



Exploration & Production

GENERAL SPECIFICATION

STRUCTURAL

GS STR 653

F(P)SO - Hull fabrication requirements

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1. Scope

This specification aims at defining the minimum requirements, which are applicable to the fabrication of a new hull for an F(P)SO Floating (Production) Storage Offloading.

This specification addresses the minimum requirements for the hull material and fabrication which are covered by the GS STR 201 and 301 respectively with the relevant deviations as defined in the following sections for the specific application of a hull.

This specification does not address any material (resp. fabrication) requirements for topsides modules or hull appurtenances as defined in **GS STR 652**, (such as topsides support stools, riser supports and protectors, mooring supports and protectors, flare supports, crane pedestal, winch foundations, etc.), which are covered in **GS STR 201** (resp. **GS STR 301**).

This Specification shall be taken as a basis for construction standard and quality level.

2. Reference documents

The reference documents listed below form an integral part of this General Specification. Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published at the EFFECTIVE DATE of the CONTRACT.

The present Specification shall be read and taken as a complement to Classification Society Rules, Regulations, Codes and Standards that are required as applicable or referenced by Contract, project specifications and General COMPANY Specifications.

Where national regulations exist, their provisions and those of the standards and codes to which they refer shall apply, supplementing or amending the provisions of this document.

If there are no national regulations covering all or part of the subject of this document, the following reference documents are applicable as described in the following sections. When not explicitly referred in the following sections they may be used as guidance when relevant.

Only the main reference documents are mentioned; the CONTRACTOR shall be responsible for complying with all secondary reference documents dealing with the subject of this document.

Standards

Reference	Title
AWS D1.1	American Welding Society - Structural welding code steel
AISC	American Institute of Steel Construction - Manual of steel construction
ISO 19901-5	Offshore structures Weight control during engineering and construction
ISO 9001-2000	Quality Assurance system – Requirements
ASTM/AISI	American Society testing and materiel/American Iron Steel Institute

Codes

Reference	Title
Not applicable	

Professional Documents

Reference	Title
API RP 2A	Planning design and construction of fixed offshore platform
IRCN	Quality standards of Steel Hull for Ships 2001

Regulations

Reference	Title
Not applicable	

Other documents

Classification Society Rules

Reference	Title
ABS	Guide for Building and Classing Floating Production Installations
Bureau Veritas	Rules for the Classification of Offshore Units NR 455 DTO ROO E 1998
DNV OSS 102	Rules for Classification of Floating Production and Storage Units
Lloyd's Register	Rules and Regulations for the Classification of a Floating Offshore Installation at a fixed location
IACS	Shipbuilding and Repair Quality Standard (no. 47) dated 1996

Total General Specifications

Reference	Title
GS COR 351	External protection of structures and equipment by painting Floating Structures
GS STR 001	Weight monitoring and weighing offshore units
GS STR 101	Design of Offshore Jacket and Subsea Structures
GS STR 102	Design of offshore topsides structures
GS STR 201	Materials for offshore steel structures
GS STR 301	Fabrication of offshore steel structures
GS STR 652	F(P)SO - Steel Hull design requirements

3. Quality assurance

The CONTRACTOR or its designated SUB-CONTRACTOR in charge of the fabrication and assembly of the hull (hereafter called “the Builder”) shall operate under a third party certified [ISO 9001-2000](#) (Quality Assurance system – Requirements) and maintain this Quality Assurance system during the whole construction period.

Within this [ISO 9001-2000](#) quality assurance requirements, some requirements specific to shipbuilding activity are required within the present specification.

The Builder will demonstrate, prior to any Contract, that he uses normally or is able to implement efficiently the quality and reliability enhancement procedures that are referred in the present specification.

Such specific procedures cover the following topics:

- Material Identification & traceability
- Dimensional Control & performance follow-up of cutting, machining, positioning & welding equipment
- Welding procedures
- Welders qualification & Follow-up Production
- Welding Traceability
- Quality control standards for dimensional tolerances
- Fabrication procedures with Erection and Assembly method Planning
- NDE procedures & performance & reporting
- Inspection personnel qualification
- Repair procedures
- Tank testing procedures
- Remedial actions/ repair traceability system

All fabrication including pipe penetration, cable penetration, outfitting etc...shall strictly follow the construction drawings submitted to Company and Class. In case of discrepancy,

CONTRACTOR shall issue a Non Conformance report and propose some remedial actions or repair.

In case some sub-assembly is performed outside shipyard, SUB-CONTRACTOR shall be approved by Company, and CONTRACTOR shall organize one audit with Company, in order to check whether potential SUB-CONTRACTOR follows agreed quality procedures.

4. Materials

4.1 Structural steel

4.1.1 General

CONTRACTOR shall provide for approval to Company, the standards for material quality control and acceptance.

The minimum requirements of the **GS STR 201** for the hull material are applicable with the relevant deviations as defined in the following sections for the specific application of a hull.

All steels for the hull construction shall be fresh new steel produced by a steel maker holding valid **ISO 9001-2000** certification, tested and certified according to Class requirements.

The steel maker shall be approved by the COMPANY.

Specifications for purchasing materials shall have prior approval of Class and COMPANY.

All materials shall have been approved at steel MANUFACTURER's plant by Classification Society.

CONTRACTOR shall provide on a weekly basis a status of purchasing, delivery and location of steel plates and profiles.

Any material may be inspected by the Classification Society or COMPANY Representative before entering the fabrication process.

Shipyard shall demonstrate that average thickness of the plates is over the required thickness. Any local under-thickness higher than 0.3mm is forbidden.

