



Offshore Design Section
Engineering Services
ISO – 9001:2008

**FUNCTIONAL SPECIFICATION
FOR Welding & NDT**

Spec. No.	2009F
Rev. No.	8
Discipline	Quality Assurance
Page: 1 OF 36	

**FUNCTIONAL SPECIFICATION
FOR
“Welding & NDT”**

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1.0. SCOPE

This specification covers the minimum technical requirements for welding & inspection of Piping, Pressure Vessels, Structural & Subsea Pipeline work. For piping, this specification covers CS, CS NACE, SS and Cu-Ni. For piping DSS material welding & NDT, Annexure I shall be referred. This specification modifies and/or supplements the referenced codes that apply to all piping, pressure vessels, structural and pipeline welding. These requirements cover welding done at Contractor's fabrication plant, Contractor's Yard, Vendor / Supplier Premises or field installation, either onshore or offshore. This specification also covers the acceptance standards to be applied to production welds inspected by various NDT Techniques like RT, UT, AUT, MPI & LPT.

1.1. Regulatory Considerations

In addition to this specification, Contractor shall also comply with all applicable regulatory and national code requirements.

1.2. Abbreviations

AISC	American Institute of Steel Construction	NDE	Non Destructive Examination
API	American Petroleum Institute	NDT	Non Destructive Testing
ASME	American Society of Mechanical Engineers	ONGC	Oil and Natural Gas Corporation Ltd.
ASNT	American Society for Nondestructive Testing	PAUT	Phased Array Ultrasonic Testing
ASTM	American Society for Testing and Materials	PCN	Personnel Certification in NDT
AUT	Automated Ultrasonic Testing	PQR	Procedure Qualification Record
AWS	American Welding Society	PWHT	Post Weld Heat Treatment
BPVC	Boiler and Pressure Vessel Code	pWPS	Preliminary / Proposed Welding Procedure Specification
CRA	Corrosion Resistant Alloy	QA	Quality Assurance
CS	Carbon Steel	RT	Radiographic Testing
CTOD	Crack Tip Opening Displacement	SMYS	Specified Minimum Yield Strength
Cu-Ni	Cupro Nickel	SS	Stainless Steel
DCN	Design Change Note	TMCP	Thermo Mechanically Controlled Process
DCR	Design Change Report	TOFD	Time Of Flight Diffraction
DNV	Det Norske Veritas	TPI	Third Party Inspection
DSS	Duplex Stainless Steel	UT	Ultrasonic Testing
ECA	Engineering Critical Assessment	WPQR	Welding Procedure Qualification Record
FCAW	Flux Cored Arc Welding	WPQT	Welding Procedure Qualification Testing
GMAW	Gas Metal Arc Welding	WPS	Welding Procedure Specification
HAZ	Heat Affected Zone	Company	Shall mean ONGC
HRC	Rockwell Hardness		
HV 10	Vicker's Hardness (10 Kg Load)		
ITP	Inspection & Test Plan		
LPT	Liquid Penetrant Testing		
MPI	Magnetic Particle Inspection		
NACE	National Association of Corrosion Engineers		
NCR	Non Conformance Report		



1.3. Quality Assurance

QA 1.3.1 Procedures/ITP:

Before commencing fabrication / installation, the Contractor shall submit a quality plan and a set of fabrication procedures to Company for review and approval. These documents shall include the following minimum requirement:

1. Welding & Consumable Control Procedures,
2. Welder Qualification Procedures,
3. PWHT Procedures and illustration of their proposed areas of application.
4. List of proposed all type of Welding Procedures and their areas of application.
5. List of Qualified all type of Welding Procedures and their areas of application.
6. Material identification & control procedure.
7. Detailed procedures for Non Destructive Testing, Technique sheet & Inspection.
8. Procedures for control of tolerances during fabrication.
9. DCN / DCR Control Procedure
10. Material handling procedure at Fabrication shop, Yard, Offshore installation separately
11. Painting/coating procedure
12. Name of fabrication/NDT agencies involved at Fabrication shop, Yard, Offshore installation with complete address of works & respective activities/job of the project and valid ISO 9001: 2008 certificate.

The quality plan shall include brief details and the sequence of all examinations that will be performed by the Contractor. The names of the individuals responsible for the implementation of all quality assurance and quality control functions shall also be included.

The contractor shall prepare a comprehensive ITP showing the role & scope of various agencies involved in inspection and same shall be submitted for Company's review and approval before commencement of fabrication / installation activity.

Contractor shall be required to do of his own QA internal audit at least 2 times at each yard/offshore activities.

QA 1.3.2 Manpower:

All personnel involved in welding related tasks shall have adequate qualifications and understanding of welding technology. The qualification level shall reflect the tasks and responsibilities of each person in order to obtain the specified quality level. The organization responsible for welding shall nominate at least one authorized welding coordinator in accordance with ISO 14731 – Welding Coordination – Tasks and Responsibilities (or equivalent) to be present on the location where welding is performed. The coordinator shall have comprehensive technical knowledge according to ISO 14731, paragraph 6.2a or equivalent.

The Contractor shall employ sufficient number of qualified inspectors. When an item is ready for inspection, the contractor QA personnel shall inspect it first and should be satisfied before offering the same to the Company inspector.

The contractor shall give tentative inspection schedules in advance so that the Company inspectors can effectively plan for the inspection.

QA 1.3.3 NDT:

In addition to visual inspection, NDT Techniques like RT, UT (Manual UT, PAUT, AUT & TOFD), MPI & LPT are required to be used for inspection. Radiography shall preferably be with X-ray.

γ (Gamma) ray can be used as explained below. However, use of Cobalt 60 Isotope is not allowed.

RT/PAUT as applicable for Piping & Structural welding(CS & CS NACE) is as follows:

1. The X-ray must be used till 10mm thickness joint of Piping & Structural welding.
2. RT-Gamma ray can be used without separate permission of ONGC, from 11 mm thickness till 25mm for Piping & Structural welding joint. However the "Project specific procedure qualification" is must ..



3. Beyond 10mm in case of Piping joints, beyond 19 mm in case of Structural joints , the PAUT can be done without separate permission of ONGC . However the “Project specific procedure qualification” is must.

Only personnel certified in accordance with PCN or ASNT recommended practice SNT-TC-1A shall be allowed to carry out Non Destructive Examination. PCN is the preferred qualification.

1.The technique sheet for the referred NDT shall be prepared by the LSTK contractor. The technique sheet preferably should be concise & precise in single page separately for each type of job & each type of NDT method used.

2.The technique sheet along with NDT procedure shall have approval of PCN or ASNT -Level III qualified (respective NDT method) personal of CA /ONGC.

3.The same technique sheet shall be displayed in the laboratory/workplace by the NDT operator.

4.The NDT operator of LSTK contractor must have to demonstrate/ go for the “Project specific procedure qualification” to be witnessed by ONGC/CA/TPI for the 1st time during start of NDT techniques”.

This entire point referred above shall be applicable for all type of NDT method as applicable in piping, pipeline & structural application.

QA 1.3.4 Calibration of NDT instruments:

For standardisation of calibration of instruments used for referred NDT method ,it is essential to have valid calibration certificates for all NDT instruments, Portable Gas detectors, tong tester etc. from NABL accelerated laboratories (India) or from labs which are authorised by local government bodies or from the original manufacturer of the instrument.

All the NDT instruments indicated in ASME Section V needs also the calibration certificate.

Further for RT regarding NDT instruments (RT machine, isotope) shall require valid permission from the local government-regulatory body at the location of use”

QA 1.3.5 Mechanical integrity :

Mechanical integrity of all flange joints has to be ensured in proper record.

A standard checklist for the activity along with post box-up checkup should be developed & practiced. The checklist shall include the following:

- a) i) Alignment of flanges
- ii) Inspection of gasket surface for possible defects such as bends or greases.
- iii) Inspection of mating flanges for dirt, mechanical damage and corrosion. Use suitable solvent to clean the surface. The contact area of flanges shall be free from excess pitting and radial scratches.
- iv) Ensuring the gasket is properly seated
- v) Ensuring that fasteners are tightened as per tightening procedures and using specific values with well maintained tools and torque wrenches.
- b) Each joint shall be boxed up and tightened by only skilled technician.
- c) Ensuring right type of gaskets & fasteners etc. confirming to the specifications.
- d) Ensuring that the stud & nuts are free of dirt and corrosion. The studs should be straight and threads free from nicks, burr and chips etc.
- e) Checking of individual joint for any leak during commissioning/ pressure testing by special tapes, soap solution or as per relevant code.”

