

GENERAL SPECIFICATION

STRUCTURAL

GS EP STR 301

Fabrication of offshore steel structures

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General Specification		GS EP STR 301
Fabrication of offshore steel structures		
Rev.: 18	Effective date: 11/2018	Page: 2 of 124

Contents

1. Scope	5
2. Reference documents	5
3. General	8
3.1 Definitions	8
3.2 Approval of documents/Documentation	8
3.3 Quality Assurance/Quality Control	10
3.4 Execution of the work	10
3.5 Inspection by the Company	11
3.6 Technical Queries/Non-Conformance Reports	11
4. Drawings	11
4.1 General	11
4.2 Shop Drawings	12
4.3 As-built drawings	12
4.4 Other Drawings and Data	12
5. Materials	12
5.1 Classification of members	12
5.2 Selection of materials	13
5.3 Company's supplied materials	13
5.4 Contractor's supplied materials	13
5.5 Substitution of materials	14
5.6 Storage and care of materials	14
5.7 Identification of materials	14
5.8 Materials traceability	14
6. Preparation of structural members	15
6.1 General	15
6.2 Member identification	15
6.3 Cutting	15
6.4 Forming	15

7. Fabrication	19
7.1 General	19
7.2 Erection loads and stability	19
7.3 Welded connections	20
7.4 Bolted connections	20
7.5 Fabrication of welded tubulars and node cans	22
7.6 Fabrication of legs, piles and bracings	24
7.7 Fabrication of buoyancy tubes and flotation tanks.....	25
7.8 Welded Plate Girder (WPG) and Box Girder (BG) fabrication	25
7.9 Splice fabrication and welding	25
7.10 Welded tubular connections (or tubular joints, tubular nodes).....	26
7.11 Shape to shape connections	29
7.12 Fabrication of pad eyes	29
7.13 Permanent attachments.....	29
7.14 Temporary attachments welds.....	30
7.15 Temporary openings.....	30
7.16 Rat-holes	30
7.17 Fabrication and Installation of ancillaries	31
7.18 Finishing of surfaces	32
7.19 Identification and marking of members.....	33
7.20 Transport and handling of members.....	33
7.21 Correction of members	33
8. Welding	33
8.1 General	33
8.2 Surface and edge preparation	34
8.3 Fit-up.....	35
8.4 Welding processes	35
8.5 Welding consumables.....	36
8.6 Welding Procedure Specifications (WPS)	39
8.7 Welding Procedure Qualifications (WPQ).....	40
8.8 Welder and welding operator qualification.....	55
8.9 Production welding	57

9. Fracture Mechanics Analysis and Post-Weld Heat Treatment (PWHT).....	62
9.1 Reference Thickness	62
9.2 Fracture mechanics analysis (ECA)	62
9.3 PWHT procedure specification	63
9.4 Performance of PWHT.....	63
9.5 PWHT treatment records	64
10. Welding inspection	64
10.1 General	64
10.2 Non-Destructive Testing procedures and standards of acceptance	65
10.3 Extent of Non-Destructive Testing	69
10.4 Inspection reports	72
10.5 Weld History Summary	72
11. Leak testing	72
12. Tank hydrostatic testing.....	73
13. Welding repairs	74
14. Dimensional tolerances.....	74
14.1 General	74
14.2 Tolerances for prefabricated members.....	75
14.3 Tolerances on final fabrication.....	84
15. Re-used structures	87
Bibliography.....	88
Appendix 1 Flux dryness	89
Appendix 2 Welding Details.....	91
Appendix 3 Weld History Register model	124

General Specification		GS EP STR 301
Fabrication of offshore steel structures		
Rev.: 18	Effective date: 11/2018	Page: 5 of 124

1. Scope

This specification defines the Company's general requirements for fabrication, welding and bolting assemblies, heat treatment and inspection to apply in the fabrication of offshore steel structures.

It covers steel structures to be installed in **Cold Seas, Temperate Seas** or **Warm Seas** (as defined in Table 5.5 of **GS EP STR 201**).

Very Cold Seas cases are not treated in this Specification. A Particular Project Specification shall be issued for fabrication, subject to Company approval.

This Specification shall be used in conjunction with a Project Particular Specification (PPS), if any, detailing the additional tests and requirements or the possible modifications to the present specification, based on the particular design conditions of the steel structures.

No deviation from the requirements stated in the present specification shall be permitted unless prior written approval has been obtained from the Company. Refer to para. 3.6 of this specification.

Attention is drawn too on certain structures that shall be subject to comply with requirements of classification society or any particular state regulation. In that case, fabrication of these structures 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.

This specification doesn't apply for fabrication of stainless steel structure, for which **AWS D 1.6/D 1.6M** or equivalent construction code approved by Company shall apply.

2. Reference documents

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

Applicable specifications and documents are listed hereafter in the present section.

The order of precedence of the applicable documents shall be:

- The Purchase Order or Contract
- The Project Particular Specification (PPS)
- The Present General Specification
- The Codes and Standards in reference.

Unless otherwise specifically indicated in writing, the Contractor 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 requested in the present specification.

The requirements of this specification shall take precedence over the referenced codes and standards. Where this specification states no overriding requirements the referenced codes and standards shall apply in full.

Fabrication of offshore steel structures

Rev.: 18

Effective date: 11/2018

Page: 6 of 124

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

External Documents

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

Reference	Title
AISC 325	Steel Construction Manual
AISC 360	Specification for Structural Steel Buildings
API RP 2A-WSD	Planning, Designing, and Constructing Fixed Offshore Platforms-Working Stress Design
API SPEC 2B	Specification for the Fabrication of Structural Steel Pipe
ASME BPVC Section V	ASME Boiler and Pressure Vessel Code (BPVC) - Section V: Nondestructive Examination
ASTM A578/A578M	Standard Specification for Straight-Beam Ultrasonic Examination of Rolled Steel Plates for Special Applications
ASTM E112	Standard Test Methods for Determining Average Grain Size
ASTM E165/E165M	Standard Practice for Liquid Penetrant Examination for General Industry
ASTM E23	Standard Test Methods for Notched Bar Impact Testing of Metallic Materials
ASTM E709	Standard Guide for Magnetic Particle Testing
ASTM F1554	Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength
AWS D 1.1/D 1.1M	Structural Welding Code - Steel
AWS D 1.6/D 1.6M	Structural Welding Code - Stainless Steel
BS 7910	Guide to methods for assessing the acceptability of flaws in metallic structures
EN 462-1	Non-Destructive Testing-Image Quality of Radiographs - Part 1: Image Quality Indicators (Wire Type) Determination of Image Quality Value
ISO 11666	Non-destructive testing of welds - Ultrasonic testing - Acceptance levels
ISO 11699-1	Non-destructive testing - Industrial radiographic film - Part 1: Classification of film systems for industrial radiography

Fabrication of offshore steel structures

Rev.: 18

Effective date: 11/2018

Page: 7 of 124

Reference	Title
ISO 12135	Metallic materials - Unified method of test for the determination of quasistatic fracture toughness
ISO 14344	Welding consumables - Procurement of filler materials and fluxes
ISO 148-1	Metallic materials - Charpy pendulum impact test - Part 1: Test method
ISO 15590-1	Petroleum and natural gas industries - Induction bends, fittings and flanges for pipeline transportation systems - Part 1: Induction bends
ISO 15653	Metallic materials - Method of test for the determination of quasistatic fracture toughness of welds
ISO 17636-1	Non-Destructive testing of welds - Radiographic testing - Part 1: X- and gamma-ray techniques with film
ISO 17638	Non-destructive testing of welds - Magnetic particle testing
ISO 17640	Non-destructive testing of welds - Ultrasonic testing - Techniques, testing levels, and assessment
ISO 23279	Non-destructive testing of welds - Ultrasonic testing - Characterization of indications in welds
ISO 3452-1	Non-destructive testing - Penetrant testing - Part 1: General principles
ISO 3834-2	Quality requirements for fusion welding of metallic materials - Part 2: Comprehensive quality requirements
ISO 4063	Welding and allied processes - Nomenclature of processes and reference numbers
ISO 5580	Non-destructive testing - Industrial radiographic illuminators - Minimum requirements
ISO 6892-1	Metallic materials - Tensile testing - Part 1: Method of test at room temperature
ISO 8501 (All parts)	Preparation of steel substrates before application of paints and related products - Visual assessment of surface cleanliness - All parts
ISO 9712	Non-destructive testing - Qualification and certification of NDT personnel
RCSC/AISC	Specification for Structural Joints Using High-Strength Bolts (ed. 2009)

General Specification		GS EP STR 301
Fabrication of offshore steel structures		
Rev.: 18	Effective date: 11/2018	Page: 8 of 124

Total General Specifications

Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and addendums, is the latest revision published.

Reference	Title
GS EP STR 201	Materials for offshore steel structures
GS EP STR 202	Cast materials for steel structures
GS EP STR 203	Forged materials for Offshore steel structures
GS EP STR 304	Fabrication of welded plate girders (W.P.G.) and Box Girders (B.G.)
GS EP STR 901	Design rules and construction standards for ancillary structures of offshore installations

3. General

For the purpose of this document, the following terms and definitions apply.