4.1.2 Additional requirements for Materials

The following minimum requirements of Company General Specification **GS STR 201** "Materials for offshore steel structures" apply for the FPSO hull in addition to the Classification Rules requirements:

- Pcm requirements from **GS STR 201**, section 5.3.3 and table 5.7, shall be applied, since Classification Rules for Ships do not state limits for Pcm.
- Impact energies requirements from **GS STR 201**, table 5.3, shall be applied.
- Temperature tests at 20°C required by Class shall be replaced by temperature tests at 0°C.
- Ultrasonic testing from **GS STR 201**, paragraph 7.11, shall be applied with the following clarifications.

Section 7.11.1: For hull and hull appurtenances, plates may be ultrasonically inspected in accordance with procedure and acceptance criteria of [ASTM A-578](#) level B 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.
- Based on COMPANY review of rolling mill Automatic UT procedure, COMPANY may require the following for Z-steel: manual UT to be applied on areas to be welded in order to verify the absence of lamination"

Section 7.11.2 is not applicable.

Section 7.11.3 is maintained.

- Inspection shall be as per [GS STR 201](#), paragraph 16 as clarified below.

Section 16.3.2:

1) For special & first category materials:

Inspection shall be performed in accordance with [EN 10204 3.1.C](#). However the scope of inspection shall be as per section 16.3.3.

2) For other materials:

Inspection shall be performed in accordance with EN 10204 3.1.B.

4.1.3 Definition of structural categories

For the purpose of hull fabrication, i.e. when considering welding, NDE extent, material traceability, edge preparation, production tests, etc., the definition of hull structural categories shall be as follows:

- **Special category:** structural elements and welds which are part of first category element located in way or at the vicinity of critical load transmission areas, stress concentration locations, or highly fatigue sensitive locations. Highly fatigue sensitive locations are defined in [GS STR 652](#) – Appendix Section 6.
- **First category:** structural elements and welds which are carrying main loads, essential to the overall structural integrity of the FPSO, or located in fatigue sensitive areas.
- **Secondary category:** structural elements and welds other than those classified in first or special category.

Important note: the above definitions of steel categories are different from the ones used in the BV Classification Ship Rules. However, the steel "categories" as per BV Ship Rules refer to different locations in the ship's hull for the sole purpose of steel grade selection: to these categories / locations are attributed a certain Class number (I, II, III), which in turn determines the steel grade according to element thickness and required material strength. It is to be noted that DNV Ship Rules do not refer to "Categories" as BV, and only use "Class" for the selection of steel grades. Therefore, to avoid any confusion with the above definitions of steel Categories, it is recommended not to refer to the term "Category" when using BV Ship Rules for steel grade selection, and to only refer to the element location and corresponding "Class".

The following table shows the category classification for different structural elements and welds of the hull. Other locations may be classified as special and/or first category, according to the results of strength and fatigue analyses.

Special	First	Secondary
Welds of web frames and stringers end connections to longitudinal bulkheads	Bilge, sheerstrake and stringer plates within the whole length of the FPSO.	others
On side shell: longitudinal stiffener penetrations into watertight bulkheads within splash zone.	Deck plating in way of superstructures ends.	
Non inspectable areas, if any.	Deck and bottom plating in midship region or a larger region if necessary on account of unusual weights or loads distribution.	
	Upper and lower strakes of longitudinal bulkheads in midship region or a larger region if necessary on account of unusual weights or loads distribution.	
	Welding of primary and secondary members to the shell under design waterline.	

Note: Steel member categories for appurtenances, including their foundations inside the hull, are addressed in COMPANY specification **GS STR 301**.

4.1.4 Materials for hull fittings

Materials for hull fittings (such as rails, manholes, hatches, pipe supports, cable ways, etc.) shall be either corrosion resistant with compatibility to hull steel and painting systems or black steel suitably protected either by paint or hot dip galvanised.

Galvanized and stainless steel parts should be mechanically protected during construction against grit & grinding debris.

4.1.5 Bolts & mechanical items

All bolts, nuts, and similar mechanical items used for hull fittings shall be made of stainless steel ASTM 193 B8M. For manholes and hatches only, hot dipped galvanised and coated carbon steel can be used for bolts and nuts.

Gaskets where needed to be marine quality neoprene.

Gaskets & non metallic parts used in fittings within oil tanks shall be oil resistant type.

4.2 Steel identification & traceability

Mill certificates in conformance with class requirements shall be provided for every steel to be used in the hull construction in accordance with COMPANY General Specification **GS STR 201** § 15. Copies of original certificates are acceptable provided they are certified by BV, Lloyd's, DNV, ABS or other body approved by the COMPANY. Confirmation tests and inspections shall be performed in accordance with the requirements of the Classification Society, and at COMPANY request, if deemed necessary by COMPANY.

The mill certificates shall show the results of testing required by the materiel specification .They shall include complete steel composition (showing any elements intentionally added, elements restricted by the material specification, elements in the carbon equivalent formula and other



residual elements identified but not normally required to be reported) and mill inspections performed.

A record of all certificates of used steel shall be maintained during the construction and supplied to the COMPANY on delivery.

Mill & Batch number code to be marked on each steel product at delivery.

Marking system on parts shall not create crack sensitive points.

Each grade of steel shall be marked by coded marks to distinguish easily the various grades of parts.