Digital radiography in lieu of film radiography can be used with the permission from ONGC on submission & approval of following documents.

- 1.Past track record of the technology/vendor in offshore application on similar material (Parent & welding consumable). PO copy & performance report of the user is required.
- 2.Complete procedure of using the technology with specification, protection of 1st image, calibration, validation of software, Technique etc. with respect to all the relevant standard.
3. The specific training & “procedure qualification “on the subject is required to be provided to ONGC/CA/TPI free of cost.
4. For storage of data a dedicated PC of sufficient memory for entire project with viewing software etc. must be provided without extra cost to ONGC..
5. Optimum nos. of re-use of film is restricted to 150 nos. or damaged whichever is earlier..



QA 1.3.6 ISO QMS certification :

ISO QMS 9001: 2008/2015 – valid certification of all the agencies/ subcontractors engaged (by LSTK contractors) for NDT and fabrication/welding activities shall be required.”

QA 1.3.7 Inspection of material::

It shall be the responsibility of the contractor to inspect all materials upon receipt and to ensure that the correct grade of material has been supplied and that identification, dimensions, material quality and end preparation are in accordance with the requisite standards and specifications. Different materials shall be kept in discrete sections of the storage area and all material shall be marked in a manner that allows it to be related to the original manufacturer's certification.

Procedures for the transfer of material identification marks shall be agreed with the Company prior to the commencement of fabrication. Any material which is not readily identifiable shall be removed from the worksite and quarantined until its material grade and source can be confirmed.

QA 1.3.8 Welding machines :

Welding shall not be performed when the ambient temperature is lower than zero degree C, when surfaces are wet or exposed to rain, snow or high wind velocities, when welders are exposed to inclement conditions, or when conditions prevent required inspections.

Only welding equipment that is in good working condition and that is properly grounded shall be used. All welding machines shall be calibrated prior to commencement of fabrication and calibration certificates shall be available for ONGC QA audits. Certification shall be valid for 6 month periods, or as per manufacturer's recommendation.

*All the welding machines/transformers shall be based of **Inverter technology** or better one instead of conventional transformer/rectifiers based one.*

***All welding machines shall be calibrated** prior to commencement of fabrication from NABL accelerated laboratories (India) or from labs which are authorised by local government bodies or from the original manufacturer of the machines.*

All the welding cables, Grinder cables shall be free from any intermittent joints and shall have proper industrial explosion proof electrical plug-top. All used pipes for Gas- cutter shall be in good conditions with armoured & quality stamped.

QA 1.3.9 Grounding of Equipment & air strikes:

- Each welding machine and panels shall be individually grounded to the platform or portion of the platform being welded.
- No machine or panels shall be grounded to floating equipment during welding on the structure.

Arc strikes should be made in weld groove. Arc strikes on the surface of base metal shall be removed by grinding, including any hardened zone beneath the strike. Any such repair shall be visually and magnetic particle inspected.

Low hydrogen electrodes shall be used for structural and piping welding. Low hydrogen



QA 1.3.10 Welding consumables :

Company shall approve all consumables including brands. Welding Consumables shall have physical, chemical, fatigue and corrosion resistance properties comparable to base metal. Manufacturer's batch test certificate shall be submitted for each batch of consumables used. Test results shall include chemical, physical (including impact), corrosion resistance (if welding material for sour service application or with NACE requirements) & fracture toughness (if welding material or WPS with CTOD Requirements). If these batch test results are not readily available (like corrosion test results, fracture toughness etc.), contractor shall carry out additional batch testing to confirm the same.

The welding consumables which shall not be in no case of a date manufacture older than one year with effect from date of starting the fabrication.

Apart from above, prior to Production welding, the contractor has to do HIC test separately for welding consumables as guided by CA or Company."

The control of Welding Consumables shall be in accordance with a well documented procedure. This procedure shall include techniques for storage, handling, recycling and re-baking of welding consumables to ensure that the diffusible Hydrogen content of weld metal is maintained at less than 5ml per 100 g of weld metal. The procedure shall, as a minimum, be in accordance with the manufacturer's recommendations. Since a variety of welding consumables may be in use at any manufacturing location, strict control shall be exercised to prevent loss of identification or the use of incorrect weld metal.

QA 1.3.11 Miscellaneous requirement :

The welder and weld area shall be provided with protection during periods of inclement weather and/or excessive wind conditions. The procedures shall include means of protecting electrodes, wires, fluxes, etc. Good House Keeping is essential in the job-area

Gas shielded welding processes should generally be used only for shop fabrication or in enclosed conditions. When used outdoor, suitable windshields must be provided to allow adequate gas coverage of molten puddle.

Heated quivers or rod boxes shall be placed at each welding location when low hydrogen welding electrodes are used.

The implementation of the procedures will be audited by ONGC QA team during the phase of Design, Fabrication & Installation activity at least two times par phase. Apart from audit the surprise checking also may be carried out by ONGC QA team at any time. ONGC shall be informed about the timely corrective actions taken by the fabricator as a result of any CAR/NCRs issued during such audit.

Copies of various QA procedures shall be readily available and shall be referenced in the quality plan and shall be made available during QA audit by Company.

Welders and welding operators shall be qualified as per the applicable specification. When using welding processes which have high potential for non-fusing type defects, in addition to the NDT requirements specified in the respective Codes, bend test shall also be carried out. GMAW and FCAW are regarded as welding processes with high potential for non-fusing type defects.

Welder Qualification Tests shall be witnessed by Company representative and/or by a reputed TPI agency. The Company representative shall be advised in advance that the Contractor is conducting welder qualification to enable auditing of test facilities.



Qualification test welds shall be made on test coupons prepared in accordance with the relevant standard. Certified as per QA1.3.4, the “Amp/volt tong tester” shall be available at the Contractor’s establishment at all times. For temperature measurement during welding as per WPS, the IR-type temperature measuring instrument shall be used.

The Contractor shall be responsible for all costs, including labor and laboratory testing, associated with welder qualification tests and retests.

All welders working on the project shall wear identification cards made at contractor’s cost which shall contains photograph, welders name, welder no. Procedure qualified and Company’s/Engineer’s representative’s signature. If the fabricator has a different system for welder’s identity card, same can be followed after agreement.

The period of validity of welder qualification shall be in accordance with the Standard used for qualification. A qualification can be cancelled if the welder / welding operator show inadequate skill, knowledge and performance.

No wooden planks shall be used in any stage of fabrication job as platform of scaffolding.

During fabrication at yard there must have two independent escape route for workers..

QA 1.3.12 Production Records :

At all stages of fabrication, the Contractor shall maintain all relevant production records using a recording system agreed by the Company. The records shall include:

1. Material & Welding consumable certificates.
2. PWHT Records.
3. Fit-up reports.
4. Weld visual reports.
5. Painting/top coat report with surface finish report.
6. Dimensional inspection together with NDE & pressure test records.
7. Welder & welding operator qualification.
8. Approved Isometric drawings marked with unique weld numbers / NDT Drawings.
9. Authenticated copies of NDT operator’s certificates.
10. Records of any agreed deviations to the fabrication standards.

Welding Procedures shall be tested to demonstrate that acceptable welds can be made by the procedure. During WPS Qualification, the quality of welds shall be determined by both non- destructive & destructive testing as per the applicable code. Additional testing requirements specified in this specification shall also be carried out. The Welding Procedure Qualification Testing (WPQT) shall be witnessed by Company representative and also by a reputed TPI agency. Only qualified and approved WPSs shall be used for production welding.

QA 1.3.13 CTOD Testing:

1. Material subjected for CTOD Testing shall be tested and shall meet or exceed CTOD value of 0.35mm.
2. Welding consumable subjected for CTOD Testing shall be tested and shall meet or exceed CTOD value of 0.25mm.
3. WPS subjected for CTOD testing shall be tested and shall meet or exceed CTOD value of 0.20 mm.
4. CTOD testing shall be done from Govt. labs or Govt. accelerated labs with prior information to ONGC.



PP2.0. PIPING & PRESSURE VESSELS

PP2.1. Codes & Standards

The following Codes shall be the minimum acceptable standards for welding and inspection during piping & pressure vessel fabrication. The latest edition, addenda, code cases and supplement available at the time of bidding will be used. Any part of any other non-listed code referred to in these listed codes as augmentation is to be considered applicable.

ASME B31.3	Process Piping
ASME B31.4	Pipeline Transportation System for Liquid Hydrocarbons and other Liquids
ASME B31.8	Gas Transmission and Distribution Piping System
ASME BPVC Sec.VIII, Div.1	Rules for Construction of Pressure Vessels
AWS A2.4	Standard Symbols for Welding, Brazing and Nondestructive Examination.
ASME BPVC Sec.IX	Welding & Brazing Qualification
NACE MR0175	Standard Material Requirements - Metals for Sulfide Stress Cracking and Stress Corrosion Cracking Resistance in Sour Oilfield Environments
NACE TM0284	Standard Test Method - Evaluation of Pipeline and Pressure Vessel Steels for Resistance to Hydrogen-Induced Cracking
NACE TM0177	Standard Test Method - Laboratory Testing of Metals for Resistance to Sulfide Stress Cracking and Stress Corrosion Cracking in H ₂ S Environments
ASME BPVC Sec. V	Nondestructive Examination
ASME Sec. II, Part C	Specification for Welding Rods, Electrodes and Filler Metals
ASTM E164	Standard Practice for Contact Ultrasonic Testing of Weldments
ASTM E165	Practice for Liquid Penetrant Inspection Methods
ASTM E709	Practice for Magnetic Particle Examination
ASTM E94	Standard Guide for Radiographic Examination
ASTM E384	Standard Test Method for Knoop and Vickers Hardness of Materials
ISO 14731	Welding Coordination – Tasks and Responsibilities
ASNT SNT-TC-1A	Personnel Qualification and Certification in Nondestructive Testing



PP2.2. Weld Procedure Qualification & Documentation

The Contractor shall not commence production welding until appropriately qualified welding procedures have been accepted by the Company.

A. Piping

Weld procedures including brazing procedures shall be qualified as per ASME Code Section IX & ASME B31.3

The applicable WPQT (Welding Procedure Qualification Testing) was done in last 2 years for ONGC Job dated with effect from date of starting fabrication. If it is not of ONGC project, it shall be fresh WPQT for project specific. "

Such previously qualified welding procedures may be considered for use for CS & CS NACE Piping, where they comply with the present document and are appropriate to the scope of work. These WPSs should have been qualified by the same fabricator in the presence of reputed TPI agencies. New, project specific WPS shall be prepared using the old WPQT as explained above of earlier qualified WPSs as supporting documents. In this exercise, good engineering practice and guidelines given in ASME Sec. IX shall be followed and using PQRs in an arbitrary manner to support a new WPS will not be acceptable.

However, for critical applications involving the welding of CRA materials (SS, DSS, Cu-Ni, Cu etc.), previously qualified procedures are not acceptable and fresh project specific WPQT & WPS is required.

Mechanical testing of WPQT coupons for CS piping shall confirm to the requirements of ASME Sec. IX / ASME B31.3. In addition to the above requirement, hardness testing shall be performed on each test coupon. Maximum hardness value shall be 325 HV10 for normal service piping. For Sour Service piping, a maximum permitted hardness of 248 HV10 (22 HRC) shall apply. CVN (Charpy V Notch) Impact Testing of Carbon Steel Pipe work shall be performed in accordance with ASME B31.3 Table 323.2.2.

For each welding process, the welding procedures shall specify all equipment settings. The Contractor's Welding Supervisor shall check daily and record machine settings for each weld procedure used during welding activities. This record shall be available for audit by the Company representative.

B. Pressure Vessels

Welding Procedures shall be qualified as per ASME Sec. IX & ASME BPVC Sec. VIII Div.I



PP2.3. Welder Qualification

Welders shall be qualified as per ASME Boiler and Pressure Vessel Code, Section IX.

Qualification on production welds is not permitted.

A welder shall not be permitted to weld on pipe work or attachments to pipe work unless they are qualified to the procedure in use and the documentary evidence has been sighted by the Company representative.

Tack welds shall be made by a qualified welder using the same type of electrode as is used for the root pass.

The Company may request a retest of any welder at any time and from time to time during the work. If a welder fails to qualify, then at the discretion of the company representative, all non- installed welds completed by that welder shall be examined by additional radiographic tests, over and above that which would normally be required or specified in the drawings for that pipe work and the same shall be charged to the Contractor's account.

Welds not identified and recorded, or welded by unqualified welders, shall automatically be rejected. It will be the Contractor's responsibility to prove that the welds conform to the applicable Specification. This may require 100% radiography.

PP2.4. Production Welding

1. The quality of piping welding shall be such that a weld efficiency factor as defined in ASME B 31.3 of 1.0 is achieved.
2. The deposited filler metal shall match the chemistry, corrosion resistance (if required) and minimum physical properties of the parent metal when similar metals are welded.
3. Circumferential welds on pipes shall be staggered at least four times the pipe wall thickness or 25 mm, whichever is greater, apart.
4. Branch connections shall be joined to their headers with full penetration welds.
5. Backing rings, back-up rings or chill rings shall not be used.



6. Back or seal welding of screwed fittings is prohibited unless specified in the drawing or is part of the approved welding procedure.
7. Oxy-acetylene torches shall not be used for pre-heating.
8. Pipes of dissimilar materials shall not be welded to each other but shall be flanged unless otherwise approved.
9. Compressor and turbine piping, including lube and seal oil piping, and other piping requiring special cleaning as shown in the drawings provided by the supplier shall have the root pass deposited by the gas tungsten arc process. The backside of the root pass shall be purged with inert gas.
10. If the bore of the pipe is different from the bore of fittings or flanges, to which it is welded, by more than 3mm (total bore diameter), the thicker member shall be bored, taper bored or ground smooth to match the specified bore. Figure 328.4.3 of ASME B 31.3 will governs the geometry of all taper boring and beveling.
11. Coupling or other weld-on type branch connection shall be located at least 80 mm away from any weld joint.
12. When socket weld fittings or valves are used, pipe shall be spaced approximately 1/16 inch to avoid “bottoming” which could result in excessive welds stress.
13. The inside of the brazed fitting and outside of the tube shall be cleaned with sand Paper. Flux paste to be evenly applied to the joint.
14. Reinforcing pads shall be added only after external and internal visual inspection of the attachment. Reinforcing pads shall be provided with ¼” tapped weep hole. Weep holes should be plugged after welding of pads is over.
15. Exposed machined and threaded surfaces shall be protected from oxidation during heat treatment.
16. Flange bolt holes shall straddle the established horizontal and vertical centerlines of the pipe except where connection to equipment dictates otherwise.
17. Cleaning of the piping after fabrication and heat treatment shall be performed externally and internally to remove all loose scale, weld spatter, sand and other foreign materials.



18. Welding shall not be done when quality of completed weld would be impaired by prevailing weather conditions, air borne moisture, blowing sand or high winds. Windshields may be used when practical.
19. Temporary attachments to the outside of surface of the pipe shall not be made without the approval of Company. Any such attachments which are permitted shall be removed by grinding or by using Oxy – Acetylene torch to 3 mm above permanent material surface, removal of the remaining 3mm shall be by grinding, followed by MPI / DPI. Company may require an ultrasonic check to establish that the remaining wall thickness is not less than the design minimum. Arc air gouging, hammering or other mechanical means shall not be used for the removal of temporary attachments.
20. Welder shall be supplied with temple stick – thermal crayons or pended gauges so that welders and inspector can check and control the temperature of element.
21. No weld shall be coated, painted, hydro tested before it has been inspected and accepted.
22. No weld is to be cooled by quenching or by any means other than natural cooling.
23. Welding for Severe Cyclic Condition: The weld reinforcement shall be smooth and shall blend smoothly with the external surface of the pipe to minimize possible stress concentration effects.
24. Field Welding
- Where field welds are designated, the prefabricated pipe shall be cut off 150 mm longer than the dimensions shown on the pipe fabrication drawings to allow for modification then precise fit-up in place.
 - Additional field fit welds may be included in a spool by the Contractor for those spots which may have restricted site access or which may be cumbersome for transportation.
 - The location of field welds, where not indicated on the drawings, will be the responsibility of the Contractor.

PP2.5. NDT Techniques

NDT Techniques like RT, UT, MPI & LPT shall be used for the examination of welds as per the requirements given in this specification.



Radiography:

1. Radiography will be performed for every pipe thickness and material grouping and for each welding process and procedure, progressively throughout entire job. At least one of each type and position of weld made by each welder will be examined. A record shall be kept by the Contractor of the quality and extent of each welder's work.
2. Radiography is not required for the welds on slip-on flanges or socket welds or seal welds.
3. Fluorescent intensifying screens such as calcium tungsten shall not be used.
4. For each weld found to be defective two additional welds made by the same welder who produced the defective weld will be subjected to radiographic examination. These additional examinations will be made immediately after the defective welds is found and are in addition to the minimum examination requirements for the line class as specified in the drawings or specifications.
5. Weld repairs shall be re-examined by the same method used to detect the original defect.

PP2.6. NDT Procedure

Contractor shall prepare NDT Procedures covering all aspects of the work. NDT Procedures shall be submitted to the Company representative for review and approval. Written NDT Procedures shall be qualified as per the requirements of ASME Sec. V, in the presence of Company representative. Qualification of the NDT procedures shall be required before NDT can be performed on production welds.

A. Piping

NDT Procedures shall be prepared as per the requirements of ASME B31.3, ASME Section V and the applicable ASME Code Cases.

B. Pressure Vessels

NDT Procedures shall be prepared as per the requirements of ASME BPVC Sec. VIII Div.1 and ASME Sec. V



PP2.7. Extent of NDT Coverage

A. Piping

- I. Random radiography (10%) shall be performed covering on one weld in each 10 welds for each welder on the following:
 1. Water (in case of carbon steel)
 2. Air
 3. Chemical
 4. Diesel
 5. Closed & Open drain
 6. Relief
 7. Hydraulic Oil
 8. Oily water
 9. Glycol & Thermoil
 10. Vent gas
 11. Lube oil & Seal oil
- II. 100% Radiography shall be performed on size 2" and above and 10% on below 2" for the following:
 1. Crude oil
 2. Jet fuel
 3. Fuel gas / instrument gas
 4. Process gas
 5. Production flow lines (well fluid)
 6. Injection water
 7. Hydrocarbon (process)
 8. Water (in case of 90/10 Cu-Ni)
 9. H.P. and L.P. Flare lines.
 10. Piping system not covered under any of the above services
- III. For fillet welds and brazed joints where carrying out radiography is not possible, magnetic particle test or dye penetrant test shall be carried out. The extent of inspection shall remain same as for radiography.

All the lines which are stress relieved or have design pressure more than 50 Kg/ cm² shall be radiographed for 100% of weld joints even if not required as per I to III

Field welded joints, which cannot be leak tested due to unavoidable circumstances & reasons shall be 100 % examined by RT and MPI/LPT.



In addition to the requirements mentioned above, for welded joints of NACE material, 100 % hardness test shall also be carried out.

Welds, which cannot be radiographed because of their location, inaccessibility, excessive & impractical radiographic exposure time required or due to safety reasons, can be examined by ultrasonic and / or liquid penetrant / magnetic particle method as applicable with permission from Company. The extent of inspection shall be the same as for radiography

B. Pressure Vessels

NDT Coverage shall be as per the requirements given in ASME BPVC Sec.VIII Div.I and the design documents.

PP2.8. NDT Operator

NDT Operator Qualification & experience records shall be submitted for Company's review. NDT Operators shall be minimum Level II qualified, PCN qualification is preferred. Skill levels of NDT Operators shall be further examined by Company through practical mock tests & written examination. Contractor shall make necessary arrangements for the same with no additional cost to Company.

PP2.9. Advanced UT Techniques

PAUT (Phased Array Ultrasonic Testing) can be used for the examination of CS & CS NACE piping welded joints with thickness beyond 10 mm for which separate permission from Company is not required. However "*Project specific procedure qualification*" to be witnessed by ONGC/CA/TPI for the 1st time during start of NDT techniques..

The permission to use PAUT will be subject to satisfying the following conditions:

1. Past track record of the agency performing PAUT shall be submitted for Company's review and approval.
2. Written PAUT Procedure shall be prepared as per the applicable code and shall be submitted for Company's review and approval.
3. PAUT Procedure shall be demonstrated and qualified as per the Code requirements and to the satisfaction of the Company in the presence of Company Representative. During the demonstration, it shall be established that the scanning technique employed covers the entire weld volume and HAZ.
4. NDT Operator Qualification records (minimum level II) including experience in PAUT shall be submitted for Company's review and approval.
5. Skill levels of NDT Operators will be further examined through practical mock tests and written tests. Contractor shall make the necessary arrangements for the same with no additional cost to Company.
6. Familiarisation and interpretation Training on PAUT shall be provided to Company's inspectors as and when required with no cost to ONGC.



7. For any ambiguous indication observed in PAUT, especially in the case of volumetric discontinuities, if ONGC desires, RT of that joint shall be carried out without any additional cost to ONGC.
8. Soft copy of scan data (A-Scan, C-Scan, Sector Scan etc.) of each joint along with the software for viewing the same shall be submitted to ONGC.

PP2.10. NDT Acceptance Criteria

A. Piping

Technique	Material	Acceptance Criteria
RT	CS , SS	ASME B31.3
	CS NACE, Cu-Ni	ASME BPVC Sec.VIII Div. I, UW 51
UT	CS, CS NACE	ASME B31.3
PAUT	CS, CS NACE	ASME B31.3 & Code Case 181
MPI	CS, CS NACE	ASME B31.3
LPT	CS, CS NACE, SS, Cu-Ni	ASME B31.3

- a. Internal weld protrusion in pigged lines shall not exceed 1.6 mm.
- b. Orifice flange butt weld shall be internally ground smooth and flush.

B. Pressure Vessels:

ASME BPVC Sec. VIII Div.1

PP2.11. Heat Treatment

1. Preheat and post-weld heat treatment (PWHT) shall be in accordance with ASME B 31.3. ASME B31.4, ASME B31.8 or ASME BPVC Sec.VIII, Div.I, as applicable.
2. The method and equipment used in heat treatment shall be acceptable to the Company.
3. All threaded connections shall be protected from oxidation during heat treatment and be chased or gauge checked after heat treatment.
4. Exposed machined and threaded surfaces shall be protected from oxidation during heat treatment.
5. Cleaning of pipe work after fabrication and heat treatment shall be performed, externally and internally to remove all loose scale, weld spatter, sand and other foreign materials.



6. For all welds requiring PWHT, the specified inspection and NDT shall be performed after completion of PWHT process but not before the welds have cooled to ambient temperature. NDT prior to PWHT, performed in addition to mandatory NDT following PWHT, shall be at the discretion of the Contractor. However, where defects requiring repair are located by this inspection, it shall be brought to the notice of Company.
7. Machined surfaces shall be protected by a suitable paint or compound to prevent damage from scaling during PWHT.
8. After final heat treatment, the Contractor shall identify the piping as having received PWHT. The method of identification shall be recorded on the as-built isometric and P&ID together with the other recorded information.
9. A legible heat treatment chart shall be provided to the Company. This chart must show the rate of increase of temperature, the holding temperature and time and the rate of decrease of temperature.

PP2.12. Repair Welding

If the company representative considers a weld to be grossly defective, it shall be cut out and the joint re-welded and all costs associated therewith shall be the Contractor's responsibility.

Mechanical defects such as scratches and gouges may be ground smooth provided the depth of the defect does not exceed 10% of the nominal wall thickness of the pipe.

Repair welding shall only be carried out in accordance with an approved repair procedure. Minimum Pre-heat for repair welding shall be 50⁰C more than that used for production welding.

After gouging to remove the defects, the area shall be ground smooth and shall be examined with MPI to ensure that the entire defect has been removed. LPT shall be used for non-ferromagnetic materials. As a minimum, completed repairs shall be examined by the same NDT methods used for the original weld.

Only two times repairs are allowed on any welded joint.

Dents or grooves whose depth is greater than 10% of the nominal pipe wall thickness shall be removed by cutting out and replacing that length of pipe in which the defect occurs. The minimum length of a cutout shall be four times the nominal diameter or 150 mm, whichever is the lesser.

Internal weld metal projecting into the pipe on weld neck orifice flanges shall be removed and ground smooth with the pipe.



ST3.0. STRUCTURAL

ST3.1. Codes & Standards

The following Codes shall be the minimum acceptable standards for welding and inspection during Structural Fabrication. The latest edition, addenda, and supplement available at the time of bidding will be used. Any part of any other non-listed code referred to in these listed codes as augmentation is to be considered applicable.

AWS D1.1	Structural Welding Code - Steel
AWS D1.3	Structural Welding Code – Sheet Steel
AWS A2.4	Standard Symbols for Welding, Brazing and Nondestructive Examination.
AISC	Manual of Steel Construction – Allowable Stress Design. Specification for Structural Steel Buildings
API RP 2A	Recommended Practice for Planning, Designing and Constructing fixed Offshore Platforms – Working Stress Design
API Spec. 2B	Specification for Fabricated Structural Steel Pipe
API RP 2X	Recommended Practice for Ultrasonic & Magnetic Particle Examination of Offshore Structural Fabrication and Guidelines for Qualification of Ultrasonic Technicians
ASME BPVC Sec. V	Nondestructive Examination
ASME Sec. II, Part C	Specification for Welding Rods, Electrodes and Filler Metals
ASTM E164	Standard Practice for Contact Ultrasonic Testing of Weldments
ASTM E165	Practice for Liquid Penetrant Inspection Methods
ASTM E709	Practice for Magnetic Particle Examination
ASTM E94	Standard Guide for Radiographic Examination
ASTM E384	Standard Test Method for Knoop and Vickers Hardness of Materials
BS7448	Fracture Mechanics Toughness Tests
EEMUA158	Construction Specification for Fixed Offshore Structures in the North Sea
ASNT SNT-TC-1A	Personnel Qualification and Certification in Nondestructive Testing
ISO 14731	Welding Coordination – Tasks and Responsibilities



ST3.2. Welding Processes

Only Gas Metal Arc (GMAW), Gas Tungsten Arc (GTAW), Submerged Arc (SAW), Shielded Metal Arc (SMAW), or Flux Cored Arc (FCAW) welding process shall be used for production welding. Other welding processes shall not be used. Automatic stud welding machines can be used for welding of studs to steel (for fixing insulation etc.).

Use of GMAW process shall be limited to the following:

- GMAW welding shall not be exposed to air drafts greater than 8 Km/h.
- GMAW-S can be used for groove welds in materials 10 mm or less using a procedure qualified by the contractor.
- GMAW-S can be used for fillet welds of 20 mm or less
- GMAW-S may be used for the root pass only in combination with SAW welding, and for the root pass in non-critical joint applications.
- Spray transfer mode of metal deposition for GMAW is limited to the flat position. f)

Weld areas shall be blasted or ground to white metal prior to welding when GMAW or GMAW-S is used.

Use of FCAW process shall be limited to the following:

- FCAW welding with external gas shielding shall not be exposed to air drafts greater than 8 Km/h.
- Electrode diameters greater than 3 mm are not acceptable.
- Self – shielded flux core shall not be used as root or fill pass beneath other processes.
- FCAW welding shall not be used at any case for piping & structural welding during installation or otherwise in offshore environment."*

ST3.3. Weld Procedure Qualification & Documentation

The Contractor shall not commence production welding until appropriately qualified welding procedures have been accepted by the Company. All weld procedures to be utilized on this project shall be qualified.



Welding procedures shall be qualified in accordance with AWS D1.1 Structural Welding Code – Steel, except as modified by this specification: The essential variable list of all welding processes shall be increased to include any change in the manufacturing process for the base metal, i.e. separate procedures are required for As Rolled, Controlled Rolled, Normalized, Quench & Tempered or TMCP steel.

Welding of thin sheet shall be as per AWS D1.3 – Structural Welding Code – Sheet Steel.

Unless otherwise specified, all welds shall be full penetration multi-pass welds.

Draft / Proposed WPS shall be agreed with the Company prior to the commencement of procedure qualification.

The applicable WPQT (Welding Procedure Qualification Testing) was done in last 2 years for ONGC Job dated with effect from date of starting fabrication. If it is not of ONGC project, it shall be fresh WPQT for project specific."

Such previously qualified welding procedures may be considered for Structural Welding where they comply with the present document and are appropriate to the scope of work. These WPSs should have been qualified by the same Contractor in the presence of reputed TPI agencies. New, project specific WPS shall be prepared using the old WPQTs as explained above of earlier qualified WPSs as supporting documents. In this exercise, good engineering practice & AWS D1.1 guidelines shall be followed and using PQRs in an arbitrary manner to support a new WPS will not be acceptable.

In addition to the testing requirements specified in AWS D1.1 following tests as applicable shall also be carried out during WPS qualification.

A. Hardness Testing

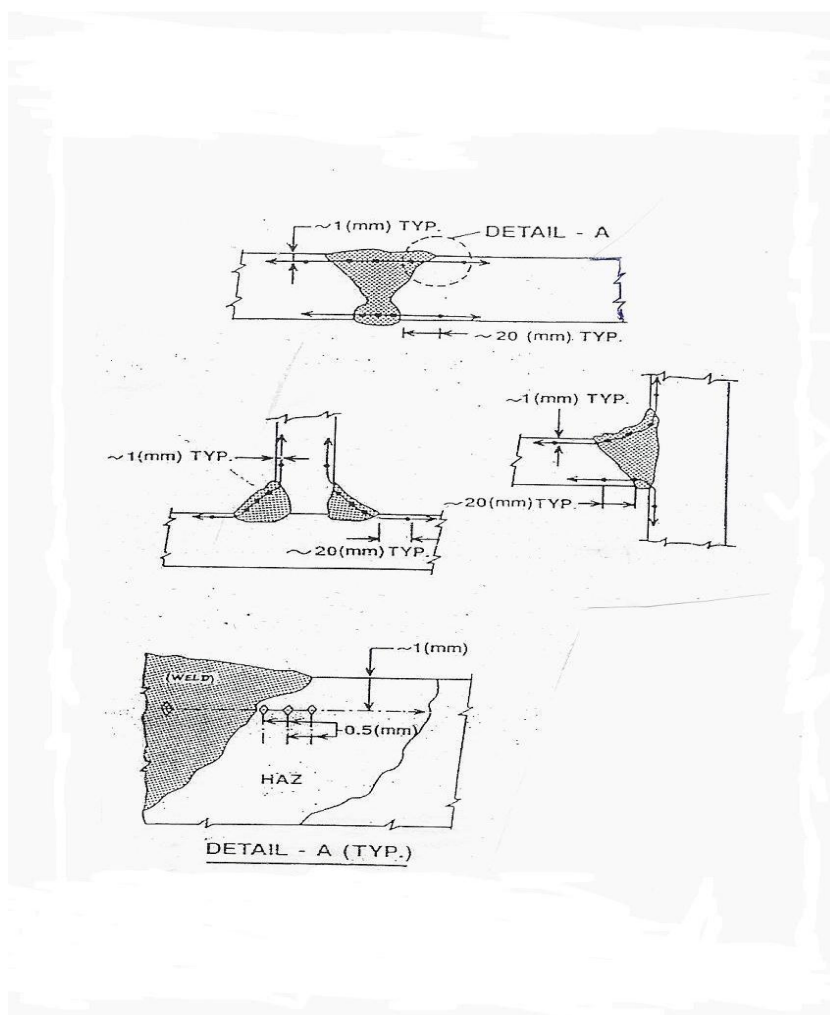
Welding procedure qualification shall include a hardness traverse of the HAZ, Weld Metal and base metal.

1. Hardness testing shall be performed along the transverse shown in Fig. 1.
2. The required hardness survey shall be tested on a suitable macro section machined from the same welded test assembly made to determine other weld joint properties.
3. The hardness surveys shall be prepared and tested in accordance with ASTM E 384, Standard Test Method for Knoop and Vickers Hardness (Hv) of Materials, using an applied load of 10 kgf.
4. Indentations shall be made along all of the transverses shown for each type of weld tested, approximately 1 mm below the surface of the base metal. In the weld metal, a minimum of three equally spaced indentations along the traverse shall be made. In the heat-affected zone, the indentations shall start as close to the fusion line as practicable. A minimum of three readings shall be taken at



each weld toe. One additional reading shall be taken at least 20 mm from the fusion line at each traverse to represent unaffected base metal.

5. The maximum hardness value obtained from any indentation shall not exceed 350 Hv. If any single value exceeds 350 Hv and a retest adjacent to the failed test also produces one or more values exceeding 350 Hv, the procedure qualification test has failed these requirements and a new test weld shall be made with some planned modifications of essential variables or techniques (change heat input, increase preheat, later bead sequence, etc.) and retest.
6. A photomacrograph of the hardness test section shall be included in the PQR clearly showing the hardness impressions.





B. Impact Testing

All groove welding procedure qualifications for Class A and Class B steels shall include Charpy V-notch impact testing of the deposited weld metal and the heat affected zone (HAZ). Locations for the weld and HAZ specimens shall be generally as shown in AWS D1.1, except that three sets of HAZ specimens shall be located at: (1) the fusion line (FL) (2); a position 2.0 mm into the HAZ from the fusion line (FL+2mm); and (3) a position 5.0 mm into the HAZ from the fusion line (FL+5mm). An additional set of specimens shall also be taken from the location centred within the root pass of the weld. For acceptance the average impact energy shall meet the minimum requirement of the relevant Specification with no single value more than 6.5J lower than the average requirement. When different classes of material are to be joined the required energy level is equal to that of the lower class joined. Testing temperature shall be -10°C.

C. CTOD Testing

CTOD testing may be used to justify an increase in the maximum thickness of material that can be welded without the application of PWHT as defined elsewhere in this Spec.

CTOD testing shall be carried out as per BS 7448/ISO15653. Each set of CTOD tests shall comprise a minimum of three valid specimens.

CTOD testing is required on full penetration test welds representing the maximum thickness of materials that are to be welded by any single process or combination of processes.

Separate tests are required to qualify single and double sided preparation.

The steel selected for performance of the test programme shall have minimum Carbon Equivalent not less than 0.02 of the maximum CE value to be used on the project. All test plates shall be welded using heat inputs representative of the highest to be used during production welding.

For each test the least values of δ_c , δ_u or δ_m shall be greater than or equal to 0.20mm when tested at 0°C unless specified otherwise in the relevant drawings.

Heat Input

Charpy qualification of weld deposit and HAZ is valid only for welding procedures with heat inputs maintained within $\pm 25\%$ of the tested weld. This may require more stringent tolerance on travel, speed, voltage and amperage.



In similar fashion the inter pass temperature is limited to that actually achieved and sustained during the procedure test.

ST3.4. Welder & Welding Operator Qualification

Welders shall be qualified as per AWS D1.1 Structural Welding Code – Steel. All welder qualification must have been performed on the entire weld thickness. ‘Tack Welders’ or ‘Fillet Welders’ partial qualification is not allowed. Qualification on production welds shall not be allowed.

ST3.5. Production Welding

1. **Chill rings and backing strips** can provide improved root beads on single sides welds. Their use, however is prohibited as they may cause fatigue crack initiation.
2. Unless otherwise specified, all welds shall be **full penetration multi-pass welds**. Full Penetration Welds shall be used for built-up-girders.
3. **All faying surfaces shall be seal welded.**
4. Welding shall proceed in a manner that **minimizes residual stresses or distortions**. The Contractor shall be responsible for preventing or correcting distortions. If excessive distortion becomes evident, corrective methods shall be applied as agreed with the Company Representative.
5. Welds shall **not be quenched or cooled other than by contact with the natural atmosphere**. Welds shall be protected from rapid cooling caused by rain, wind, or other inclement weather.
6. **Gas shielded welding processes (eg. FCAW, GTAW and GMAW), when used outdoor shall be provided with proper wind protection.**
7. **Pre-heat requirements**
Welding pre-heat shall be as specified in the Qualified Welding Procedure, but shall not be less than as specified in AWS D1.1 (Table 3.2). The guidelines given in Appendix XI of AWS D1.1 shall also be taken into account and adopted as appropriate. If any metal is damp or less than 10°C, a minimum preheat of 38°C shall be required regardless of thickness.



Preheating shall be carried out by using Oxy-fuel bulbous type torches, induction or electric resistance heating. Oxy-Acetylene cutting torches shall under no circumstances be used for preheat application.

8. **Inter – pass temperature**

The temperature of previously deposited weld metal and surrounding base metal within 75 mm of each side of the weld and throughout the wall thickness shall meet the following requirements prior to depositing subsequent beads

Minimum – Not less than the specified pre heat.

Maximum - 200°C or the maximum sustained and documented during procedure qualification, not to exceed 260°C.

9. **Arc Strikes and Temporary Attachments**

Arc strikes shall be ground out and repaired. After repair, MPI shall be carried out. Temporary attachments shall be removed by grinding or by using Oxy – Acetylene torch to 3 mm above permanent material surface, removal of the remaining 3mm shall be by grinding, followed by MPI / DPI. Company may require an ultrasonic check to establish that the remaining wall thickness is not less than the design minimum. Arc air gouging, hammering or other mechanical means shall not be used for the removal of temporary attachments.

10. **Post Weld Heat Treatment**

PWHT shall be required in the following circumstances or when shown on the design drawings:

- a) When fabricating tubulars with d/t ratios less than 20.
- b) For nodal joints where the minimum throat thickness exceeds 40mm.
- c) For other areas where the minimum throat thickness exceeds 50mm.

PWHT shall be carried out for all above three cases individually for Onshore-Yard fabrication in compliance to ST 3.5-point no.11. PWHT shall be carried out for all type of non-TMCP steel. For any special steel as specified by steel manufacturer and approved by ONGC for obviating PWHT with CTOD may be considered.

However PWHT is waved off for welding during installation phase at offshore and CTOD shall be carried out with qualified PQR (fresh) per every new project & subsequent WPS (fresh) is required for structural welding. In this case (offshore) the Fracture Mechanics Assessment (FMA) , its (FMA) separate report, Crack Tip Opening Displacement (CTOD) method and its (CTOD) test report , as per BS 7448/ISO15653 shall be used to obviate the requirement for PWHT (as for all applicable cases separately for b & c only).

Fracture Mechanics Assessment Report and CTOD, as per BS 7448/ISO15653 may be used to obviate the requirement for PWHT (as per b c), if approval in writing is given by the Company. In this case CTOD test shall be carried out during the WPS qualification.

This entire clause of ST .3.5.10 shall also be applicable for welding jobs with piping.



11. Criteria for PWHT

All PWHT shall be performed in accordance with AWS D1.1 and the applicable welding procedure qualification.

- The CONTRACTOR shall inform the COMPANY prior to any PWHT operation.
- No welding shall be performed on fabrications subsequent to PWHT.
- PWHT requirements shall be stipulated on the relevant WPS and shall comply with AWS D1.1, Section 5.8. The temperature for PWHT shall be $600^{\circ}\text{C} \pm 20^{\circ}\text{C}$ unless recommended otherwise by the steel manufacturer.
- For all welds requiring PWHT, the specified inspection and NDT shall be performed after completion of PWHT process but not before the welds have cooled to ambient temperature. NDT prior to PWHT, performed in addition to mandatory NDT following PWHT, shall be at the discretion of the Contractor. However, where defects requiring repair are located by this inspection, it shall be brought to the notice of Company.
- The contractor shall submit a heat treatment procedure for approval by the Company. This procedure shall define heat and cooling rate, holding time at temperature and details of temperature measurement and control methods.
- PWHT temperature/time charts shall be clearly identified and retained for inclusion in the project records.

12. Weld Through Primers

Weld through primers to be used during fabrication are subject to the approval by the Company and shall be included in the weld procedure qualification. During Weld Procedure Qualification, the thickness of weld through primer shall be measured. Any increase in thickness of primer in production shall necessitate re-qualification of the affected WPS.

ST3.6. NDT Techniques

NDT Techniques which are to be used for inspection are Visual Inspection, RT, UT and LPT / MPI.

ST3.7. NDT Procedures

Contractor shall prepare detailed written NDT Procedures and shall submit the same for Company's review and approval.

Structural	Technique	Specification
Structural General	RT, MPI & LPT	ASME Sec.V & AWS D1.1
Butt & T, K, Y Joints	UT	API RP 2X
UT of Tubular – (Factory Manufactured) Long Seam	UT	ASTM E-273 or ASTM E-164 and AWS D1.1
Butt Joints	Advanced UT System	ASME Sec. V, AWS D1.1 and applicable Code Cases



NDT Procedures including equipments shall be qualified as per the requirements of AWD D1.1, API RP 2X and ASME Sec. V as applicable in the presence of Company representative.

ST3.8. Extent of NDT Coverage

NDT coverage shall be as per API RP 2A with the following modifications.

A. Structural Tubulars

Radiographic Examination shall be performed for the following welds

1. 10 % RT of Longitudinal Weld Seams (L)
2. 100 % RT of all girth welds in tubular - Circumferential Weld Seams (C)
3. 100 % RT of Intersection of long seams (L) and Circumferential Seams (C)

Inspection requirement for mill fabricated structural tubular, who are authorized to put API monogram, shall be as per the applicable code (like API 2B).

B. Tubular Joints:

1. 100 % UT & MPI of Major brace to chord welding.
2. 100% UT & MPI of Major brace to brace welding.
3. Before fit-up, UT Lamination check shall be carried out on the area of the chord where bracing will be welded to ensure that the area is free from laminations.

C. Miscellaneous Bracing

1. 10% UT & MPI of Conductor Guide Bracing
2. 10% UT & MPI of secondary bracing and subassemblies, i.e., splash zone and / or mudline secondary bracing, boat landing etc.
3. 100% UT & MPI of attachment weld connecting secondary bracing / sub assemblies to main members

D. Deck Members

1. 100 % RT of all primary full penetration welds like splices in main skid beams, main truss beams and deck beams.
2. 10 % RT of all secondary full penetration welds including secondary deck beams.
3. 100 % Visual & MPI of all partial penetration welds including fillet welds.



Chevron / Transverse crack check using UT is required for primary steel with thickness > 25 mm welded using SAW process. Scanning shall be carried out along the weld cap.

100% UT and / MPI shall be carried out on all welds in built-up girders.

Notes:

1. Partial inspection should be conducted as 10 percent of each piece, not 100 percent of 10 percent of the number of pieces. Partial inspection should include a minimum of three segments randomly selected unless specific problems are known or suspected to exist. All suspect areas (e.g., areas of tack welds) shall be included in the areas to be inspected. If rejectable flaws are found from such 10% inspection, additional inspection should be performed until the extent of rejects has been determined and the cause corrected.
2. Welds, which cannot be radiographed because of their location, geometry, inaccessibility, excessive & impractical radiographic exposure time required or due to safety reasons, can be examined by ultrasonic and / or liquid penetrant / magnetic particle method as applicable with permission from Company. The extent of inspection shall be the same as for radiography

ST3.9. NDT Acceptance Criteria

Technique	Acceptance Criteria
RT	AWS D1.1
UT – Butt & TKY Joints	API RP 2X Level C
UT – Long Seam of Mill Fabricated Tubular	API RP 2X Level A

ST3.10. NDT Operator

NDT Operator Qualification & experience records shall be submitted for Company's review. NDT Operators shall be minimum Level II qualified, PCN qualification is preferred. NDT Operators doing examination of TKY joints should have previous verifiable experience in similar job. Skill levels of NDT Operators will be further examined through practical mock tests & written examination. Contractor shall make necessary arrangements for the same with no additional cost to Company.

ST3.11. Advanced Ultrasonic Systems

Phased Array UT (PAUT)/TOFD shall be used where the thickness is beyond 19 mm, for which permission is not required from Company. However *The PAUT/TOFD used shall satisfy the following conditions which has to be established by the NDT agency during the "Project specific procedure qualification" to be witnessed by ONGC/CA/TPI for the 1st time during start of NDT techniques.*

The **PAUT/TOFD** will be used subject to satisfying the following conditions:

1. Past track record of the agency performing PAUT / TOFD shall be submitted for Company's review and approval.



2. Written UT Procedure shall be prepared as per the applicable code and shall be submitted for Company's review and approval.
3. PAUT / TOFD Procedure shall be demonstrated and qualified as per the Code requirements and to the satisfaction of the Company in the presence of Company Representative. During the demonstration, it shall be established that the scanning technique employed covers the entire weld volume and HAZ.
4. NDT Operator Qualification records (minimum level II) including experience in PAUT / TOFD shall be submitted for Company's review and approval.
5. Skill levels of NDT Operators will be further examined through practical mock tests and written tests. Contractor shall make the necessary arrangements for the same with no additional cost to Company.
6. Familiarisation & interpretation Training on PAUT / TOFD shall be provided to Company's inspectors as and when required with no cost to ONGC.
7. For any ambiguous indication observed in PAUT / TOFD, especially in the case of volumetric discontinuities, if ONGC desires, RT of that joint shall be carried out without any additional cost to ONGC.
8. Soft copy of scan data (A-Scan, C-Scan, Sector Scan etc.) of each joint along with the software for viewing the same shall be submitted to ONGC.

ST3.12. NDT Waiting Period

NDT of primary structural welded members should generally be carried out 24 hrs after completion of welding.

ST3.13. Inspection of Low Fatigue Joints

All low fatigue joints shall be inspected for acceptance to required profile and toe grinding shall be performed, if required.

Disk test shall be performed as mentioned in AWS D1.1.

ST3.14. Repair Welding

Repair welding shall be performed strictly in accordance with the qualified repair welding procedure.

Removal of Defects



Removal of defects for repair may be by any of the following methods: machining, grinding, chipping, or air carbon arc gouging. The method shall produce a clean uncontaminated surface for installation of the repair weld.

Gouging

Oxygen gouging shall not be used in quenched and tempered, normalized or TMCP steels. All gouges shall be ground, power wire brushed, or grit blasted to remove all traces of residual carbon and oxidation.

After gouging to remove the defects, the area shall be ground smooth and shall be examined with LPT to ensure that the entire defect has been removed.

Completed repairs shall be examined by the same NDT methods used for the original weld

Only two times repairs are allowed on any joint.



PL4.0. SUBSEA PIPELINE SYSTEM

PL4.1. Codes & Standards

The following Codes shall be the minimum acceptable standards for subsea pipeline welding and inspection. The latest edition, addenda, code cases and supplement available at the time of bidding will be used. Any part of any other non-listed code referred to in these listed codes as augmentation is to be considered applicable.

DNV OS F101	Submarine Pipeline System
BS 7910	Guide to methods for assessing the acceptability of flaws in metallic structures
ASTM E1961	Standard Practice for Mechanized Ultrasonic Testing of Girth Welds Using Zonal Discrimination with Focused Search Units
AWS A2.4	Standard Symbols for Welding, Brazing and Nondestructive Examination.
NACE MR0175	Standard Material Requirements - Metals for Sulfide Stress Cracking and Stress Corrosion Cracking Resistance in Sour Oilfield Environments
NACE TM0284	Standard Test Method - Evaluation of Pipeline and Pressure Vessel Steels for Resistance to Hydrogen-Induced Cracking
NACE TM0177	Standard Test Method - Laboratory Testing of Metals for Resistance to Sulfide Stress Cracking and Stress Corrosion Cracking in H ₂ S Environments
ASME BPVC Sec. V	Nondestructive Examination
ASME Sec. II, Part C	Specification for Welding Rods, Electrodes and Filler Metals
ASTM E164	Standard Practice for Contact Ultrasonic Testing of Weldments
ASTM E165	Practice for Liquid Penetrant Inspection Methods
ASTM E709	Practice for Magnetic Particle Examination
ASTM E94	Standard Guide for Radiographic Examination
ASTM E384	Standard Test Method for Knoop and Vickers Hardness of Materials
ISO 14731	Welding Coordination – Tasks and Responsibilities
ASNT SNT-TC-1A	Personnel Qualification and Certification in Nondestructive Testing

PL4.2. Welding Processes

Various welding processes as given in DNV-OS-F101 can be used for production welding. If the contractor propose to use mechanized welding process, a complete description of the process including examples of previously qualified welding procedures and subsea pipeline



projects completed using proposed process shall be submitted for Company's review and approval. Mechanised and Automatic welding systems shall be subject to a detailed pre-qualification programme or documentation before they may be used. The extent and the contents of a pre-qualification programme for such mechanised welding systems shall be agreed before start up. The Contractor shall prove and document that the welding systems are reliable and that the process can be continuously monitored and controlled.

PL4.3. Welding Consumables

Welding consumables and welding processes shall give a diffusible hydrogen content of maximum 5ml / 100g of weld metal.

Cellulose coated electrodes may be used only subject to agreement for welding of Pipeline Girth welds in CS Line pipe with SMYS \leq 450 MPa. If used, the delay between completion of root pass and the deposition of hot pass shall be simulated during welding procedure qualification. If the use of cellulosic electrode has been agreed, the following additional requirements shall apply:

1. Pre-heat shall be minimum 100⁰C.
2. Delay between the completion of root pass and the start of depositing the hot pass shall be minimum 6 minutes.
3. Immediately upon completion of welding during welding procedure qualification, the test pieces shall be water quenched as soon as the temperature of the test piece is below 300⁰C.
4. Non destructive testing of the test pieces shall be by Automated Ultrasonic Testing (AUT) or by Radiographic Testing and Manual Ultrasonic Testing.

Low Hydrogen Electrodes with uphill techniques shall be used for all repairs, when external lineup clamp is used, tie-in, special crossings and **fillet welds**.

PL4.4 Welding Procedure Qualification

Welding Procedure shall be qualified as per DNV-OS-F101(Submarine Pipeline Systems) except as modified by this specification. Previously qualified welding procedures are not acceptable. However, for welding of CS & CS NACE Line Pipes (Girth welds) of SMYS < 450 MPa, WPS for new production job may be based on a previously qualified WPQR (Welding Procedure Qualification Record) provided

- a. The applicable WPQT (Welding Procedure Qualification Testing) was done in last 2 years for ONGC Job dated with effect from date of starting fabrication. If it is not of ONGC project, it shall be fresh WPQT for project specific.
- b. WPQT was witnessed by a reputed TPI agency.
- c. Meet all the requirements of this specification and DNV-OS-F101.
- d. Match all the essential parameters as given in DNV-OS-F101.
- e. Written approval shall be obtained from Company.

For new WPS, the contractor shall first submit the Preliminary WPS (pWPS) for Company's review and approval. The pWPS shall contain all the relevant information required for the applicable welding process, as given in Clause D700 of DNV-OS-F101. After getting the approval of pWPS, the contractor can go ahead with the WPS qualification as per the requirements given in



DNV-OS-F101. Qualification welding shall be performed using the type of welding equipment to be used for production welding and under conditions that are representative of the actual working environment for the work (for WPSs to be used on pipelay barges, qualification welding has to be carried out on floating vessels / barges).

WPS qualification shall be witnessed by Company Representative and a reputed TPI agency.

Repair welding procedure shall be qualified separately. Pre-heat for repair welding shall be minimum 50°C above the minimum specified pre-heat for production welding. Re-repair welding procedure shall also be qualified separately.

In case of riser line, as it is considered part of pipeline, this WPQT & WPS is applicable till the flange joint of shutdown valve or launcher whichever is earlier. In case, this riser line is prefabricated in yard, the same WPQT & WPS is applicable. However internal/external line clamp may not be required as mentioned in clause PL4.6.”

PL4.5. Welder and Welding Operator Qualification

Welders and Welding Operators shall be qualified as per the requirements of DNV-OS-F101 in the presence of Company Representative and a reputed TPI agency. Welders shall be qualified under conditions that are representative of the actual working environment. (Pipeline welders shall be qualified on floating vessel / barge)

PL4.6. Production Welding

The type of welding Equipment and Welding Procedure shall be qualified prior to the start of installation welding.

Internal line-up clamp shall be used for pipeline of size 6” and above. Internal lineup clamp shall remain in place at least until the root pass is completed around the full circumference.

External lineup clamp shall not be removed until a minimum of 50% of root pass, uniformly spaced around the circumference, has been completed.

Arc strikes – arc shall be struck only on fusion faces and not on other areas of the pipe.

The pipelay barge shall not be moved before the first hot pass is completed.

PL4.7. Non Destructive Testing

The extent of NDT for installation girth welds shall be 100% Automated Ultrasonic Testing (AUT) or Radiographic Testing. Radiography shall be carried out using X-ray with panoramic exposure. Gama ray may be used in case of inaccessible joints with approval of ONGC (with submission of specific joint details & with AFC).

For wall thickness > 25 mm, AUT should be used. For >25mm, if RT is used, it shall be supplemented with Ultrasonic Testing.

While using GMAW (like mechainsed or semi-automatic welding) or FCAW welding process, AUT is the preferred NDT technique.



100% Ultrasonic Testing of first 10 welds shall be carried out while using GMAW or FCAW processes, when starting installation or when resuming production after suspension of welding and when radiographic testing is the primary NDT technique. If Ultrasonic Testing reveals defects not discovered by radiography, the extent of Ultrasonic Testing shall be 100% for the next 10 welds. If the results of this extended testing are unsatisfactory, the welding shall be suspended until the causes of the defects have been established and rectified.

UT lamination check shall be carried out on 50 mm wide band at the flame cut pipe ends.

For "Golden Welds" (critical welds e.g. tie-in welds that will not be subject to pressure testing, etc.) 100% ultrasonic testing, 100% radiographic testing, and 100% magnetic particle testing or 100% liquid penetrant testing of non-ferromagnetic materials shall be performed. If the ultrasonic testing is performed as automated ultrasonic testing, the radiographic and magnetic particle/liquid penetrant testing may be omitted subject to agreement.

Prior to commencement of WPS qualification, contractor shall prepare and submit NDT Procedures (RT, MPI, LPT, UT/AUT) for Company's review and approval.

NDT Procedures, Equipment qualification and Acceptance Criteria shall be as per the requirements given in Appendix D of DNV-OS-F101.

AUT Procedures, Equipment and qualification for AUT shall be as per the requirements given in Appendix E of DNV-OS-F101. Defect Acceptance Criteria shall be arrived at using ECA. AUT

shall be performed in accordance with DNV-OS-F101 Appendix E and ASTM E1961.

If the Contractor proposes to use AUT, the contractor shall arrange familiarization and interpretation training on AUT for Company inspectors as and when required without any additional cost to Company

If using AUT, Contractor shall carry out ECA to arrive at weld acceptability criteria which is subject to approval by Company. As a minimum, requirements of Appendix A of DNV-OS-F101 shall be met. Details of laboratory / agency performing ECA shall be submitted to Company for review and acceptance. The agency should have skilled personnel and previous experience to carry out ECA as per BS 7910 requirements.

The effectiveness of the AUT Procedure shall be demonstrated by a qualification programme in accordance with DNV-OS-F-101, Appendix E, Section H. The AUT system must demonstrate the ability to detect and accurately size length and vertical height of indications with a resolution compatible with the applicable acceptance criteria.

NDT Operators shall be qualified and certified in accordance with the requirements of Level II of the latest edition of SNT-TC-1A or equivalent PCN or CSWIP Level II.



Additionally, AUT operators shall have received a sufficient level of training of Automated Ultrasonic Testing, including practical and theoretical aspects applicable to the equipment and configuration to be examined. This training shall be documented and will be verified by the Company.

PL4.8. Repair Welding

Repair welding shall be performed in accordance with a qualified repair welding procedure. After grinding / gouging, Magnetic particle testing or liquid penetrant testing of non-ferromagnetic materials shall be performed to verify complete removal of defects before commencing weld repairs.

Pre-heat for repair welding shall be 50⁰C more than that used for production welding.

Only two times repairs are allowed on any joint.

If the repair welding station is after the pipe tensioner, a weld repair analysis shall be carried out.

The analysis shall determine the maximum allowable excavation length and depth combinations taking in to account all stresses acting at the area of the repair. The weld repair analysis shall be subject to agreement.

PL4.9. Other Materials

For materials other than CS & CS NACE, contractor shall prepare various procedures like WPS, NDT etc. and shall submit for Company's review and approval.



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ANNEXURE I

WELDING OF DUPLEX STAINLESS STEEL

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WELDING SPECIFICATION FOR DUPLEX STAINLESS STEELS

1.0 WELDING PROCESS

Shielded Metal Arc Welding (SHAW), Gas Tungsten Arc Welding (GTAW), Submerged Arc Welding (SAW) and Plasma Arc Welding (PAW) processes are suitable for Duplex stainless steel. These Welding methods along with the related operational precautions such as cleanliness and protective gas shielding should be used for making duplex stainless steel welds. Shielding / purging gases shall be selected ensuring freedom from hydrogen.

2.0 MICROSTRUCTURE

The ferrite content of the weld metal estimated through metallographic examination, should be between 30% to 55% to obtain weld joints with the best ductility and corrosion resistance. The filler metal composition and the welding heat input should be so selected as to give the ferrite content of the weld metal between 30% to 55%.

3.0 FILLER METALS (Welding Consumables)

Table 1 enclosed herewith tentatively lists the different filler metals used for duplex stainless steels conforming to UNS S 31803. Welding consumables shall be used only after conducting consumable qualification tests. Consumables shall be degreased or baked and stored in accordance with the manufacturer's recommendations.

4.0 MECHANICAL PROPERTY REQUIREMENTS

The weld metal should have the following mechanical properties :

4.1	Tensile Strength	-	680 – 880 N/mm ²
4.2	Yield Strength (0.2% Offset)	-	450 N/mm ² (Min.)
4.3	Elongation	-	25% (Min.)



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4.4 Impact Energy (Charpy V-notch Valves)

At + 20°C (68°F) - 100 Joules Average (72 ft. lb)
75 Joules Average (54 ft. lb)

At –30°C (-22°F) - 60 Joules Average (43.2 ft. lb)
40 Joules Average (28.8 ft. lb)

5.0 QUALIFICATION TESTS

5.1 Welding Procedure Qualification Tests

5.1.1 General

Each particular welding procedure shall be specially qualified for the job; no previous test reports shall be recognized as a qualification of the work to be performed. The welding filler metal to be used shall be of a grade, which will yield a weld metal equivalent to that of the base metal. Welding consumables shall be subjected to initial qualification testing and the consumable shall require company's approval. During Procedure Qualification, the heat input for 22% