 6507](#), [ISO 10893-6](#), [SIS 05-59-00](#).

General Specification		GS EP STR 201
Materials for offshore steel structures		
Rev.: 12	Effective date: 10/2013	Page: 76 of 90

## **Appendix 1    Material equivalences between GS EP STR 201 and ASTM/API/JIS Stds (Non-mandatory information)**

### **Foreword**

**Table 1 - Plates/ASTM Stds**

**Table 2 - Plates/API Specs**

**Table 3 - Rolled sections/ASTM Stds**

**Table 4 - SAW tubulars (straight seam)/ASTM Stds**

**Table 5 - SAW tubulars (straight seam)/API Specs**

**Table 6 - Seamless tubulars/ASTM Stds**

**Table 7 - Seamless tubulars/API Specs**

**Table 8 - Plates, shapes/JIS G 3106**

General Specification		GS EP STR 201
Materials for offshore steel structures		
Rev.: 12	Effective date: 10/2013	Page: 77 of 90

## Foreword

1. The aim of this technical Appendix is to give equivalence in grade and quality between the steels defined in this specification and those existing in ASTM Stds, API Specs or JIS Stds, for the following products:

- Steel plates
- Rolled sections
- Longitudinally SAW tubulars
- Seamless tubulars.

The first intent of this Appendix is to use it for small purchase order or small additional orders which can be supplied from stocks only. It shall not be used as a substitute to the main specification **GS EP STR 201**.

2. The present Appendix constitutes only a guide. It is not part of **GS EP STR 201**, but is included for information purposes only. Note that all the possible alternate steels are not stated in this Appendix. It is the responsibility of the Engineering Company/ Contractor to check the equivalence of proposed alternate steel against that of **GS EP STR 201**. Relaxation may be granted by the Company on a case to case basis according to the severity of the construction.
3. All steel qualities (e.g. KL 0, KT - 20, etc.) shall be selected **first** according to provisions of **GS EP STR 201**.
4. The equivalences between steels are based on **Yield Strength (YS)** and **Tensile Strength (TS)** only. Where the equivalence is restricted to a certain thickness range, this means that beyond the said range the tensile properties as required in **GS EP STR 20** are not met by the alternate steel.
5. Any steel substitution shall not release the steel Supplier/Contractor to produce the acceptance tests and documentation as required in **GS EP STR 201**.
6. For compliance with grades and qualities of spec. **GS EP STR 201**, certain characteristics of the alternate steel shall have to be checked or otherwise measured/confirmed by tests because these characteristics are not normally mandatory in the said equivalent standard. Such characteristics are highlighted in column "characteristics to be checked" shown in tables of this Appendix, using the following key.
7. Any substitute steel acceptable to Company shall then be designated as required in par 5.4 of **GS EP STR 201** in all documentation, such as calculations notes, drawings, etc. (the original designation of steel cannot be used)

General Specification		GS EP STR 201
Materials for offshore steel structures		
Rev.: 12	Effective date: 10/2013	Page: 78 of 90

#### Appendix 1

#### Key:

- \* This grade is not recommended
- K CHARPY-V impact properties shall be checked against **GS EP STR 201**
- (K) Checking of CHARPY-V impact properties may be omitted
- Normalised Steel shall be supplied in the normalised condition
- C% Carbon Content%
- CE% Carbon Equivalent% (or Pcm% when applicable)
- BM Base Metal
- WM Weld Metal
- HAZ Heat Affected Zone
- TS Tensile Strength

**Materials for offshore steel structures**

Rev.: 12

Effective date: 10/2013

Page: 79 of 90

**Appendix 1**
**Table 1 - Plates/ASTM Stds**

<b>GS EP STR 201</b>		<b>ASTM</b>	<b>Characteristic to be particularly checked</b>
S 235	KL + 20	A 36	C% - CE% - (K)
		A 131 Grade A	Up to ½" thick
		A 131 Grade B	K
		*A 515 Grade 65 (1)	Up to ¾" thick - C% - CE% - (K)
		A 573 Grade 65	C% - CE% - K
		A 709 Grade 36 F1	C% - CE%
		A 709 Grade 36 T1	C% - CE%
	KL 0	*A 36	Normalised - C% - CE% - K
		A 131 Grade D	K
		A 131 Grade DS	K
		A 516 Grade 65 (1)	Normalized - C% - CE% - K
		A 573 Grade 65	Normalized - C% - CE% - K
		A 709 Grade 36 F2	C% - CE%
	KT 0	A 131 Grade D	K
		A 131 Grade DS	K
		A 516 Grade 65 (1)	Normalized - C% - CE% - K
		A 573 Grade 65	Normalized - C% - CE% - K
		A 709 Grade 36 F3	Normalized - C% - CE%
(S 255)	KL - 20	*A 516 Grade 65 (1)	Normalized - C% - CE% - K
	KT 20	A 131 Grade E	Normalized - (K)
		A 131 Grade CS	Normalized - (K)
	KL 40	A 131 Grade E	Normalized
		A 131 Grade CS	Normalized
S 275	KL +20	A 299	C% - CE%
		A 572 Grade 42	(K)
		A 573 Grade 70	C% - CE% - K
	KL 0	A 299 (1)	Normalized - C% - CE% - K
		A 573 Grade 70	Normalized - C% - CE% - K
	KT 0	A 573 Grade 70	Normalized - C% - CE% - K
	KL - 40	A 633 Grade A	K
	KT - 40	A 633 Grade A	K

**Table 1 - Plates/ASTM Stds (continued)**

<b>GS EP STR 201</b>		<b>ASTM</b>	<b>Characteristic to be particularly checked</b>
(S 295)	KL + 20	A 299 A 572 Grade 42	Only for t > 25 mm - C% - CE% Only for t > 16 mm - TS ≥ 470 MPa - (K)
	KL 0	A 131 Grade AH 32 A 299 (1) A 573 Grade 70	K Only for t > 25 mm - Normalised - C% - CE% Only for t > 30 mm - K
	KT 0	A 131 Grade AH 32	K
	KL - 20	A 131 Grade DH 32	Normalized - K
	KT - 20	A 131 grade DH 32	Normalized - K
	KL - 40 KT - 40	A 131 grade EH 32 A 131 grade EH 32	Normalized Normalized - K
S 355	KL +20	A 572 Grade 50 A 709 Grade 50 F1	For t above 16 mm - TS ≥ 490 MPa - (K) For t above 30 mm - C% - CE%
	KL 0	A 131 Grade AH 36 A 709 Grade 50 F2	K For t above 30 mm - C% - CE%
	KT 0	A 131 Grade AH 36 A 709 Grade 50 F3	Normalized - K For t above 30 mm - C% - CE% - K
	KL - 20	A 131 Grade DH 36 A 537 Class 1 (1) A 633 Grade C	Normalized - K For 16 mm < t ≤ 65 mm only - C% - CE% - K For 30 mm < t ≤ 50 mm - K
	KT - 20	A 131 Grade DH 36 A 537 Class 1 (1) A 633 Grade C	Normalized - K For 16 mm < t ≤ 65 mm only - C% - CE% - K For 30 mm < t ≤ 50 mm - K
	KL - 40	A 131 Grade EH 36 A 537 Class 1 (1) A 633 Grade C	Normalized - K For 16 mm < t ≤ 65 mm only - C% - CE% - K For 30 mm < t ≤ 50 mm - K
	KT - 40	A 131 Grade EH 36 A 537 Class 1 (1)	Normalized - K For 16 mm < t ≤ 65 mm only - C% - CE% - K

**Particular note to above table**

(1) Requirements of S 5 and S 12 of A20/A20M Standard shall be met.

**General notes relating to plates (Table 1)**

All plates shall be inspected by ultrasonics when thickness is as follows:

- t ≥ 12 mm for qualities: KT - 20, KT - 40, KL - 20 and KL - 40
- t ≥ 20 mm for qualities: KT 0 and KL 0.

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



General Specification		GS EP STR 201
Materials for offshore steel structures		
Rev.: 12	Effective date: 10/2013	Page: 81 of 90

Appendix 1

**Table 2 - Plates/API Specs**

GS EP STR 201		API Spec	Characteristic to be particularly checked
S 275	KL - 40	2H Grade 42	S1
		2W Grade 42 (3)	S1
		*2Y Grade 42 (4)	S1
	KT - 40	2H Grade 42 2W Grade 42 (3) *2Y Grade 42 (4)	S1 S1 - Direction of K specimens Same comment as above
S 355	KL - 40.Z 35	2H Grade 42	S1 - S4 - S5 - Z $\geq$ 35%
		2W Grade 42 (3)	Same comments as above
		*2Y Grade 42 (4)	Same comment as above
	KT - 40.Z 35	2H Grade 42 2W Grade 42 (3) *2Y Grade 42 (4)	S1 - S4 - S5 - Z $\geq$ 35% S1 - S4 - S5 - Z $\geq$ 35% - Direction of K specimens Same comment as above
S 355	KL - 40	2H Grade 50	(1) - S1 - TS $\geq$ 490 MPa
		2W Grade 50 T (3)	(2) - S1 - TS $\geq$ 490 MPa
		*2Y grade 50 T (4)	Same comment as above
	KT - 40	2H Grade 50 2W Grade 50 T (3) *2Y grade 50 T (4)	- S1 - TS $\geq$ 490 MPa - S1 - TS $\geq$ 490 MPa - Direction of K specimens Same comments as above
S 355	KL - 40.Z 35	2H Grade 50	(1) - S1 - S4 - S5 - Z $\geq$ 35% - TS $\geq$ 490 MPa
		2W Grade 50 T (3)	(2) - S1 - S4 - S5 - Z $\geq$ 35% - TS $\geq$ 490 MPa
		*2Y grade 50 T (4)	Same comments as above
	KT - 40.Z 35	2H Grade 50 2W Grade 50 T (3) *2Y grade 50 T (4)	(1) - S1 - S4 - S5 - Z $\geq$ 35% - TS $\geq$ 490 MPa (2) - S1 - S4 - S5 - Z $\geq$ 35% - TS $\geq$ 490 MPa - Direction of K specimens Same comments as above

**Particular Notes to above Table 2**

- (1) For t above 16 mm.
- (2) For t above 16 mm.
- (3) This steel is produced by Thermo-Mechanical Controlled Process.
- (4) This steel is produced by Quenching and Tempering.
- (5) S1, S4, S5 indicate the related Supplementary Requirements of the Standard which are to be met.

**General notes relating to plates**

All plates shall be inspected by ultrasonics when thickness is as follows:

- $t \geq 12$  mm for qualities: KT - 20, KT - 40, KL - 20 and KL - 40
- $t \geq 20$  mm for qualities: KT 0 and KL 0.

For special and first category plates with thickness  $\geq 16$  mm, the sulphur and the phosphorus contents in the ladle analysis shall not exceed 0.005% and 0.020% respectively.

General Specification		GS EP STR 201
Materials for offshore steel structures		
Rev.: 12	Effective date: 10/2013	Page: 82 of 90

Appendix 1

**Table 3 - Rolled sections/ASTM Stds**

GS EP STR 201		ASTM	Characteristic to be particularly checked
S 235	KL + 20	A 36 A 131 Grade A A 709 Grade 36 F1 Grade 36 T1	C% - CE% - (K) C% - CE% - (K) C% - CE% C% - CE%
	KL 0	*A 36 A 709 Grade 36 F2	C% - CE% - K C% - CE%
S 275	KL + 20	A 572 Grade 42	(K)
	KL 0	A 131 Grade AH 32	K
	KL - 40	A 633 grade A	(Normalized) - K
S 355	KL + 20	A 572 Grade 50	For t above 16 mm - TS $\geq$ 470 MPa (K)
	KL 0	A 131 Grade AH 36	K
	KL - 20	A 633 grade C	For 30 mm < t $\leq$ 50 mm - K

**Particular Notes to above Table 3**

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

**Table 4 - SAW tubulars (straight seam)/ASTM Stds**

<b>GS EP STR 201</b>		<b>ASTM</b>	<b>Characteristic to be particularly checked</b>
S 235	KL + 20	*A 139 grade B	Up to 25 mm thick - C% - CE% - (K) - SAW straight seam
		A 381 Class Y35	C% - CE% - (K)
		*A 671 Grade CB65	As per A515 Grade 65 plate
		*A 671 Grade CB 70	As per A515 Grade 70 plate
		A 672 Grade C70	As per A516 Grade 70 plate
	KL 0	A 381 Class Y35	Normalized - C% - CE% - K
		A 671 Grade CC65	As per plate A 516 Grade 65 - K
		A 671 Grade CC 70	As per plate A 516 Grade 70 - K
		*A 672 Grade C65	As per plate A 516 Grade 65 - K
		*A 672 Grade C70	As per plate A 516 Grade 70 - K
	KT 0	A 671 Grade CC65 A 671 Grade CC 70	As per plate A 516 Grade 65 - K As per plate A 516 Grade 70 - K
	KL - 20	*A 671 Grade CC65	As per plate A 516 Grade 65 - K
S 275	KL + 20	A 381 class Y42	C% - CE% - (K)
		A 671 Grade CK 75	As per plate A299 - For t less than 25 mm
		*A 672 Grade N75	As per plate A299 - For t less than 25 mm
	KL 0	A 381 class Y42 A 671 Grade CK 75 *A 672 Grade N75	Normalized - C% - CE% - (K) As per plate A299 - For t less than 25 mm As per plate A299 - For t less than 25 mm
(S 315)	KL + 20	A 381 class Y46	C% - CE% - (K)
	KL 0	A 381 class Y36	Normalized - C% - CE% - K
S 355	KL + 20	A 381 Class Y 52	C% - CE% - (K)
	KL 0	A 381 Class Y 52	Normalized - C% - CE% - K
	KL - 20	A671 Grade CD70 (1)	As per plate A 537 class 1 - K
	KT - 20	A671 Grade CD70 (1)	As per plate A 537 class 1 - K
	KL - 40	A671 Grade CD70 (1)	As per plate A 537 class 1 - K
	KT - 40	A671 Grade CD70 (1)	As per plate A 537 class 1 - K

**Particular Notes to above Table 4**

- (1) This steel may be used up to 65 mm only when a mini YS of only 345 MPa is granted by the Company.
- K: Charpy requirements shall be met in BM, WM and HAZ.
- The indication "as per plate A... Grade..." means that the requirements of related plate quality as stated in previous tables for plates shall be met.

General Specification		GS EP STR 201
Materials for offshore steel structures		
Rev.: 12	Effective date: 10/2013	Page: 84 of 90

**Appendix 1****General notes relating to SAW tubulars**

1. All plates to be used for pipe fabrication shall be inspected by ultrasonics when thickness is as follows:
  - $t \geq 12$  mm for qualities: KT - 20, KT - 40, KL - 20 and KL - 40
  - $t \geq 20$  mm for qualities: KT 0 and KL 0.
2. The longitudinal weld shall be subject to 100% UT or RT.
3. In addition to CHARPY-V test, the longitudinal weld of tubulars in grade S 315 (as a minimum) and above shall be subject to a HV5 hardness survey.

General Specification		GS EP STR 201
Materials for offshore steel structures		
Rev.: 12	Effective date: 10/2013	Page: 85 of 90

Appendix 1

**Table 5 - SAW tubulars (straight seam)/API Specs**

GS EP STR 201		API Spec.	Characteristic to be particularly checked
S 235	KL +20 (1)	5L Grade B	C% - CE% - K
	All qualities	2B (2)	(3) - K
S 275	KL + 20 (1)	5L Grade X 42	C% - CE% - K
	All qualities	2B (2)	(3) - K
(S 315)	KL + 20 (1)	5L Grade X 46	C% - CE% - K
	All qualities	2B (2)	(3) - K
S 355	KL + 20 (1)	5L Grade X 52	C% - CE% - K - TS $\geq$ 480 MPa
	All qualities	2B (2)	(3) - K

**Particular Notes to above Table 5**

- K: Charpy requirements shall be met in BM, WM and HAZ.
- (1) This quality is considered as an ordinary one. However, other qualities can be obtained with this grade when a special order is placed including Charpy requirements.
- (2) Tubulars shall be fabricated from plates as listed in Tables 1 and 2.
- (3) Requirements of related plates as specified in Tables 1 and 2 shall be met.

**General notes relating to SAW tubulars (reminder)**

1. All plates to be used for pipe fabrication shall be inspected by ultrasonics when thickness is as follows:
  - $t \geq 12$  mm for qualities: KT - 20, KT - 40, KL - 20 and KL - 40.
  - $t \geq 20$  mm for qualities: KT 0 and KL 0.
2. The longitudinal weld shall be subject to 100% UT or RT.
3. In addition to CHARPY-V test, the longitudinal weld of tubulars in grade S 315 (as a minimum) and above shall be subject to a HV5 hardness survey.

General Specification		GS EP STR 201
Materials for offshore steel structures		
Rev.: 12	Effective date: 10/2013	Page: 86 of 90

Appendix 1

**Table 6 - Seamless tubulars/ASTM Stds**

GS EP STR 201		ASTM	Characteristic to be particularly checked
S 235	KL + 20	A 53 Grade B A 106 Grade B A 501 A 524 Grade I	C% - CE% - (K) C% - CE% - (K) C% - Mn% - CE% Up to 3/8" thick - CE%
	KL 0	A 106 Grade B *A 524 Grade I	Normalized - C% - CE% - K Up to 3/8" thick - CE%
	KL - 20	A 333 Grade 6 A 334 Grade 6	Normalized - C% - CE% Normalized - C% - CE%
	KL - 40	A 333 Grade 6 A 334 Grade 6	Normalized - C% - CE% - K Normalized - C% - CE% - K
S 275	KL + 20	*A 500 Grade B	Up to 0.50" thick - C% - Mn% - CE%
(S 315)	KL + 20	*A 500 Grade C	Up to 0.50" thick - C% - CE%

**General notes relating to seamless tubulars**

1. Tubulars shall be manufactured by the hot rolling process and, where necessary, subsequently normalized.
2. Tubulars shall be subject to 100% UT (for longitudinal and transverse defects).

General Specification		GS EP STR 201
Materials for offshore steel structures		
Rev.: 12	Effective date: 10/2013	Page: 87 of 90

Appendix 1

**Table 7 - Seamless tubulars/API Specs.**

GS EP STR 201		API Spec.	Characteristic to be particularly checked
S 235	KL +20 (1)	5L Grade B	C% - CE% - K
S 275	KL + 20 (1)	5L Grade X 42	C% - CE% - K
(S 315)	KL + 20 (1)	5L Grade X 46	C% - CE% - K
S 355	KL + 20 (1)	5L Grade X 52	C% - CE% - K - TS $\geq$ 480 MPa

**Particular Note to above Table 7**

- (1) This quality is considered as an ordinary one. However, other qualities can be obtained with this grade when a special order is placed including Charpy requirements.

**General notes relating to seamless tubulars (reminder)**

- Tubulars shall be manufactured by the hot rolling process and, where necessary, subsequently normalized.
- Tubulars shall be subject to 100% UT.

**Materials for offshore steel structures**

Rev.: 12

Effective date: 10/2013

Page: 88 of 90

**Appendix 1**
**Table 8 - Plates, shapes/JIS G 3106**

<b>GS EP STR 201</b>		<b>JIS</b>	<b>Limitation use</b>	<b>Characteristic to be particularly checked</b>
S 235	KL +20	SM400B/C		CC, CE%, K (indiv. Value)
	KL 0	SM400B/C		CC, CE%, K (indiv. Value)
S 275	KL +20	SM490B/C)		CC, CE%, K (indiv. Value)
	KL 0	SM490B/C)		CC, CE%, K (indiv. Value)
S 355	KL +20	SM490YA/YB SM520B/C		CC, CE%, K CC, CE%, K (indiv. Value)
	KL 0	SM490YA/YB SM520B/C		CC, CE%, K CC, CE%, K (indiv. Value)

**General notes**

All plates shall be inspected by ultrasonics when thickness is as follows:

- $t \geq 12$  mm for qualities: KT - 20, KT - 40, KL - 20 and KL - 40
- $t \geq 20$  mm for qualities: KT 0 and KL 0.

All shapes shall be inspected by ultrasonics when web thickness is as follows

- $t \geq 12$  mm for Special Category
- $t \geq 20$  mm for First Category.

For special and first category plates with thickness  $\geq 16$  mm, the sulphur and the phosphorus contents in the ladle analysis shall not exceed 0.005% and 0.020% respectively.



General Specification		GS EP STR 201
Materials for offshore steel structures		
Rev.: 12	Effective date: 10/2013	Page: 89 of 90

## Appendix 2 Flux dryness

Applicable for steel grades with SMYS of 440 MPa and greater

Manufacturer can choose one of the following **specification** to guarantee the flux dryness  
(The resulting diffusible Hydrogen in weld deposit shall be 5 ml/100 g **max.**)

**Specification A:** (Originally a dry flux is packed in moisture proof sealed packing)

### 1 - Procurement of flux

**At the time of flux packing**, the diffusible hydrogen content in SAW weld deposit shall be checked on a sample of the batch of flux and shall be lower than 5 ml/100 g of weld deposit.

(This measurement may also be done through by the moisture content measurement, when evidence of correlation can be provided by flux manufacturer, based on previous comparative tests of diffusible Hydrogen versus flux moisture content. Otherwise, the acceptable maximum moisture content shall be 0.03%. The "Karl Fisher" method shall be applied).

For diffusible hydrogen testing or for moisture measurement, **NO PRE- DRYING NEITHER ANY PRE-HEATING OF FLUX SAMPLE** will be carried out before testing.

(Tests shall be carried out with the flux as it is at the time of sampling /packing. Moisture measurement will be carried out at 982°C without pre-heating of the sample.)

Results of diffusible hydrogen or moisture measurement shall be reported on the 3.1 B flux certificate for each batch. The testing condition, as stated above, shall be confirmed on the certificate.

**Packing shall be of moisture proof type.**

Metallic/stiff plastic drums with rubber gasket for the top tightness or double polyethylene top welded bags are acceptable.

### 2 - Storage of flux

Flux shall be stored in a controlled hygrometry room where the relative hygrometry shall be permanently maintained below 60%. The maximum duration of storage shall be one year (after the date of packing). Over one year, a spot check of diffusible hydrogen/moisture content shall be required.

### 3 - Use of flux

Drums/bags shall be checked before use. They shall be undamaged (flux in damaged bag shall be scrapped).

They shall be opened just before pouring the flux in the welding machine hooper where the temperature shall be maintained at 120°C minimum.

In case of welding stop, the remaining flux stored in hoppers shall be scrapped after 12 hours maximum.

The system of feeding, downstream the hoppers, shall be drained off before welding restart when welding has been interrupted 2 hours max.

General Specification		GS EP STR 201
Materials for offshore steel structures		
Rev.: 12	Effective date: 10/2013	Page: 90 of 90

## Appendix 2

The feeding from hoppers shall be done by gravity where possible. Where pressurized air is used for flux conveying, the said air shall be dried with adequate equipment.

### 4 - Flux recycling

When Manufacturer intends to recycle welding excess flux, his recycling procedure shall be submitted to Company for approval prior production starts. The procedure shall include a sketch showing the circulation of recycled flux and of sucking air.

#### Specification B (any other procedures)

Contractor shall demonstrate that its procedure allows obtaining dry flux at the welding point.

Flux shall be sampled at the welding point and checked at the start of production and then once per shift for inside welding and once per shift for outside welding, rotating among the welding machines.

Inspector shall have the right to impose the time of sampling when it is justified to his opinion.

Check tests and results shall comply with the above paragraph 1.