CONTRACTOR will develop and apply a traceability system enabling to identify the item / batch number of steel plating in the finished hull and of section profiles up to the coating stage. Such system is to be submitted to the COMPANY prior to steel plating and section profile ordering & fabrication. Consumables, applied welding procedures, welders, NDE results and reports shall be included in the traceability system.

After delivery, Company shall be able to trace with a computerized system any part of the hull, and get the origin of all structural part of the hull (i.e. mill certificates, welding process, NDT performed etc...).

4.3 Material storage and handling

All structural material shall be stored on flat surfaces, platforms or other COMPANY approved supports in such a way to be free of significant deformations and free draining. Materials to be free from dirt, grease, paint (other than primer), any aggressive chemicals and shall be protected from corrosion by a primary coating compatible with hull coating specification.

COMPANY may reject any fabricated part or subassembly that would be showing evidence or strong suspicion of inappropriate storage or handling.

Steel for the hull shall be stored in identified agreed location separated from other shipyard projects. Various steel grades shall be stored separately and with clear identification.

Materials shall be handled and transported with appropriate means, preventing any significant deformation, not creating any surface damage.

Material Storage & handling procedure shall be submitted to COMPANY for review.

Prior to steel cutting, CONTRACTOR shall organize with Company inspection in the storage area in order to audit the application of the storage and handling procedure.

5. Fabrication of parts & components

The minimum requirements of the GS STR 311 for the hull fabrication are applicable with the relevant deviations as defined in the following sections for the specific application of a hull.

5.1 Workmanship

Two weeks before steel cutting, CONTRACTOR shall organize some training of his QA and line QC foremen. COMPANY Supervisors and Class Supervisors shall be invited. Main differences between VLCC construction and FPSO standard shall be highlighted. List of "Offshore" interfaces and details" shall be stressed. Main key points of QA procedures, schedule shall be reminded.

At all levels, CONTRACTOR shall make sure that all workers shall be well informed that they are not working on a “normal hull” but on an “offshore type vessel” with particular specifications and standards to be applied.

5.2 Straightening

All rolled plates, bars and sections shall be flattened, straightened and free from twist before entering the fabrication process.

Such flattening and straightening shall be obtained in accordance with the requirement of Classification Society without excessive heat or local mechanical damage. Hot flattening and straightening procedures shall be qualified. Mechanical tests shall demonstrate that steel characteristics are not affected.

5.3 Cutting & machining

Cutting of parts shall be made essentially on Computer Assisted cutting machines and using qualified procedures and cutting parameters ensuring an adequate dimensional control of parts and a good edge smoothness and profile. All edges shall be free of flaws.

CONTRACTOR has to perform regular dimensional control of parts and edges inspection and report to COMPANY.

Hand cutting shall be limited to the practical minimum and performed under controlled parameters and by qualified personnel.

Machining procedure, when performed, shall ensure that edges are free from crack initiators or metallurgical degradation detrimental to subsequent welding.

COMPANY may require special welding qualification when applied to such machined edges.

5.4 Edges preparation

Edges not intended to be further welded shall be clean, smooth and free from notches and flaws and meeting Steel Preparation Standard associated to Painting Specification. A minimum 3C edge grinding shall apply for all free edges in fatigue sensitive and high fatigue sensitive areas, regardless of any fatigue improvement which may be necessary following fatigue analysis

Edge preparation shall be in accordance with WPS, which is to be approved by Company, and in accordance with the requirement of Classification Society.

Edges in fatigue sensitive areas shall be free from notches and ground smooth.

5.5 Forming

Forming of steel plates and shapes, when needed, may be done either by hot or cold forming.

Cold forming shall be limited to strain ratio of 5% or a curvature radius to plate thickness ratio of 10.

Cold forming with higher strain ratio above 5% of PS defined in Section 6.4 of **GS STR 301** shall be followed by strain ageing tests or appropriate heat treatment of the material.

Hot forming shall be performed according to qualified procedures proven through qualification metallurgical tests of same extent as welding procedure tests (tensile, hardness and bend tests, Charpy tests for grades for which minimal impact toughness values are required).

6. Welding

The minimum requirements of the **GS STR 311** for the hull material are applicable with the relevant deviations as defined in the following sections for the specific application of a hull.

6.1 General

The hull structure shall be of welded construction throughout. All butt welds shall be full penetration welds. Welding processes using a temporary ceramic backing are allowed. Welds with permanent backing are not allowed for any category.

Manual shielded metal arc welding (SMAW), single or double wire automatic submerged arc welding (SAW) or gas tungsten arc welding (GTAW) processes are acceptable.

Flux core wire (FCAW-GS) is acceptable provided that:

1. Wire diameter max: 1.6mm
2. Sufficient past experience of use of this process by SUBCONTRACTOR to be investigated by CONTRACTOR in terms of:
 - a) track records of SUBCONTRACTOR showing long practice of the process
 - b) Sufficient training of the welders.
 - c) Mechanical characteristics in weld (included HAZ).
 - d) satisfactory weld soundness through NDE records
 - e) Visual examination of weld seam: concave profile, good merging with base material.

CONTRACTOR shall submit a report to COMPANY.

3. Welding access allows easy use of the process. Otherwise SMAW shall be applied
4. Sufficient protection against wind during welding

Provided the above conditions are fulfilled, COMPANY will give a preliminary acceptance. Then COMPANY inspector shall review above conditions on site and will confirm the acceptance of the application of the process.

Use of other processes shall be subjected to approval of COMPANY.

Automatic process shall be preferred as far as possible.

Continuous welding shall be used throughout the hull.

Welding equipment shall be of adequate capacity and well maintained (including electrical wires) in order to get and maintain the required weld quality throughout the construction of the hull. CONTRACTOR to perform regular checking of welding equipment (functioning and safety) and report to COMPANY.

Most of the welding work should be performed in workshops or under shelter and with good access and favourable position.

No welding shall be performed under rain or excessive wet conditions, neither when steel temperature is below -10°C.

Preheat and Post-heat shall be performed according to approved procedures and with adequate temperature checking and recording equipment.

In fatigue and high fatigue sensitive areas, welds shall be ground smooth with minimum 15mm radius, depending on weld throat size.

6.2 Procedures

Prior to start of fabrication, CONTRACTOR shall submit Welding Procedures Specifications, including the following information:

- Welding procedure designation
- Planned range and conditions of use
- Description of the welding process
- Steel grade (or range of grades)
- Joint geometry and preparation including design fit up and tolerances
- Range of thickness
- Detail of Welding consumables (including Supplier product identification, supplier name and reference to acceptance)
- Baking arrangement and product identification if applicable
- Number and sequence of runs (sketch)
- For each run, welding parameters and welding speed
- Details of preheat and post heat if required
- NDE techniques and extent.
- Qualification tests records with extent of tests according to Class requirements.

All Welding procedures shall be approved by Class. In case one welding procedure has already been used by CONTRACTOR for some other projects, CONTRACTOR shall provide the records of the defects recorded for the project prior approval.

Sequences of welding to control distortion and shrinkage shall be included in the procedures

6.3 Welding procedure qualification

Welding Procedure Qualifications, including those for repairs, shall be performed as per **GS STR 301** requirements and limitations.

Qualified welding procedures from previous orders may be considered provided that they meet the conditions of specifications **GS STR 301**. When qualifications are not in full compliance with the relevant specification, it will be acceptable to complete it with additional testing on production tests, as far as it is technically acceptable to the COMPANY welding Representative.

6.4 Welding products

Welding products material (including ceramic backing material) and maker shall be approved by the Classification society and the COMPANY.

Preferably a single product brand & reference shall be used for each type as far as possible.

Products shall be checked on receipt and stored and preserved according to supplier recommendations. Procedures for storing, drying, handling and flux recycling shall be approved.

Welding products requiring damp control shall be maintained in closed boxes or heating devices until their individual use.

6.5 Welders qualification

All welding including tack welding, flame cutting, hot forming and similar fabrication processes shall be performed by qualified personnel.

Qualification for welders shall follow the welder agreement procedure as required by the Classification society.

CONTRACTOR shall establish and maintain a record book of workers qualification.

Qualification of welders shall be periodically checked by qualification renewal tests and/or production quality results analysis.

Welders on project shall wear a specific tag, enabling inspectors to check their qualification.

Similar qualification system shall be used for operators of:

- Cutting machines
- Forming equipment
- Automatic/robot type positioning/welding equipment

6.6 Welding & fabrication traceability

CONTRACTOR shall establish and maintain a traceability system for materials, welding and inspection, for special and first category joints, to be approved by COMPANY prior to any fabrication work, enabling record and correlate, for any weld or similar work::

- The date of execution
- The name or identification of worker
- The identification of used procedure, equipment, products type and batch number
- The reference of inspections, and NDT performed.

Such records are to be regularly submitted to COMPANY for review.

Each subassembly or prefabricated block submitted to COMPANY acceptance shall be associated with a complete record of fabrication, dimensional and quality inspection by CONTRACTOR.

Copy of WPS sheet shall be available nearby the weld seam to be welded.

6.7 Repairs

CONTRACTOR shall prepare and submit to COMPANY approval repairs procedures for cases of defective work. Repair welding may be performed according to already qualified WPS, provided COMPANY has given its approval on a case by case basis..

Such procedures to cover, as a minimum:

- Local Surface defects in plates and rolled profiles
- Edges defects (flaws, notches, indents)
- Inappropriate local weld joint fitting geometry

- Various types of welds defects: porosity, undercuts, flaws, inappropriate weld size, bad profile, etc.
- Bad alignment

Such procedure shall define the steps of removal of defective work and repair and the limits of acceptability of repair extent.

Components or subassemblies showing extent of repairs exceeding acceptable limits shall be completely removed and replaced by new works.

In case of mis-cut, misalignment etc... CONTRACTOR shall make an alteration drawing and propose a repair method to Class and Company. This drawing shall be reviewed by CONTRACTOR's hull design department. Repair shall only starts with Company and Class approval.

6.8 Production welds test

Company may request production test for any weld on the hull.

6.8.1 Extent

The production test frequency shall be as a minimum of one production test per each new welding consumable batch. For SAW process, flux batch shall be considered as a variable as well as the wire batch.

Production tests performed for hull construction may cover the appurtenances welding production tests, provided that the same consumable batches are used and that below stated requirements are met.

Classification Society may require additional production tests.

6.8.2 Organisation

The manufacturer shall organise the system in such a way that only tested and accepted batches are made available to the production staff. CONTRACTOR shall advise COMPANY when new consumable batch(es) are delivered for further use.

Moreover, the traceability of the batches is strongly recommended in case of any further production problems.

6.8.3 Carrying out of production tests

The base metal shall be one of highest specified tensile characteristic, for which the lowest impact test temperature is required and for which the welding procedure use the concerned consumable. To make easier the organisation of production test without disturbing the workshop production, there will be no particular requirements relating to the highest Ceq or to plate thickness or to a particular welding procedure, except when production tests are intended to complete a welding procedure qualification, refer to paragraph 6.8 here-below.

The production test shall be a full penetration butt weld (1 side or 2 sides). It shall be welded in production area, using the production welding machines and procedures.

6.8.4 Testing

NDE on the production test sample is of the CONTRACTOR responsibility.

Mechanical tests shall be those required for welding procedure qualification in specification **GS STR 301** paragraph 8.7 but, limited as follows (except when more tests are necessary to complete a welding qualification):

- a) 1 tensile test transverse to weld
- b) 1 set of impact tests 3 specimens with notch centred in weld metal axis
- c) 2 guided bend tests,
- d) 1 macro hardness
- e) 1 set of impact tests 3 specimens in HAZ at FL, and 1 set of impact tests 3 specimens in HAZ at FL+ 2 mm

The results of testing shall meet the requirements of the relevant specifications and **GS STR 301** paragraph 8.7.8

6.8.5 Failure

Production test weld which fail the requirements of paragraph 8.7.8 for any of the a), b), c) or d) test, shall disqualify the consumable batch used for the production test. The concerned batch shall be discarded and not used in production.

Production test weld which fail the requirements of paragraph 8.7.8 for e) test shall be rejected. The cause of the failure shall be established by CONTRACTOR. COMPANY and Classification Society shall be immediately informed of the investigation and corrective action plan proposed by CONTRACTOR, which is to be approved by COMPANY and Classification Society.

6.9 Welding of non-structural steel

Welding of ancillary structures, pipe supports, electrical supports, lining etc... must be performed with good workmanship. In order to achieve acceptable standards CONTRACTOR shall develop specific welding procedures for small outfitings: low energy input must be ensured with small wire. Welding details shall be based on detailed design approved by Company.

Welding appearance shall be such that it allows for good corrosion protection after painting (with proper surface preparation). 100% visual inspection must be performed also on these non-structural welding.

7. Assembly

7.1 Erection sequences

CONTRACTOR shall develop, document and submit to COMPANY the intended erection sequence: list of sub-assemblies and blocks shall be made. Schedule of fabrication, erection and lifting shall be made and updated on a weekly basis. CONTRACTOR shall locate all sub-assemblies and blocks within its production facility and keep Company informed.

Such sequences shall ensure that the fabrication and erection process minimise the number of field joints, the residual stresses and allow a proper line-up and geometry of field erection joints.

Erection butt joints shall be clear from the bracket toes of web frames and horizontal stringers in accordance with the Builder's practice, but not less than 100mm, subject to Class.

7.2 Blocks prefabrication

Subassemblies and block prefabrication shall be performed as much as possible in workshops well sheltered from rain and damp, wind and excessive cold/hot temperatures.

Fabrication sequence shall enhance the favourable weld positions.

Subassemblies and blocks shall be finished and completed as far as compatible with further assembly prior to be inspected and passed to further stage.

Post inspection repairs shall be performed in principle using same position and process than the initially planned work.

COMPANY may refuse that a subassembly or block is incorporated in the next stage if such subassembly or block has not passed satisfactorily the inspection.

7.3 Handling of components and blocks

Individual components such as plates and individual parts, rolled & fabricated beams shall be handled with appropriately sized non aggressive means, and stored in adequate position and support to prevent distortion and allow easy identification.

Sub assemblies and prefabrication blocks shall be handled under controlled conditions: CONTRACTOR will develop, maintain and apply a procedure for handling of subassemblies.

Main structural parts handling such as lifting of blocks using multi hook systems, skidding, jacking and similar operations shall be analysed and documented and submitted to COMPANY approval.

Temporary supports and foundations shall be carefully designed to avoid any distortion of blocks, allow fine adjustment of fit while providing a complete safety of support. All padeyes used for temporary lifting are special category members and shall be designed and inspected accordingly.

COMPANY may require that design documentation be submitted for unusual or especially heavy temporary support.

7.4 Fitting tolerances

Fitting tolerance shall match the limits as defined by approved Welding Procedures Specifications, by design drawings and standards and those resulting from the overall dimensional planning, mainly in view of proper support of topside equipment and other interfaces.

7.5 Correction of assembly induced distortions

When assembly results in post welding deformations exceeding the allowable standards - such as out of straightness of stiffeners or out-of flatness of plating -, deformation shall be corrected according to a correction procedure developed on a case by case basis, approved by COMPANY and qualified by test if so required by the COMPANY.

Corrective steps such as spot heating, jacking, etc., shall be done according to procedures qualified in the same way as welding procedures as per § 6.

In case where the correction would result in excessive hot work or excessive cut & re-weld, COMPANY may require that the excessively deformed work shall be removed and replaced by new steel. Corrective local design shall be submitted to CONTRACTOR's design department, COMPANY and Class for approval prior start of work.

7.6 Dimensional control

CONTRACTOR shall establish a dimensional control procedure enabling to minimise corrective work during assembly and to allow a good match for topside structures and equipment.

Such procedure shall demonstrate that the retained fabrication and erection method is able to match the dimensional tolerances as defined in design drawings in terms of structural geometry as well as in terms of interfaces to Topside Structure and Equipment.

Such dimensional control procedure shall address at least the following topics:

- Regular measurement of parts, prefabricated panels and subassemblies
- Technical & statistical analysis of dimensional measurements to detect cutting/positioning machines errors or drift and to enable preventive compensation of welding distortion
- Corrective loop to restore as quickly as possible the geometrical precision of the production equipment and process
- Overall dimensional planning strategy.

Dimensional control shall be performed using certified instruments, by qualified personnel and in controlled thermal environment. Measurements shall in principle be recorded at the same period of the day, excluding days of unusual/excessive cold/hot temperatures.

For each major interfaced foundation (topside, riser, mooring etc...), CONTRACTOR shall submit a dedicated dimensional check sheet sample for Company's approval prior start of fabrication. Tolerance shall be such to enable proper connection of the two parts, without unacceptable stress concentration at the connecting joints.

7.7 Examination & inspection

7.7.1 General

CONTRACTOR shall perform himself and according to Quality Inspection Procedures approved by COMPANY all inspection and tests required to demonstrate the quality of the work and compliance with technical requirements of the contract.

CONTRACTOR shall establish and submit to COMPANY reports of inspection:

Detailed report of inspection at least for each prefabrication block.

Regular synthesis reports (weekly) with trends analysis.

In addition, works shall be submitted to COMPANY Site Representative for COMPANY inspection and acceptance according to a COMPANY Approved Hull Acceptance and Inspection Plan.

7.7.2 Inspection at block stage

CONTRACTOR Inspection shall be performed at least at block stage and preferably at subassembly level stage as far as practicable.

Such inspection shall include, as a minimum:

- Check of material quality, scantling according to COMPANY approved drawings and check of traceability of material including handling fittings.
- Dimensional Check report

- Check of welds type and size, check of weld traceability
- Visual inspection of welds
- Extent and acceptability of NDE according to NDE plan.

7.7.3 Inspection at assembly stage

Prior to proceeding to the assembly welds, an inspection for fit is to be performed and reported. COMPANY may require to perform its own inspection prior start of welding.

Inspection at assembly stage shall be same extent as for block stage defined above for the parts involved in the assembly.

Moreover, an inspection shall be performed throughout the assembled block and its vicinity to ensure that no significant distortion or other damage has resulted from the assembly work.

8. Special operations

8.1 Lifting of super-blocks

In case of heavy lifts by floating crane, CONTRACTOR shall provide all details showing the operation is well prepared as any offshore heavy lift operation (ref. **GS STR 401**).

8.2 Keel laying

CONTRACTOR shall provide the drawing of the supports and corresponding calculation showing that the hull structure can withstand the corresponding stresses. Supports shall be positioned in order to make sure the full bottom of the hull can be coated. CONTRACTOR shall provide the erection sequence of the blocks in the dry-dock.

8.3 Launching

CONTRACTOR shall provide the launching procedure at least two weeks before the operation. One week prior to the operation, CONTRACTOR shall make the exhaustive list of the remaining works to be performed prior to the operation, and organize daily inspections with Company in order to check the progress and quality.

Prior the hull floats, inspection of the inside compartments shall be made to check for any leakage.

If some compartments need to be filled to balance weight of the hull, fully coated ballast tanks shall be used preferably.

Procedure shall show how the hull is pulled from the dock, and how risks to damage the outfitting on the side shell are mitigated.

Documents to be gathered are:

- General Float-out procedure including step by step drawings of line and tug movements.
- Hull ballast configuration (if any)
- Calculations of hull lightship trim, heel, intact stability & damage stability (for hull in current state of completion)
- Diagrams of expected horizontal/vertical clearances of hull (and outfitting) to dock

- Wall/floor & support blocks for all phases of removal.
- Environmental criteria limit for the operation.

8.4 Mooring at quay

CONTRACTOR shall provide details of the mooring at quay planned, at least 2 weeks prior to launching. Following information shall be made available:

- Mooring drawing
- Mooring calculation (including one line damage case)
- Weather limitation
- Fendering details
- Mooring bollards characteristics
- Line certificates
- Ballasting configuration.
- Contingency plan in case of heavy wind (typhoon), and decision process.

8.5 Tightness & strength tests

CONTRACTOR shall develop and submit to COMPANY Approval the testing Plan for tightness and strength of capacities.

Testing method, procedure and extent shall generally comply with Class requirements, but not less than:

- Hydraulic test (strength test) of all bulkheads of cargo, diesel, methanol, ballast and water tanks.
- Leak tests (air test) for others compartments.

Checkerboard strength tests of cargo tanks are acceptable, subject to Class approval.

Fresh Water tanks after hydraulic tests shall be cleaned with high pressure fresh water or steam. Procedure is to be submitted to HSE.

Seawater may be used for hydraulic tests. Specific inspection is to be organized by the yard to check the tank cleanliness and absence of debris prior to tank filling in order to avoid subsequent damage to pumps.

8.6 Sea trials

In case of sea trials, CONTRACTOR shall indicate the tug configuration and limiting environmental condition. Contingency plan shall be established.

Communication channels and decision process shall be well established and agreed by all parties.

9. Non destructive examination

The minimum requirements of the **GS STR 311** for the hull fabrication and extent of NDT are applicable with the relevant deviations as defined in the following sections for the specific application of a hull.

9.1 Extent of NDE

The extent of NDE required depends on the element category, type of weld, welding process, fabrication stage. The welding process parameter is introduced in order to reflect less NDE extent for fully automatic welding processes versus manual welding processes.

The first table (see attachment 1) presents the welding process categories and second table (see attachment 1) presents the extent of NDE required.

Table for welding process:

Welding Process	Pre-fabrication	Erection
2 sides, Automatic (SAW with or without back gouging)	2AP	2AE
2 sides, Manual or FCAW including butt weld on ceramic backing (CB), 1 side	2MP	2ME
1 side Manual or FCAW except (CB)	1MP	1ME
EGW		EGW



Table for Extent of NDE

Element Category	Type of Weld	Welding Reference	Visual 100%	Radiographic (RT) (1) (2) (6)	Ultrasonic (UT) (2)	Magnetic Particle (MPI) (2) (3)
Special or highly fatigue sensitive	Butt			100%	10% (7)	100%
	T-Butt full pen			-	100%	100%
	Fillet or deep pen			-	-	100%
Primary/ First Category or fatigue sensitive	Butt	2AP		10% of Crossings (8)	The rest of Crossings (i.e 90%) (8)	20 % (X)
		2AE		5% of Crossings	The rest of Crossings (i.e 95%) (8)	20 % (X)
		2MP		10% of Crossings (8)	The rest of Crossings (i.e 90%) (8) + 20% of weld body (X)	20% (X)
		2 ME		5% of Crossings (8)	The rest of Crossings (i.e 90%) (8) + 20% of weld body (X)	20% (X)
		1MP, 1ME		100%		100% (9)
	T-Butt full pen	EGW		10%	100% of weld body	50%
		2AP, 2AE			30% of weld body	20% (X)
		2MP, 2 ME			100% of weld body	20% (X)
		1MP, 1ME			100% of weld body	100% (9)
	Fillet or deep pen					20% (X)

Secondary/ Second Category	Butt T-Butt full pen Fillet or deep pen			10% (Z) 100% of weld body -	20% (Z) 20% (X) 20% (Z)
Non structural part			(4)		(5)
Temporary attachments in special area		Grinding is smooth			100% after removal
Temporary attachments in primary/First and Secondary/Second Category		Grinding is smooth			100% after removal
Temporary attachment elsewhere		Grinding is smooth			

- (1) Radiographic is completed by UT control in case of uncertainties
- (2) When the specified percentage does not cover 100%:
 - a) where "X" is indicated, the specified percentage shall apply to each weld seam and shall include the weld extremities and a part of the weld body
 - b) where "Z" is indicated, the specified percentage shall apply to the total length of the concerned joints of same thickness, welded with the same procedure,
 - c) COMPANY inspector shall have the right to specify the parts of welds to be inspected. When a defect is found out of the acceptance criteria, the inspection extent on the concerned weld seam shall be doubled at either sides of the concerned area. Should any defect be found again at the extended inspection stage, then the inspection shall be extended to 100 % of the concerned weld seam.

Where inspection is specified "Z", 2 other weld bodies from the same batch work (welder, day, procedure...) shall be inspected 10%.
- (3) MPI is required on both sides where access is possible. LPT shall be applied where MPI is not found appropriate for access or efficiency.
- (4) Extent of RT (when necessary) to be limited at special areas or where weld looks visually questionable or poor.
- (5) MPI to 100% extent only when welding on high carbon steels ($C > 0.25\%$) steels and alloyed steels liable to quenching and cold cracking under welding operation. Purpose of inspection is mainly to ensure freedom of cracks, excessive undercuts or other injurious notch defects.
- (6) Where radiographic is impracticable, UT and MPI shall be used in place of RT.
- (7) If UT detect unacceptable defects missed by RT, then 100% UT shall apply to the concerned weld
- (8) 200 mm in length for each direction on intersection or 200 mm of weld ends where ends are not at a crossing location
- (9) 20% on face and 100% on root.

CONTRACTOR shall issue a weld map showing among other information, the weld quality required as defined in the above table. For example, Special or highly fatigue sensitive: Q1; Primary/First Category or fatigue sensitive: Q2; etc. This document shall be submitted to COMPANY approval prior to start production.

Classification Society may require more or different testing. In such a case, their requirements shall not replace but shall be additional to the COMPANY here stated requirements.

9.2 NDE methods & procedures

9.2.1 General

Visual Inspection and Non Destructive Examination (NDE) shall be carried out at least 48 h after completion of welding, except for secondary elements for which this time may be reduced to 24 h.

However, NDE on special and first category welds may be reduced to 24 h after completion of welding providing that CONTRACTOR can demonstrate that the consumables moisture content (coated electrodes and SAW flux) is such that the equivalent diffusible hydrogen content is less than 5 ml / 100g at the welding stage.

Inspection & NDE shall be performed after completion of the whole welding work in an area.

9.2.2 NDE performance

NDE shall be performed according to procedures in accordance to [AWS D1.1](#), using tested and certified equipment.

NDE operators shall be certified according to [EN 473 std](#) or CSWIP std or equivalent std approved by COMPANY and by the Classification Society. The involvement of a third party in the qualification shall be required.

By such, ASNT qualification is considered not sufficient unless evidence of recognised experience is submitted to COMPANY for approval.

9.3 Acceptance criteria for NDE

9.3.1 Reference codes and standards

Acceptance criteria shall be based on:

- Classification Society Standards
- the tables hereafter

9.3.2 Application to structural categories

Notes on the following tables, regarding Visual Examination, MPI, Radiographic inspection and Ultrasonic testing acceptance criteria:

- Any form of crack or suspected crack shall be considered unacceptable regardless of its size or location.
- Occurrence of cracks will initiate more extensive NDT and revision of the welding procedure.

- If separate elongated defects are situated on line and the distance between them is less than the length of the longest indication, the defects are to be evaluated as one continuous defect.
- Lack of fusion and undercuts are not acceptable in welds of pad eyes of components subject to concentrated lifting loads (e.g. hooking parts of lifting devices and accessories).
- "t" is the nominal thickness of weld or the material reference thickness, whichever the lesser.

9.3.2.1 Visual examination

Parameter	Joint Classification		
	Special or Highly fatigue sensitive	Primary/First Category or Fatigue sensitive	Secondary/Second category
Cracks, incomplete penetration, lack of fusion	Not acceptable	Not acceptable	Not acceptable
Surface porosity	Not acceptable	Max 3 mm	Max 3 mm
Weld profile for tubular Paragraph	API RP2A Paragraph 11.1.3.d apply	API RP2A Paragraph 11.1.3.d apply	
Weld profile for all other welds			
- Butt Weld Toe Angle	< 30°	< 45°	< 60°
- Fillet Weld Toe Angle	< 45°	< 60°	< 75°
Butt Weld Undercut	Not acceptable	Not acceptable	Depth ≤ 0.8 mm Length ≤ 50 mm
Fillet Weld undercut	Not acceptable	Not acceptable	Depth ≤ 0.8 mm Length ≤ 50 mm
Fillet Weld Throat Size	No undersize	No undersize	No undersize

Note : Weld with permanent backing is not allowed for any category.

9.3.2.2 Magnetic Particle Inspection

Parameter	Joint Classification		
	Special or Highly fatigue sensitive	Primary/First Category or Fatigue sensitive	Secondary/Second category
Cracks	Not acceptable	Not acceptable	Not acceptable
Lack of fusion at weld toe	Not acceptable	Not acceptable	Length < t/12, max 10 mm
Surface porosity	Not acceptable	Max 3 mm	Max 3 mm
Undercut	Not acceptable	Not acceptable	Depth ≤ 0.8 mm Length ≤ 50 mm
Elongated indications (Length > 3 X width)	Not acceptable	(1)	(1)
(1) Summation of imperfections: any accumulation of indications, including undercuts, shall not exceed 50 mm in first category and 100 mm in second category in any 300 mm of continuous weld. The acceptance criteria to be applied for MPI after removal of attachments shall be those applicable to the inspected relevant category.			

9.3.2.3 Radiographic inspection

Parameter	Joint Classification		
	Special or Highly fatigue sensitive	Primary/First Category or Fatigue sensitive	Secondary/Second category
Cracks	Not acceptable	Not acceptable	Not acceptable
Incomplete penetration, lack of fusion	Not acceptable	According to AWS D1.1 § 6.12.1	According to AWS D1.1 § 6.12.1
Discontinuities	According to AWS D1.1 § 6.12.2		

9.3.2.4 Ultrasonic testing

Parameter	Joint Classification		
	Special or Highly fatigue sensitive	Primary/First Category or Fatigue sensitive	Secondary/Second category
Discontinuities	AWS D1.1 § 6.13.2 table 6.3.	AWS D1.1 § 6.13.3.1 class R	AWS D1.1 § 6.13.3.1 class R

9.4 Complementary inspection in cases of defects

In case of defects found during NDE, the extent of NDE shall be adjusted such as to enable a precise and complete evaluation of the defect extent.

In case where several defects occur in the same joint or in the same batch of work (welder, day) COMPANY may request an increased extent of NDE in this joint or batch, to the level required to get satisfactory assurance of the quality of the remaining weld.

9.5 Correction of defects & repairs

Correction of defects and repairs shall be performed according to section 6.6 and according to repair principles as per Classification Society standards and IACS document "Shipbuilding and Repair Quality standard" (no 47)..

Correction of defects in joints of primary/first category/fatigue sensitive and special/highly fatigue sensitive structures shall be submitted to case by case COMPANY approval with supporting analysis for acceptability of repair.

9.5.1 Grinding

In case where grinding is to be used for correction of weld profile or local surface defects, in primary/first category/fatigue sensitive and special/highly fatigue sensitive structures, the grinding shall be finished with fine grain and in a direction such that the final grinding marks shall be transverse to the weld axis.

10. Temporary works & fittings

10.1 General

Temporary works shall be limited to the minimum practicable, be planned and documented similarly to permanent work on drawings, procedures, etc., and executed and inspected same as permanent work.

10.2 Temporary fittings, lifting eyes, etc.

Minor temporary fittings, if not located in fatigue sensitive area, lifting eyes, may be left in place as far as they do not create any inconvenient to barge life and operation.

Other temporary fittings shall be removed. Removal shall be made by flame cutting or arc-air gouging according to approved procedures and by qualified personnel. The cutting shall be made at least 5 mm from the structural member, and the remainder ground flush to the base material.

The location of attachment shall be further MPI tested free of flaws.

10.3 Temporary cut-outs

Where temporary Cut-outs are necessary, they shall be documented similarly to permanent cut-outs in drawings and procedures and prepared and executed similarly to permanent cut-outs, except for edge preparation that shall match the subsequent closing weld preparation requirement.

Their closing shall be made using closing plate of same grade and thickness, butt welded to the plating according to a dedicated Approved Welding Procedure Specification including a detailed welding sequence.

As a rule, no temporary cut-out dimension shall be less than 300 mm in any direction.

11. Documentation

CONTRACTOR shall deliver to the COMPANY, at last 1 month after Hull delivery, a complete As Built file and Construction Record, containing:

- As built fabrication drawings with as built dimensions as recorded during inspection
- Traceability for materials
- Traceability for Welds and other special process
- Inspection reports
- NDE reports
- Booklet of Welding Procedures Specification and qualification records
- Reports of dimensional control
- Reports of tightness and strength tests
- Inclining experiment report
- As built documentation of all interface areas shall be separated from other areas and provided on request, and at least one month in advance from delivery.