3.1 Definitions

Inspector	The Company's representative or a member from an Inspection Agency duly appointed by the Company to act as its representative for the purpose of the Contract shall be referred to herein as the "Inspector".
Site	The yards, workshops, docks, laboratories or other locations where the fabrication inspection and testing are to be performed complete or in part, shall be referred to herein as the "Site".
Contract Documents	The drawings, equipment lists, bills of material, material specifications, etc., latest editions, issued by the Company and attached to the Contract or the Purchase Order shall be referred to herein as the "Contract Documents".
Approval	Means managing entity of the referential written assent. Approval by the managing entity shall in no way relieve the Contractor of any of his obligations, responsibilities or liabilities.
PPS	Used to designate the Project Particular Specification as defined in section 1.

3.2 Approval of documents/Documentation

The following documents shall require approval of the Company or its Inspector and of the Independent Third Party (if any) prior to allowing fabrication to proceed:

- Drawings and calculation notes for temporary works or handling operations (staking, roll-up, etc.), inclusive of foundations, support points, jacking points and sling points
- Handling and lifting equipment to be used including rigging equipment, cranes, winches, etc. with review of test certificates

General Specification		GS EP STR 301
Fabrication of offshore steel structures		
Rev.: 18	Effective date: 11/2018	Page: 9 of 124

- List of proposed welding consumables (brand and type) with their data sheets
- Consumables handling, drying, storing, flux recycling and traceability procedure
- Sequence of fabrication, assembly, welding and erection
- Inspection and Test Plan
- Weld Map and Register together with all Welding Procedure Specifications (WPS) and Welding Procedure Qualification Records (WPQR)
- Welding procedure qualification test plan (i.e. up-dated status of WPQ tests of procedures under qualification)
- The Welding Procedure Qualification Tests and welder qualification tests
- List of welders and welding operators, with certificates
- Forming procedures for tubulars
- Manufacturing Procedure Specification (MPS) and Mill certificates of Contractor's supplied materials
- Identification, control and traceability procedures for materials
- Key plans showing member identification and weld marking schemes
- Inspection, dimensional and Non-Destructive Testing procedures (including report models)
- Initial available list of Non-Destructive Testing operators, with certificates
- Post-Weld Heat Treatment procedures
- Lifting, load-out and installation procedures, including details and certification of equipment to be used
- NDT maps linked with weld maps
- All sub-contractors of Contractor
- The Quality Assurance Manual and Plan.

The following documents shall be permanently updated and shall be at the Company disposal (or Company's Inspector and or Independent Third Party) for review when requested.

- Fabrication or shop drawings showing weld arrangement, location of welding at prefabrication, on yard, at erection stages and weld details
- Updated Weld history register (see example in Appendix 3)
- Updated list of welders and welding operators, with certificates
- Inspection, Dimensional and Non-Destructive reports and production tests results if any
- Updated List of Non-Destructive Testing operators with certificates
- Post-Weld Heat Treatment charts
- All the as-built documentation.

General Specification		GS EP STR 301
Fabrication of offshore steel structures		
Rev.: 18	Effective date: 11/2018	Page: 10 of 124

At final reception of structural components, the fabricator shall constitute the final dossier as follows:

- All documentation approved by Company and Third Party Inspection (TPI) (if any) as stated above
- Last revision of Weld history register
- Last revision of Inspection, Dimensional and Non-Destructive reports and production tests results if any
- Post-Weld Heat Treatment charts
- All the as-built documentation
- Compilation of concession/deviations, if any, granted by Company and TPI (if any) during material manufacture.

3.3 Quality Assurance/Quality Control

1. The Contractor shall operate a Quality Assurance system, approved by a recognized authority. The Quality Assurance Manual shall be submitted to Company and made available to the Inspector at all times.
2. Four weeks prior to commencement of any fabrication, the Contractor shall prepare and submit to Company a written Quality Control Plan which describes the inspections to be performed during the said fabrication. The Quality Control Plan shall set forth "witness", "hold", "review" and "monitor" points.

3.4 Execution of the work

1. The Contractor shall furnish qualified personnel and all equipment, tools, instruments, etc. necessary to carry out qualification of welding procedures and welders, handling, fabrication, welding, inspection and cleaning of the structures according to this specification.
2. In particular, the Contractor shall have available on location suitable ovens for drying and conservation of low-hydrogen consumables and suitable equipment for preheating, post-heating and stress relieving, when needed, and to ensure a good cleaning and fit-up before welding. Such equipment shall be subject to approval by the Inspector.
3. The Contractor shall provide the necessary weather protection or sun protection to ensure that all work continues always as specified here above.
4. When conditions are (or may become) detrimental to fabrication or weld quality, the Contractor shall notify the Inspector immediately.
5. The Contractor shall designate a competent representative familiar with all phases of fabrication with whom the Inspector may communicate at all times.
6. Should the Contractor wish to employ a sub-contractor, he shall submit its proposals in due time in writing to the Company for prior approval. The Company reserves the right to refuse or restrict the use of a particular sub-contractor.

General Specification		GS EP STR 301
Fabrication of offshore steel structures		
Rev.: 18	Effective date: 11/2018	Page: 11 of 124

3.5 Inspection by the Company

1. All procedures shall have prior approval of the Company. All qualification tests shall take place under the supervision of the Inspector.
2. The Contractor shall notify the Inspector sufficiently in advance to enable him to be present at qualification tests and at all other tests or stages of fabrication subject to acceptance in accordance with this specification.
3. The Contractor shall ensure that the Inspector has full and free access to all parts of the Site during all fabrication stages.
4. The Company reserves the right to re-check tests or inspections carried out by the Contractor. For this purposes, the Company may request the delivery of samples or specimens for analyse in an independent laboratory chosen by the Company.

3.6 Technical Queries/Non-Conformance Reports

1. Any Contractor's requests for clarifications or deviations to Company specifications shall be submitted to Company only through Technical Queries (TQ), the format of which shall have prior approval of the Company.
2. A deviation to specifications shall not be considered as accepted if it has not been submitted to and accepted by Company through a Technical Query or equivalent document.
3. Approval given by the Company to any Contractor's work procedures, specifications, equipment, etc. shall not release in any way the Contractor from his obligation to comply with the Company's specifications.
4. Any work performance or test result which is found, at a later date, not in conformance with Company standards or agreed procedure shall be subject to a Non-Conformance Report (NCR) to be issued by Contractor for submission to Company. NCR report shall indicate the corrective and preventive (to prevent re-occurrence) actions intended by Contractor, such proposed actions shall be approved by Company before being implemented.
5. If classification of the structure is required, any Contractor's request for clarification or deviation to Classification Society Rules shall be submitted to Classification Society through a form previously agreed. Company shall be in copy of any Technical Query and Classification Society answers.

4. Drawings

4.1 General

- a) In this specification, the word "Drawings" designates those drawings to be used for the fabrication and which are carried out by the Contractor acting as the Fabricator.

According to situations, these drawings can be **Shop Drawings** and/or **Fabrication Drawings** and **As-built Drawings**. In the following, "Fabrications Drawings" shall be substituted to "Shop Drawings" when Fabrication Drawings are carried out by the Fabricator and that Shop Drawings do not exist.

- b) Fabrication Drawings, Shop Drawings and As-built Drawings shall be in accordance with provisions of [API RP 2A-WSD](#) and provisions of para. 4.2 and 4.3 of present specification.

- c) Designation of steels on drawings shall fully comply with para. 5.3 and 5.4 of **GS EP STR 201**.

4.2 Shop Drawings

- a) The Contractor shall check the Contract Documents, including the drawings, immediately upon award of the contract, and shall promptly notify the Company of any errors and/or omissions.

These drawings are based on "Approved for Construction" design drawings. Any deviation shall be documented and approved by Company through Technical Query system or equivalent.

- b) Where necessary the Contractor shall prepare Shop Drawings (to supplement the Fabrication Drawings of the designer). Particularly, shop drawings shall be made to detail the connection of equipment or skids to the structure. All shop drawings shall be issued to Company for information. Company may decide to review some of these drawings and Contractor shall then comply with Company's comments if any.

Prior to submittal to the Company, all Shop Drawings shall be checked and approved by a qualified engineer in the employ of the Contractor.

- c) A comprehensive numbering system shall be established by Contractor to identify structural members and shall be used on all Shop Drawings. This should relate to the member identification used for design purposes.
- d) The Contractor shall be solely responsible for correctness of Shop Drawings and shall make any required modifications to fabrication due to errors in Shop Drawings.
- e) Approval or review of Shop Drawings by the Company does not relieve the Contractor of his responsibility to complete the work in accordance with the Contract Documents, the Company approved Fabrication Drawings and applicable specifications.

4.3 As-built drawings

The Contractor shall prepare as-built drawings and submit each drawing to the Company.

These drawings shall incorporate all pertinent information regarding actual material supply and fabrication, and shall be submitted to the Company within thirty (30) days after completion of the work.

4.4 Other Drawings and Data

The Contractor shall furnish any other drawings and sketches that may be requested by the Company for such purposes as indicating the construction sequences (prefabricating, assembling, lifting, load-out, etc.), the progress of the work, schedules for material delivery, weld history summary, etc.

5. Materials

5.1 Classification of members

Members are divided into Structural Members and Non-Structural Members. Structural Members are in turn distributed into four categories of importance. Reference shall be made to section 4 of **GS EP STR 201**. Very Cold Seas cases are not treated in this Specification. A Particular Project Specification shall be issued for fabrication, subject to Company approval.

General Specification		GS EP STR 301
Fabrication of offshore steel structures		
Rev.: 18	Effective date: 11/2018	Page: 13 of 124

The Table 4.1 in **GS EP STR 201** shall apply for the distribution of structural members into member categories, with precedence of the Contract Documents.

The distribution of Structural Members of the construction into categories of importance shall be subject to Company's prior approval and Classification Society if required.

Castings and Forgings shall be considered as Special Category members.

5.2 Selection of materials

All materials to be used shall fully conform to the **GS EP STR 201**, **GS EP STR 202**, **GS EP STR 203**, taking into account the classification of members defined herein.

Steel qualities shall be subject to Company's prior approval and shall fully conform to **GS EP STR 201** and Classification Society Rules if required.

5.3 Company's supplied materials

5.3.1 Delivery of materials

Materials supplied by the Company shall be as listed in the Contract Documents. All other materials required to complete the entire work shall be furnished by the Contractor.

The Company shall make available to the Contractor a copy of materials Mill Certificates including chemical and physical properties, and results of performed NDT.

5.3.2 Inspection on receipt

The Contractor shall inspect all the materials supplied by the Company. He shall agree or disagree with their condition at the time of delivery on fabrication site.

The Contractor shall report all defects and damage which are rejectable on furnished materials. A confirmatory inspection may also be made by the Inspector. The Company can ask the Contractor to correct repairable defects and damage on the basis of prior and mutual agreement.

The Contractor shall be considered responsible for defects or damage which are detected after delivery on Site.

The Contractor, on accepting the responsibility of the materials, shall establish a record including date of inspection, designation and quantity of material accepted or to be repaired or replaced and any other pertinent information detailing material defects or damage and identity. This record shall be co-signed by the Contractor and the Inspector.

5.3.3 Records of materials supplied by Company

The Contractor shall establish and carefully maintain daily records showing quantities of materials received, employed in the work, remaining in stock, surplus and scrap. These records shall be available at all times for review by the Inspector.

5.4 Contractor's supplied materials

5.4.1 Quality of materials

All materials supplied by the Contractor shall be of the grades and qualities set forth in the Contract Documents and shall meet the requirements contained in the **GS EP STR 201** (see

General Specification		GS EP STR 301
Fabrication of offshore steel structures		
Rev.: 18	Effective date: 11/2018	Page: 14 of 124

para. 5.2 of the present specification). Reference shall also be made to para. 6.2 of [GS EP STR 201](#).

The Contractor shall obtain Mill test certificates for all steel products furnished as directed by the Contract Documents and [GS EP STR 201](#). These records shall be available to the Inspector at all times for review.

5.4.2 Inspection and records of materials

All materials furnished by Contractor shall be approved by the Company prior to use and may be subject to inspection and tests by the Inspector.

The Contractor shall establish and maintain daily records showing the quantities and types of all materials required, quantities in stock for the project, quantities on order and promised dates of delivery. These records shall be available at all times for review by the Inspector.

5.5 Substitution of materials

The Contractor shall not make substitution of any material specified in the Contract Documents without the prior written approval of the Company (refer to para. 6.4 of [GS EP STR 201](#)).

5.6 Storage and care of materials

All materials for the work, being the sole responsibility of the Contractor while on his premises, shall be stored in accordance with good practice, on pallets or timber blocking, off the ground and above the level of standing water.

Materials shall not be stored near sites of operations such as blast cleaning or painting that might leave undesirable deposits on the materials.

The Contractor shall store all materials for the work in a separate location, apart from those of others and shall segregate surplus and scrap materials. Different steel grades shall not be mixed.

Damaged materials or materials found to have injurious defects shall not be used in the fabrication. The Inspector shall give approval on materials that may be repaired and on repair procedures to be used.

Regarding the degree of rust, all materials found to fall into the D degree of [ISO 8501-1](#) shall be rejected.

5.7 Identification of materials

The Contractor shall also ensure that the Mill markings and identification on all materials are maintained throughout and transferred to all surplus and scrap. The markings and identification shall be visibly clear and recognized as being correct by the Inspector.

Marking of materials shall be as stated in the [GS EP STR 201](#). Minimum transferred marking shall include the principal direction of rolling and a reference that can link the piece to the name of project, steel designation and heat number.

5.8 Materials traceability

Materials traceability shall be required for Special and First category members, as a minimum, as per [API RP 2A-WSD](#).

6. Preparation of structural members

6.1 General

All operations carried out on base material for its preparation other than welding preparation shall be in accordance with the [AISC 360](#), unless otherwise specified in this specification.

6.2 Member identification

Before starting the job, the Contractor shall establish a numbering system to identify each member or element of the structure. This identification numbering system shall be used as an aid for indexing radiographs, repairs, etc. Identification system shall be furnished to the Inspector before the start of the job.

See also para. 4.2 and 5.7 of this specification.

6.3 Cutting

Cutting may be performed by machining or by gas/plasma cutting using a mechanically guided torch.

Freehand gas cutting shall not be done, unless it is approved on a case to case basis by the Inspector. Freehand cutting of sniped corners of gussets and of temporary attachments is allowed.

After cutting, suitable identification markings shall be transferred onto each of the cut parts of material: see provisions stated in para. 5.7 of present specification.

6.4 Forming

When forming process results in a percentage strain exceeding 6%, the conditions of [GS EP STR 201](#) para. 5.3.6 shall apply.

6.4.1 General

- a) Forming of plates and tubes shall be carried out according to a Contractor's procedure approved by Company, out-lining the successive and controlled steps, as well as inspection equipment and procedures (temperature checking, etc.). Base materials are supposed to have been tested and accepted at mill according to requirements of [GS EP STR 201](#).
- b) "Cold forming", "Warm forming" and "Hot forming" are conventionally defined hereafter in Table 6.1 with respect to the working temperature θ defined as the maximum temperature of the material during the forming operation.

Table 6.1 - Definition of forming types

Type of forming	Working temperature θ
Cold	$\theta \leq 150^{\circ}\text{C}$
Warm	$150 < \theta \leq 550^{\circ}\text{C}$
Hot 1 (ferritic area)	$\theta > 550^{\circ}\text{C}$
Hot 2 (austenitic area)	$\theta \geq 880^{\circ}\text{C}$

- c) Whatever the forming type and procedure, the minimum specified mechanical properties required for the base metal as stated in **GS EP STR 201** shall be maintained after forming and heat treatment, if any, are performed.
- d) Forming shall be carried out using suitable procedures and tools in order to obtain uniform surfaces free from cracks and laps, and without unacceptable thinning of the base material.
- e) The Percentage Strain (PS) due to forming is defined as follows by the maximum permanent straining percentage of the tensioned face of plate (or tube) after forming:

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

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

6.4.2 Cold forming

- a) Cold forming producing a permanent straining exceeding the percentages shown in Table 6.2, but not exceeding 6%, shall result in:
- Either a suitable heat treatment made after forming (refer to para. 5.3.6 of **GS EP STR 201**)
 - Or strain ageing tests when no subsequent heat treatment is carried out.

Table 6.2 - Percentage strain limits for cold or warm forming without subsequent heat treatment

Geographical zone	Max. acceptable Percentage Strain "PS"
Temperate Seas and Warm Seas	5%
Cold Seas	4%

- b) The strain ageing test shall be made as follows 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°C for one hour.

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

Impact test specimens shall be cut from the test sample according to the same direction with respect to principal rolling direction as that prescribed for the steel quality in question.

Impact test specimens shall be located as close as practically possible to the tensioned face of plate.

Test results shall meet the related requirements stated for the base metal at applicable test temperature (see Table 5.3 of **GS EP STR 201**).

General Specification		GS EP STR 301
Fabrication of offshore steel structures		
Rev.: 18	Effective date: 11/2018	Page: 17 of 124

- c) When subsequent heat treatment is intended, the forming procedure including heat treatment shall be reproduced on the test sample, for qualification purposes, as directed by para. 6.4.5 of this specification.

Care should be taken for selecting the soaking temperature of the heat treatment because such a temperature varies as a function of permanent deformation and deterioration of base metal may possibly result when soaking temperature is too high (in some cases, temperatures commonly used for weld stress relieving treatment may not be appropriate).

6.4.3 Warm forming

In all cases, the forming procedure shall be subject to a qualification test as directed by para. 6.4.5 of this specification.

Refer to provisions stated in para. 5.3.7 of [GS EP STR 201](#).

6.4.4 Hot forming

- a) In all cases, the forming procedure together with any proposed subsequent heat treatment shall be subject to qualification test as directed by para. 6.4.5 of this specification.

Reference shall be made to para. 5.3.8 of [GS EP STR 201](#).

- b) Normalization or quench-tempering treatment is compulsory after forming to ensure regeneration of steel microstructure and restoration of mechanical properties should procedure qualification test results fail to comply with requirements, or otherwise applied as part of the forming/heat treatment process.
- c) Production hot forming shall be performed in accordance with the conditions and limitations stated in the procedure qualification report, with accurate checking of working temperature. It must be carried out in such a way that excessive formation of scale on the surface of products is avoided.
- d) Hot forming of quenched and tempered steels shall not be permitted unless quenching-tempering is repeated after forming.
- e) Induction bending of tubular shall conform to [ISO 15590-1](#).

6.4.5 Forming procedure qualification test

Forming procedure shall be qualified except for the following cases:

- Cold forming with $PS\% \leq 5\%$ for warm and temperate seas
- Cold forming with $PS\% \leq 4\%$ for cold seas
- Induction bending of tubular (J-tubes) procedure shall conform to [ISO 15590-1](#).

6.4.5.1 Test sample preparation

The test sample to be used may be a piece of the production plate of sufficient dimensions to be representative of the product or a cut-off length of the first product produced. The latter solution will be preferred when hot forming.

General Specification		GS EP STR 301
Fabrication of offshore steel structures		
Rev.: 18	Effective date: 11/2018	Page: 18 of 124

In all cases, forming the test sample shall duplicate all conditions intended for production forming (especially, forming temperature, direction and percentage strain). When heat treatment is intended, it shall be carried out on the test sample.

6.4.5.2 Tests

a) The following specimens shall be cut for procedure qualification purposes:

- 1 tensile specimen (prismatic or round bar) to [ISO 6892-1](#)
- 1 set of 3 Charpy-V specimens to [ASTM E23](#), [ISO 148-1](#).

Impact test specimens shall be cut from the test sample in the same direction with respect to principal rolling direction as that of acceptance tests required for the quality of the base metal.

However, tensile test specimens shall always be cut longitudinally with respect to the axis of the forming (i.e. specimens cut parallel to the tubular axis).

All specimens shall be located as close as practically possible to the tensioned face of the plate.

Test results shall meet the minimum specified properties required for base metal at applicable test temperature (see [GS EP STR 201](#)) taking into account the principal rolling direction in the actual fabrication.

b) In the case of cold forming with subsequent stress relieve heat treatment (either as post forming heat treatment or as post welding heat treatment), in addition to the other specified tests, micrographic examination shall in addition to the above specified qualification tests, the micro structure from the base metal of test sample before forming and after forming/stress relieving 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 relieving, shall not be acceptable.

c) For cold forming without any subsequent heat treatment, only impact tests shall be performed on the test sample, as stated in para. 6.4.2.c of this specification.

Note: For strain ageing tests only, a straining simulation on a production plate sample by tensile so as to have the same permanent deformation as the maximum obtained in production forming, is acceptable.

6.4.5.3 Records

A record of each qualified forming procedure including the results of all inspection and tests carried out on the corresponding test sample shall be jointly signed by the Contractor and the Inspector.

For hot forming, the procedure qualification record shall clearly indicate the range of acceptable working temperatures to the satisfaction of the Inspector.

6.4.5.4 Extent of qualification

A forming procedure qualification test shall be run on a sample representative of the product with minimum and maximum permanent percentage strain in each steel source, as delivery condition,

General Specification		GS EP STR 301
Fabrication of offshore steel structures		
Rev.: 18	Effective date: 11/2018	Page: 19 of 124

grade and quality of steel. Exception is made for cold forming without subsequent heat treatment where only the maximum permanent straining is to be taken for qualification of the whole range of straining rates within the lot of products in question.

6.4.6 Forming production tests

Within the products covered by each qualified forming procedure (as defined in para. 6.4.5.4 above), production tests shall be performed regularly as follows:

- For Cold Forming: as per para. 10.9 of [GS EP STR 201](#)
- For Warm Forming and Hot Forming at temperatures below or equal to 650°C and for cold forming with subsequent stress relieving: on every 50th product per cast of steel, whatever the steel category
- For Hot Forming at temperatures above 650°C: on every 25th product per cast of steel, whatever the steel Category.

Product tests shall include, at least, the tensile and impact tests specified for qualification of the forming procedure in question (see para. 6.4.5 of this specification), except for Cold Forming without subsequent heat treatment where only impact test in the strained condition shall be carried out.

7. Fabrication

7.1 General

Fabrication shall be in accordance with provisions of [API RP 2A-WSD](#), unless otherwise stated in the present specification.

The Contractor shall submit for Company's approval sufficiently detailed documents pertaining to the proposed procedure and sequences he plans to use in fabrication and assembling the various parts of the structures. Parts to be prefabricated shall be clearly indicated.

The construction shall proceed on a flat and levelled surface having a foundation with sufficient resistance with regards to the expected structure weight and any additional construction live loads.

Structures and appurtenances shall be fabricated and shop assembled to the greatest possible extent. Items specified as field installed shall be fabricated such that subsequent field work will be minimized.

Although some welding requirements are given in the present section, requirements specifically regarding welding are stated in section 8 of this specification.

Reference shall be made to para. 5.8 regarding traceability of materials.

7.2 Erection loads and stability

The Contractor shall consider during Site assembly all temporary erection loads imposed on the structure from supports, jacking and slinging at each stage of the structure assembly.

The Contractor shall consider at each stage of the structural assembly (and tank testing) the local or overall stability from self weight and environmental loads, inclusive of scaffolding, staging, welding shelters and temporary works. The Contractor shall ensure that all stresses induced in

General Specification		GS EP STR 301
Fabrication of offshore steel structures		
Rev.: 18	Effective date: 11/2018	Page: 20 of 124

the structure, during fabrication and load out, are not greater than the allowable stresses in the [AISC 325](#).

The Contractor shall take due consideration of the effect of wind induced vortex shedding on the structure or parts of the structure during construction and take measures to prevent the occurrence thereof.

7.3 Welded connections

For welded connections and their requirements reference shall be made to para. 7.5 to 7.16 hereafter and to section 8 of this specification.

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

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

7.4 Bolted connections

7.4.1 General

Bolting will be used only when welding is not possible and will in any case be restricted to locations shown on Contract Documents. The typical case where bolting may be accepted is the offshore connection of new modules on existing platform.

All bolted connections shall be in accordance with [AISC 325](#), unless stated otherwise in this specification.

- Design and assembly of structural joints using [ASTM F1554](#) standard fasteners (grades 36 and 55) shall be in accordance with [AISC 360](#).
- Design and assembly of structural joints using high-strength carbon steel bolts or equivalent fasteners tightened to a specified tension shall be in accordance with the [RCSC/AISC](#).

The use of high strength bolts (with Specified Minimum Yield Strength above 730 MPa) is subject to prior written approval of Company.

All high strength bolts shall be used with washers.

After being finally tightened, all nuts shall be locked, except for bolted joints with controlled tightening.

7.4.2 Selection of bolts, nuts and washers

Bolts, nuts and washers shall be supplied in accordance with provisions set forth in [GS EP STR 201](#).

Only three very different diameters of bolts shall be used.

7.4.3 Preparation

Holes for bolted connections shall have diameters 1.5 mm (1/16") larger than the bolt size, unless otherwise indicated on Contract Documents.

General Specification		GS EP STR 301
Fabrication of offshore steel structures		
Rev.: 18	Effective date: 11/2018	Page: 21 of 124

Holes shall be drilled perpendicular to the surface of the member. Holes shall not be made or enlarged by burning. Enlarging of holes shall be by reaming and then only with the approval of the Inspector. Holes shall be clean-cut without torn or ragged edges. Outside burrs resulting from drilling or reaming operations shall be removed with a reamer making a 1.5 mm (1/16") 45° bevel.

Punching is not allowed in high strength steel.

All holes shall be drilled and reamed as necessary prior to any blast cleaning.

No holes shall be drilled in structural members at locations other than those indicated on the Contract Documents.

7.4.4 Assembly

7.4.4.1 General

Bolts shall be driven accurately into holes without damage to the threads.

Bolts heads and nuts shall rest squarely and tightly against the metal.

Unfinished bolts transmitting shear shall be threaded to such a length that no more than one thread will be within the grip of the structural members.

7.4.4.2 Standard bolts

The bolt shall be of a length that will extend entirely through but no more than 5 mm (3/16") beyond the nut.

Bolt heads and nuts shall be drawn tight against members with a suitable wrench.

Bolt heads shall be struck with a hammer while the nut is being tightened.

7.4.4.3 Joints with controlled tightening bolts (or so called slip critical connections)

For bolted joints with controlled tightening bolts (or slip critical connections), the ratio of the Tightened Length (TL) to the bolt diameter (d) shall not be less than 5 ($TL/d \geq 5$) and the use of washers supplied with bolts and from the same production, are required.

In all cases, the Contractor shall prepare and submit to Company a detailed procedure for using and tightening HS bolts.

The use of this bolted joint shall not be allowed where there is spraying of liquid (oil particularly), condensation or important corrosion.

For uniform joint quality and to avoid mistakes, classes of bolts, screws and nuts shall be identical in a given project.

Surfaces of high strength bolted parts in contact with the bolt head and nut shall not have a slope of more than 1/20 with respect to a plane normal to the bolt axis. Where the slope is more than 1/20, bevelled washers shall be used.

Faying surfaces shall be free of rust, mill scale, dust, oil, paint and any foreign elements which could impair a good contact between parts. Faying surfaces shall be sand-blasted to SA 2 ½ of the Swedish standard [ISO 8501-1](#). Their roughness shall be such that their Ra is 6.3 micrometres. It can be measured either by a rugotest or Press-0-Film method.

General Specification		GS EP STR 301
Fabrication of offshore steel structures		
Rev.: 18	Effective date: 11/2018	Page: 22 of 124

High strength bolted parts shall fit solidly together when assembled and shall not be separated by any material.

Before installation, appearance of bolts shall be checked, particularly with respect to their lubrication (no additional lubrication other than that carried out by manufacturer shall be allowed). Any contaminated bolt (dust or sand) shall be rejected. Finally, the condition of threads shall be carefully checked.

Unless a tensioning hydraulic equipment can be used, the high strength bolts shall be pre-tensioned to the proper proof stress in accordance with the [RCSC/AISC](#), using the turn -of- nut tightening method. When the bolts are supplied as per [GS EP STR 201](#) para. 13 requirements, it will be acceptable that the torque is calculated by the formula: $C = 0.88 \times k \times d \times P/1000$ refer to [GS EP STR 201](#). However, the tightening procedure shall be in conformance with the AISC requirements specified above.

7.5 Fabrication of welded tubulars and node cans

7.5.1 General

All tubular shall be pre-fabricated in specialized mills qualified by Company according to [GS EP STR 201](#) unless a specific agreement is granted by written.

The following applies when the use of Contractor's construction facilities are accepted.

All tubulars shall be fabricated and inspected in accordance with [API SPEC 2B](#), unless otherwise indicated in this specification.

Welded tubulars shall be fabricated from formed plates welded longitudinally using Submerged Arc Welding (double sided welds).

7.5.2 Forming

Forming shall be carried out in full compliance with all provisions of para. 6.4 of this specification.

The forming procedure shall be submitted to the Company for approval prior to any tubular being formed. This procedure shall include:

- Equipment to be used, its hot or cold rolling capacity (as appropriate) and tables relating to plate thicknesses and tubular dimensions for each machine
- Sequence of operations in forming tubulars
- Methods used for avoiding "flats" along the longitudinal seam
- For hot forming, the forming temperature, heating and cooling rates, method of temperature checking and details of any proposed subsequent heat treatment.

7.5.3 Welding and fabrication

7.5.3.1 Welding

Welding shall be carried out in accordance with requirements of sections 8 and 13 and Appendix 2 of this specification.

Correction of out of roundness by welding (i.e. "butterfly welds") is prohibited.

General Specification		GS EP STR 301
Fabrication of offshore steel structures		
Rev.: 18	Effective date: 11/2018	Page: 23 of 124

7.5.3.2 Splices

The minimum distance between girth welds in tubulars and piles shall be as stated in para. 7.9 of this specification.

7.5.3.3 Tubular ends

Tubular bevels will be defined by the Contractor in compliance with the approved WPS.

When tubulars are intended to be butt welded to other tubulars of smaller wall thickness in further fabrication, a taper of 1 to 4 shall be made to allow a proper fitting.

For brace to can connection, once bevel is finalized, a scribe line (constant distant from root face) shall be marked on the brace for root face location reference for the UT inspection.

7.5.4 Production tests

7.5.4.1 General

Production tests shall be carried out on finished tubulars pertaining to Special and 1st Category members. Production tests shall include tests on base metal and tests on welds as indicated below.

7.5.4.2 Production tests on base metal

As per para. 6.4.6 of this specification.

7.5.4.3 Production tests on welds

- a) Production test plates shall be welded as longitudinal extension pieces attached to the seams during production welding. Where the Inspector deems necessary, the Contractor shall prepare representative circumferential weld test pieces. These are not normally required where the circumferential seams are welded to an identical weld procedure as the longitudinal seams.

Each production test plate shall be labeled with a machine reference number and for longitudinal seams a tubular reference number. Test pieces for circumferential seams must be welded on identical machines and to identical procedures as the seams they represent.

- b) Weld production tests shall be carried out per each WPS regularly once in every **twelve (12)** circumferential and once in every **twelve (12)** longitudinal seams in Special category tubulars and once in every **fifty (50)** circumferential and **fifty (50)** longitudinal seams for First Category tubulars. The production test program shall be made so as to test equally, as far as possible, all the wall thicknesses covered by the said WPS.
- c) All tests specified for the welding procedure qualification test (see para. 8.7.5 of this specification) shall be carried out. However, the impact test and tensile test are modified as follows:
 - The transverse tensile test consists of only one specimen
 - The impact test consists of only two sets of specimens: one with the notch centered in the weld axis and the other one with the notch located on the Fusion Line (FL) or Heat Affected Zone (HAZ) and centered at the place where the lowest average absorbed energy has been measured during the Welding Procedure Qualification Test (i.e. on FL or 2 mm from FL or 5 mm from FL). This test location shall be agreed with the Inspector.

General Specification		GS EP STR 301
Fabrication of offshore steel structures		
Rev.: 18	Effective date: 11/2018	Page: 24 of 124

Production test pieces shall be 100% non-destructively examined and mechanically tested in full compliance with para. 8.7.8 of this specification.

- d) Failure: production test welds which fail the requirements of para. 8.7.8 of this specification shall be rejected and brought to the attention of the Inspector and the cause of the failure shall be established by the Contractor. Further examination of welds made using the same welding procedure or by the same welder shall be carried out to ensure that unacceptable welding is not present in the structure.

Corresponding welding operation shall be immediately stopped. Immediate corrective action and preventive action shall be proposed by Contractor and approved by Company before being implemented, and production can restart. However welding re-start shall be under sole Contractor's responsibility and restarted welds shall be put in quarantine until the corrective actions have been validated by Company.

7.5.5 Inspection

7.5.5.1 Weld inspection

In addition to the 100% visual inspection, radiographic and ultrasonic testing shall be carried out according to section 10 of this specification to the following extent on each finished tubular or section of tubular:

- Longitudinal weld: 100% inspection by NDT (10% NDT inspection for 2nd category tubulars), plus radiographic inspection of weld extremities over 200 mm mini.
- Girth weld: 100% inspection by NDT, whatever the tubular category.

NDT means radiography for $WT \leq 15$ mm and ultrasonics or radiography for $15 < WT \leq 25$ mm and ultrasonics for $WT > 25$ mm.

When capping or back pass is made with a process other than SAW, then MPI shall also be required to 100% extent on Special and First category members.

7.5.5.2 Dimensional tolerances

The tolerances shall be as per section 14 of this specification.

7.5.6 Repairs

- Repairs on base material: as per [API SPEC 2B](#) and section 13 of this specification.
- Repairs on weld: as per section 13 of this specification.

7.6 Fabrication of legs, piles and bracings

The provisions of para. 7.5 shall apply to prefabricated tubular members under this specification.

Specific care shall be paid on welds at the top of piles that should be ground flush internally at in order to ensure a good contact of the grippers of ILT (Internal Lifting Tool).

Specific care shall be paid on welds at bottom of piles that should be ground flush externally at pile up-ending position in order to ensure a good contact of the clamp of ELT (External Lifting Tool).

General Specification		GS EP STR 301
Fabrication of offshore steel structures		
Rev.: 18	Effective date: 11/2018	Page: 25 of 124

7.7 Fabrication of buoyancy tubes and flotation tanks

The provisions of para. 7.5 shall apply.

The flotation tanks and buoyancy tubes shall be fabricated to the same standard as the Special Category members and leak tested in accordance with section 11 of this specification.

7.8 Welded Plate Girder (WPG) and Box Girder (BG) fabrication

Unless otherwise indicated by Company, fabrication and welding of Welded Plate Girders (WPG) and Box Girders (BG) shall be in accordance with provisions of [GS EP STR 304](#).

7.9 Splice fabrication and welding

Parts to be joined may be of equal or unequal sizes but abutting thicknesses shall be such that the thicker part shall not be more than twice the thickness of the thinner part.

Note: The thickness to be considered for the thicker part is the thickness before machining the taper.

Welded field splices shall be arranged to minimize overhead welding.

Lapped joints are not permitted unless approved by the Company.

Welded joints of axially aligned structural members of different material sizes, thicknesses, diameters or widths, shall be made in such a manner that the slope through the transition zone does not exceed $\frac{1}{4}$.

The transition shall be accomplished by chamfering the thicker part, tapering the wider part, sloping the weld metal or by any combination of these. The figures in [AWS D 1.1/D 1.1M](#) code show how to design and measure the slope.

Fillers shall not be used for welded splices.

Bolted joints of axially aligned structural members of different material sizes, thicknesses or widths shall be accomplished using fillers (shims) and splice plates or by tapering the wider part. Suggested details are given in Part 4 of the [AISC 325](#).

Splices in tubulars and beams shall be in accordance with the following provisions:

- Splices in **pipes**: no two circumferential seams shall be located closer together than one pipe diameter or 900 mm, whichever is less. There shall be not more than two girth welds in any 3 meters interval of pipe. Longitudinal seams of adjoining pipe sections shall normally be radially offset by a minimum of 90 degrees wherever possible and shall not be less than 30 degrees radially offset without the prior approval of the Company. When fatigue of the circumferential weld is the driving parameter of the design, it may be useful to align the Longitudinal Seams in order to limit the local high/low and associated stress concentration factor. In such case (after Company approval) the longitudinal seam shall be grinded flush (flush means full reconstitution of the cylinder) on a length superior to 6 time the pipe wall thickness plus 50 mm ($6 \times wt + 50$) at the outside diameter and half grinded flush internally, for UT inspection purpose. Longitudinal seams in adjacent cans shall be separated at the circumferential weld by at least 250 mm.
- Splices in **piles**: the minimum distance between girth welds shall be 2 pipe diameters or 2 metres, whichever is less.

- Splices in **Welded Plate Girders** and rolled sections shall not be located closer together than twice the depth of WPG or rolled section, or 1 metre, whichever is smaller.

Splices between sections of beams (i.e. rolled or built-up sections) shall be made in a single transverse plane (i.e. welds of flanges and web in the same plane) and the design of weld grooves shall result in a continuous and full penetration weld over the complete cross-section. To ensure full penetration of flanges, thinning of the web is to be carried out by grinding in order to allow good penetration and back welding. This web thinning is then to be properly overlaid by welding followed by grinding the overlay flush to restore the web to its previous thickness and flat and uniform condition.

7.10 Welded tubular connections (or tubular joints, tubular nodes)

- Welded tubular nodes shall be prepared and welded in accordance with [API RP 2A-WSD](#) and the following.
- The Contractor shall examine carefully the distribution of the joints between pre-fabricated elements so that most of the welds in important nodes are carried out in workshops as possible.
- Unless otherwise indicated on the Contract Drawings, brace to chord welds shall be fully beveled so as to allow full penetration welds and UT inspection of the complete weld thickness, including the so-called "back-up weld".

The term "back-up weld" is referred to the representation given in details C through D of Fig. 3.8, 3.9 or 3.10 of [AWS D 1.1/D 1.1M](#).

In addition, it is highlighted that the weld groove at the heel of the node shall be designed only as stated in [API RP 2A-WSD](#) and shown on Section C-C and Section C-C (alternative) of Fig. 11.1.3 of this Std (i.e. brace feather edged through its full thickness), except that "back-up weld" is still subject to inspection, as said above.

- Fabrication schemes which allow back welding are always beneficial and shall be preferred, especially for tubular joints subject to high fatigue stresses. In this way, a more efficient groove can be prepared ensuring adequate penetration and fusion and reduced risk of root defects.

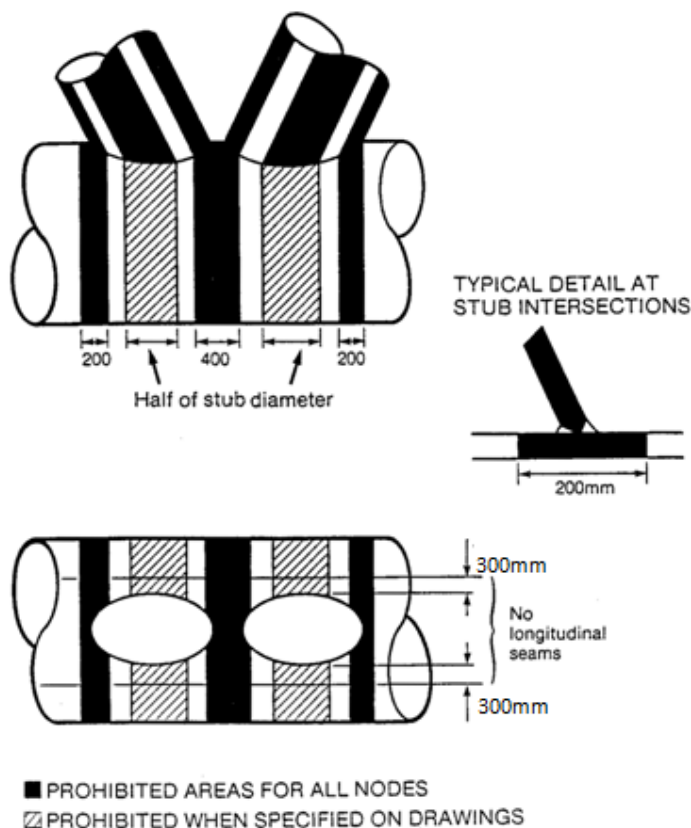
Unless otherwise agreed with the Company, double sided welds shall be required when brace O.D. exceeds 24" and/or brace thickness exceeds 38 mm (1.5"), and/or brace to can angle is less than 30°. Single sided welds may be used for brace to chord connections provided that they are stated on Company approved drawings, they have been found acceptable by an engineering fatigue assessment and that they are qualified by welding tests according to the requirements of this specification without any "back-up weld", as said above.

- When the reference thickness of tubular node welds exceeds 2.0" (50.8 mm), the welds shall be given a concave smooth profile by full grinding as per para. 2.36.6.6 (2) of [AWS D 1.1/D 1.1M](#).
- Any possible measures shall be taken to avoid the intersection of weld seams. Any longitudinal weld on a chord member shall be positioned at least 2 x chord thickness away from incoming braces, with a minimum of 75 mm: see Figure 7.1.
- Restrictions on longitudinal stub seams and circular can seams locations shall be as shown in Figure 7.1. The width of prohibited zones on braces shall be half the brace O.D. with a max. of 400 mm. Dimensions are understood as from weld toe to weld toe.

When braces of equal diameters overlap at X nodes, the brace longitudinal welds shall be located as shown on Figure 7.2.

- h) Where it is not possible to place weld seams clear of the brace to chord weld, then the weld seams on chord shall be ground flush. The weldment areas shall also be subjected to 100% NDT (i.e. U.T. + MPI) up to 50 mm minimum on either side of weld prior to fit-up the brace. The subsequent brace to chord weld shall then be smoothed by proper grinding at weld crossing areas (to avoid any undercut) and then checked by MPI. However, this is always providing that restrictions of para. f and g (here before) are fully met, where relevant.
- i) Minimum gap between bracing foot prints shall be 75 mm (see Figure 7.2). Minimum gap between weld toes shall be 50 mm. Where the achieved gap between weld toes is between 25 and 50 mm, local grinding and MPI shall be required in order to avoid local undercut and get a smooth weld profile.
- j) Temporary attachments and permanent Non-Structural attachments (such as anode attachments) to primary structure shall be at least 75 mm from any other weld, the distance being from weld toe to weld toe.
- k) Unless otherwise indicated on drawings, girth welds on cans and bracings shall be located as shown in Figure 7.3 with respect to node welds.

Figure 7.1 - Prohibited areas for stub longitudinal seams and barrel circumferential seams



General Specification		GS EP STR 301
Fabrication of offshore steel structures		
Rev.: 18	Effective date: 11/2018	Page: 28 of 124

Figure 7.2 - Location of longitudinal weld seams in X nodes

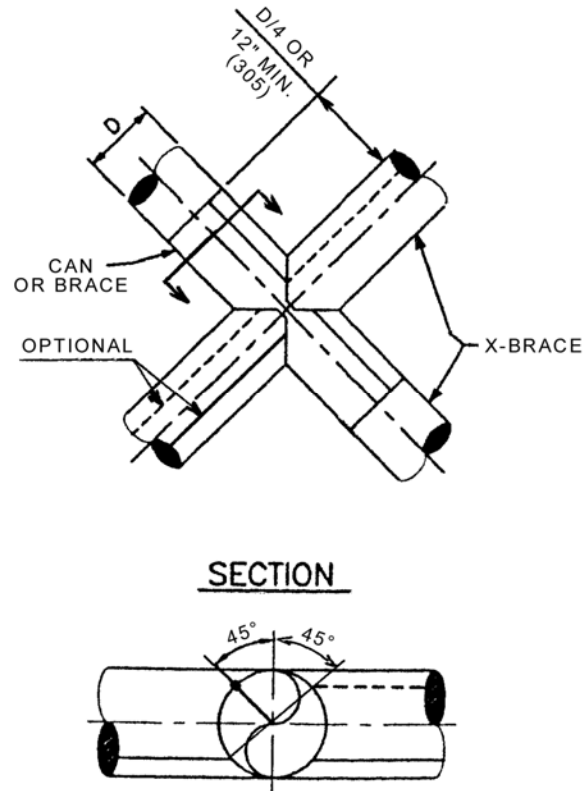
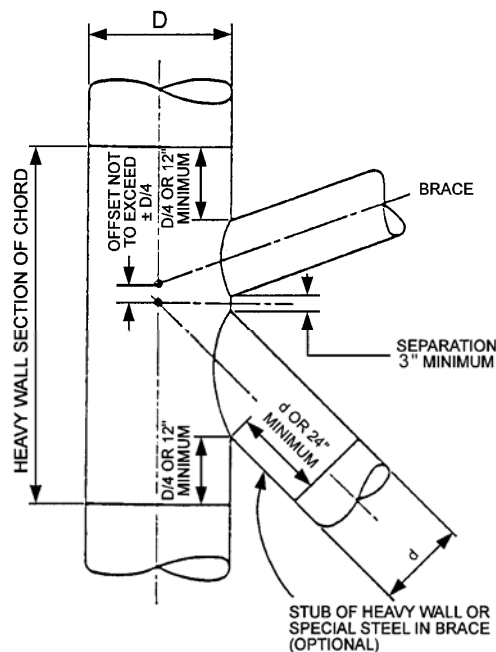


Figure 7.3 - Location of girth welds in simple joint


7.11 Shape to shape connections

When a beam frames to a column web or girder web, the design of connection and sequence of weld assembling will be such as to avoid heavily restrained welds on the web of the column or girder which might introduce lamellar tearing.

Butt welds and tee-butt welds of shapes using permanent backing strip is forbidden.

7.12 Fabrication of pad eyes

Pad eyes shall be fabricated to the standard of Special Category members. Plates shall be assembled so that the principal rolling direction is oriented in the direction of the lifting slings.

7.13 Permanent attachments

The use of doubler plates is required for fixing any permanent non-structural component with section less than 100 mm high (e.g. Hollow section 100 mm or less, HEB100 or less ...) to Special and First Category components (e.g. deck legs, primary girders, etc.) and welded and inspected as structural items. Non-structural components such as all supports of piping, cable trays, lights, etc. higher than 100 mm shall be addressed and welded as structural items.

When welding of attachment directly onto the structure is permitted, the location of such welded attachments shall be selected so as to avoid interference with the principal weld seams of the structure. Minimum acceptable clearance between welds shall be two (2) times the thickness of the structure with minimum of 100 mm. See, also, the provisions of para. 7.10 of this specification.

General Specification		GS EP STR 301
Fabrication of offshore steel structures		
Rev.: 18	Effective date: 11/2018	Page: 30 of 124

Any welding made directly onto the structure shall be performed according to the same requirements and care, including qualification and inspection that govern the structural part onto which welding is made.

7.14 Temporary attachments welds

During construction, a temporary attachment is defined as an element introduced for some specific and temporary function on the structure: lifting lugs, lugs for scaffolding and assembly temporary supports, ladders or other fabrication and erection aids.

Attachments shall preferably not be made to the highly stressed areas of the structure. Such attachments that are deemed essential shall be approved by Company and should therefore be planned in advance.

The location of such welded attachments shall be selected so as to avoid interference with the principal weld seams of the structure. Minimum acceptable clearance between welds shall be two (2) times the thickness of the structure with minimum of 100 mm. See, also, the provisions of para. 7.10 of this specification.

Welding of attachments is to be carried out according to the same procedures that govern the structural part in question (see para. 8.9.5 of this specification).

When such items are no longer required, they shall not be broken off but removed without damage to the structure by chipping or gouging off 5 mm from the member surface and relevant temporary welds shall be ground flush and inspected according to para. 8.9.5 of this specification.

7.15 Temporary openings

The Contractor shall avoid temporary openings (or cut-outs) in Special Category members, whenever possible.

In all instances, when temporary openings are deemed necessary with approval of the Inspector, they shall be prepared with the same care as for permanent openings and with suitably radius in corners (100 mm).

Temporary openings shall then be closed by employing the same material, welded and inspected with the procedures that govern the structural part into which they are carried out.

Temporary openings shall be indicated on shop drawings and as-built drawings.

7.16 Rat-holes

Open rat-holes (generic name for mouse holes or cope holes or weld access holes ...) have a detrimental effect on fatigue life and strength resistance since they cause stress concentrations. A typical open rat-hole raises stresses locally by a significant factor. The fatigue life of the structure is very sensitive to these stress increases. In addition, the application of the selected painting system is difficult when rat-holes or mouse holes are left open.

By principles, rat-holes amount shall be minimized as much as possible with a correct sequencing of work to avoid them.

No rat-holes (or mouse-holes or cope holes or weld access holes) shall be left open in the construction, unless duly considered in the design with the relevant indication on the engineering detailed drawings approved by Company.

Typically, when the weld perpendicular to a gusset is already performed and inspected (normal case), the corner or the web has just to be sniped at 45° by free hand cutting, so that the gusset weld can be continuous.

Rat-holes can be replaced by sniped corners or temporary rat-holes having 20 mm radius and plate thinning (e.g. in stiffener plate and web) to permit welding of the through weld and to provide then a close fit-up with the through weld or beam profile. Sniped corners shall be continuously welded. Corners and webs can be sniped by trimming and beveling as appropriate.

Larger rat-holes shall be filled by butt welded insert plates (with a plate of the same quality than requested for the incoming web of stiffener). Welding shall be according to a properly qualified WPS and inspected according to the most stringent Structural Category of the welded parts.

Design of temporary rat-holes shall be provided by Contractor to construction Site so that they can be properly filled using an approved welding procedure and inspected according to the most stringent Structural Category of the welded parts. See Appendix 2 Folio 1 page 2/4 Notes 11, 12, 13 and fig 4 for typical.

Particular attention shall be paid with respect to the inspection and quality of fabrication and welding in the most fatigue and strength sensitive areas.

- Rat-holes in way of high fatigue and strength prone areas will be closed either by using an insert plate or filled by welding as described above.
- Rat-holes in way of low fatigue and strength prone areas (typically low stressed areas of fixed platforms) will be closed by welding or by closing plates (5 mm thick min.) fillet welded to main structure. (**Note:** In case of closing plates, a specific attention will be paid to fabrication, inspection and painting sequences. The closing plate will be welded after the full NDT of masked welds). Definition of low fatigue and strength areas will be subject to Company approval. The closing plate shall not be considered in calculations.
- Only rat-holes in way of low fatigue and strength prone areas (typically low stressed areas cathodically protected) can be left open.
- If for some specific design change or construction reasons some rat-holes remain open (rat-holes with closing plates as described above are considered as open rat-holes for a calculation point of view), it shall be subject to CPY approval, with a documented dossier presenting the fatigue computation with SCF modified corresponding to the correct detail opening and details of corrosion protection. Structural drawing shall be revised with detail of the rat-hole remaining open.

7.17 Fabrication and Installation of ancillaries

7.17.1 Handrails, stairs, catwalks, ladders and gates

Fabrication shall be carried out according to standard **GS EP STR 901**.

Safety cages to ladders shall be provided where indicated on drawings. Even if not indicated on the drawings, the vertical ladders exceeding 6 metres in length shall be caged for safety on entire length except 2.10 m at bottom.

When fixing of handrails is performed by introducing them in external pipe sockets, a small hole shall be made at the base of each of those pipes to allow the evacuation of water and avoid corrosion problems.

General Specification		GS EP STR 301
Fabrication of offshore steel structures		
Rev.: 18	Effective date: 11/2018	Page: 32 of 124

All handrail welds shall be ground smooth.

All ladders and handrails shall be installed after surface coating or galvanizing to check the fit. At the discretion of the Company (or as shown on the drawings) certain ladders and handrails may have to be removed prior to load out. In this case, the Contractor shall mark the element prior to removal and prepare a placing drawing, which is to be supplied sufficiently in advance of the planned load-out date.

7.17.2 Bar grating

All bar grating and installation pieces shall be cut to the required dimensions and installed as dictated by the drawings. A number of bar grating panels may not be installed prior to load-out but all panels are to be test fitted and given identification marks to ease installation offshore. All bar grating supports are to be installed prior to load-out. All bar grating installed before load-out shall be secured to its supporting members, in accordance with the drawings.

Joints in grating shall occur only at points of support.

7.17.3 Riser clamps/supports

Riser clamps shall be fabricated to the requirements of this specification and to the dimensions as shown on the approved drawings.

The bolted connections shall be trial fitted to ensure that full contact is developed over the area of the connection prior to initial tightening.

The matched pairs shall be hard stamped with a unique identifying code and bolt holes shall be drilled in both halves in a single operation, to ensure matching on site.

7.17.4 Welding of anodes

For connection to structure, anodes Material Category shall be considered as NS and connected to structure with fillet welds, unless submitted to potential high fatigue (typically anodes connected to driven piles or jackets legs with driven piles). In case of potential high fatigue, connection of anodes to structure shall be made with full penetration welds and welds inspected 100% MPI with First Category acceptance criteria.

7.18 Finishing of surfaces

Planning and finishing of cut edges will not be required unless specifically called for in the PPS or included in surface and edge preparation for welding.

All exposed edges of plates and structural shapes that are not rounded to 1.5 mm (1/16") radius shall be broken with a power disc to a 1.5 mm (1/16") chamfer and dressed off with a hand file or other means to remove the resulting burrs.

As fabrication of various items or portions of the structure is completed, the Contractor shall grind all welds and remove all burrs, tack welds and other marks made by scaffolding or temporary bracing used in the fabrication procedure.

Random arc strikes shall be ground out, filled by welding and ground out, filled by welding and ground smooth when so directed by the Inspector. Refer to para. 8.9.9 of this specification.

General Specification		GS EP STR 301
Fabrication of offshore steel structures		
Rev.: 18	Effective date: 11/2018	Page: 33 of 124

7.19 Identification and marking of members

Reference is made to para. 4.2 and 6.2 of this specification.

Regulating marks for workshop or installation (erection) purposes shall be properly die stamped using low stress dies.

7.20 Transport and handling of members

All sub-assemblies, member sections, etc. shall be transported and handled by a suitable and approved method which does not induce deformation or excessive stresses.

Locations of lifting lugs and other temporary attachments are to be carefully selected to ensure that structural strength and specified material properties are maintained.

During on and off loading, transport, storage and handling, all components are to be treated in a manner such that they do not suffer damage, overload or deformation.

7.21 Correction of members

Distorted members shall be straightened in order to fulfill the requirements stated in section 14 of the present specification and para. 5.23 of [AWS D 1.1/D 1.1M](#).

The temperature of heated areas as measured by approved methods shall not exceed:

- 550°C for controlled rolled steels (TMCP)
- 590°C or tempering temperature minus 50°C (the lowest temperature) for quenched and tempered steels, and normalized and tempered steels
- 650°C for normalized steels and other C-steels and C-Mn steels.

The Contractor shall establish and submit a detailed procedure for correction of distortions. The procedure shall include details of the methods used for heating and controlling the temperature (including the position of the T°C control).

For steel grades of Special Category members with a minimum specified yield strength of 300 MPa and above, a qualification of the procedure shall be carried out. The qualification test shall include tensile test, sub-surface impact test, and hardness test if %C > 0.12%. The validity of the qualification shall be limited to the same mill, same delivery condition, same grade and production thickness shall be lower than the plate thickness used for qualification with a tolerance of 10 mm.

At production stage, if welds are located too close to the heated areas they shall be re-checked by NDT.

Cold straightening may be used provided that distortion is less than 5%.

8. Welding

8.1 General

Welding shall be governed by [API RP 2A-WSD](#) with the appropriate references to [AWS D 1.1/D 1.1M](#) code, unless otherwise indicated in the present specification.

Typical welding details (to be provided by Contractor) shall be applicable unless otherwise specified by Company.

Welding Energy shall be limited to 4.5 kJ/mm for any welding process.

For FCAW processes, Welding Energy shall be limited to 3 kJ/mm, bead width shall be limited to 20 mm, wire diameter shall be limited to 1.2 mm, Amperes at root pass shall be limited to 250 A, Amperes at hot, filling and cap passes shall be limited to 320 A.

All fabrication organization shall follow the requirement of [ISO 3834-2](#) and the requirements stated in the present specification. When both documents are in contradiction (typically with standards references), the present specification shall prevail.

8.2 Surface and edge preparation

- a) Surface and edge preparation for welding shall be as defined in the applicable qualified welding procedure. Additional requirements, except when amended herein, shall comply with the applicable requirements of the [AWS D 1.1/D 1.1M](#) code and shall be in accordance with good standard practice.
- b) All gas cut surfaces and edges for welding shall be ground to white metal finish to remove carburized metal and slag. Any excessive roughness of cut surfaces as well as occasional notches shall be removed by machining or proper grinding.
- c) Surfaces and edges to be welded shall be smooth, uniform and free from fins, tears, cracks, laminations or other defects which could adversely affect the quality and strength of the weld.
- d) The surface of chord members (plate or pipe) to be welded in a full penetration T, K or Y - joint (including temporary or permanent attachments) such as chords of tubular joints, pad eyes, supports, etc., shall be ultrasonically inspected before welding when thickness of incoming member exceeds 25 mm.
- e) The area of incoming member to chord joint shall be mapped out onto the surface of the chord. This area together with the 50 mm either side of the weld shall be subject to ultrasonic inspection. The ultrasonic inspection shall be as per [ASTM A578/A578M](#) and imperfection areas of 60 mm² and above shall not be acceptable. Material showing unacceptable imperfection indications or large quantities of acceptable imperfection indications shall be subject to review and approval of Inspector.
- e) The chord of tubular joint shall be properly rotated to avoid areas containing lamellar discontinuities.
- f) Plates in which laminations are found during cutting, forming or welding shall be examined by ultrasonics to determine the extent of the defects and decide about their acceptance or rejection in mutual agreement with the Inspector.
- g) Surfaces to be welded and surfaces adjacent to a weld shall be free from loose or thick scale, slag, rust, grease, oil, paint and moisture or other materials that would prevent proper welding. Welding directly on shop primer paint may be accepted if paint is deoxyaluminate type and welds qualified accordingly. Zn primer coating shall be systematically removed. A specific care shall be paid on Partial Join Penetration and Doubles Fillet welds with regards to the risk of blow holes.
- h) Any welding repair to be made on base material or bevel shall be subject to qualification test.

8.3 Fit-up

- a) Whenever practicable, clamps, magnets, holding devices, etc. shall be used to avoid tack welding in assembling structural members. In fit-ups where clamps cannot be used, spacer-strips will be employed to ensure the correct root gap spacing prior to tack welding. Spacer-strips shall not be welded into the joint.
- b) Misalignment between faces of parallel members of equal thickness when not indicated on drawings shall not exceed 10% of the thickness, nor 3 mm.
- c) If the thickness of abutting members are different, the maximum permitted offset when measured on any of the two faces of assembly shall not exceed:
 - 3 mm when thinner member is not in excess of 12.7 mm (1/2")
 - 4 mm when thinner member exceeds 12.7 mm (1/2") up to 25.4 mm (1")
 - 5 mm when thinner member exceeds 25.4 mm (1").

The weld contour will then ensure a smooth transition between the faces of the assembly in such a manner that the mean slope through the weld zone does not exceed $\frac{1}{4}$.

Outside the above limits, the thicker member shall be tapered by machining or grinding to a slope of not less than $\frac{1}{4}$ (see para. 7.9 of this specification).

- d) When a correction is to be applied to improve misalignment, it shall be carried out using adequate mechanical means. Heating shall not be applied unless specifically approved by the Inspector. The procedure and the maximum acceptable temperature shall be as stated in para. 7.21 of this specification.
- e) The root gap of the joint shall be as defined in the applicable qualified welding procedure. Spacing tools may be used to ensure proper root opening before welding.
- f) Weld buttering of bevel and wide gap procedures shall be subject to qualification tests. Weld built-up shall not exceed 12 mm in thickness (refer to para. 8.7.4). Only one side of the weld can be buttered.

8.4 Welding processes

- a) Shielded Metal Arc Welding (SMAW - process 111 as defined in [ISO 4063](#)), automatic Submerged Arc Welding (SAW - process 12 as defined in [ISO 4063](#)), Flux Cored Arc Welding (FCAW-SS or GS - processes 114 and 136 as defined in [ISO 4063](#)) process and Gas Tungsten Arc Welding (GTAW - process 141 as defined in [ISO 4063](#)) processes shall normally be used.

FCAW-SS process is limited to welds with supporting PQRs with Charpy testing at -20°C or higher.

GTAW process is recommended for first pass of single sided butt welds.

Semi-automatic Gas Metal Arc Welding (GMAW - processes 131, 132, 133, 135 as defined in [ISO 4063](#)) and Flux Cored Arc Welding using metal cored wire (process 138 as defined in [ISO 4063](#)) shall not be permitted for any structural categories even for tack welding excepted when totally removed with SAW process on X bevels.

Submerged Arc Welding with addition of metallic powder (SAW - process 124 as defined in [ISO 4063](#)) shall not be permitted for any structural categories.

General Specification		GS EP STR 301
Fabrication of offshore steel structures		
Rev.: 18	Effective date: 11/2018	Page: 36 of 124

Automatic Gas Metal Arc Welding (GMAW) shall be subject to Company approval on a case to case basis.

- b) Only Extra Low Hydrogen processes (max. 5 ml H₂/100 g) shall be used for welding and tack welding of Special and First Category members or materials having specified YS above 262 MPa (38,000 psi). The same requirement shall apply for any welding on castings and forgings.
- c) For Second Category members and Non-Structural members, welding processes other than Extra Low Hydrogen processes may be used, subject to prior approval by Company, for materials having specified YS up to 262 MPa together with thickness up to 12.70 mm (0.500").
- d) The number of different welding processes shall be minimized.
- e) Different welding consumables qualities (basic extra low, basic low) in a same type of consumables shall be avoided.

8.5 Welding consumables

8.5.1 Selection of consumables

- a) Consumables shall conform to [AWS D 1.1/D 1.1M](#) code and shall have been approved by an international recognized certification body (e.g. DNV, LLOYD's, etc.). Welding consumable supplier shall guarantee grade and Charpy temperature on certificate according mechanical properties requested for base metal.

Welding consumables shall be delivered with supplier's recommendation regarding electrical parameters, stick out range (even for SAW welding) and electrical polarity, with regards to toughness and strength to be achieved. The supplier's recommendation shall be issued to Company with the welding book. Testing of batches shall be based on the relevant polarity.

Selection of welding consumable shall be such as developing a weld metal with Yield Strength higher than SMYS of base metal (overmatching). For S420, overmatching shall be limited to 70 MPa, and to 50 MPa for higher grades.

- 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 maximum 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" welding consumables 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 2.40 mm on Structural Steels.

General Specification		GS EP STR 301
Fabrication of offshore steel structures		
Rev.: 18	Effective date: 11/2018	Page: 37 of 124

- 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 to **GS EP STR 201**.
- j) For FCAW-GS process and MCAW process when authorized, diameter of wires shall be limited to 1.2 mm. For FCAW-SS diameter of wires shall be limited to 1.6 mm.

8.5.2 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.

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.

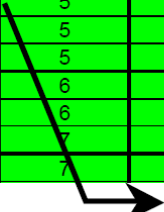
The level of testing shall be as per **ISO 14344** - Schedule 4 as a minimum.

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 1.

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							
		5	10	15	20	25	27	30	35
Relative humidity %	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.

8.5.3 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 D 1.1/D 1.1M](#) shall apply.

The permissible atmospheric exposure of low hydrogen electrodes shall be two hours max., unless shorter a time is required in [AWS D 1.1/D 1.1M](#).

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

Welders shall be provided with individual portable ovens (heating quivers with T°C reading) 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 certifies 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.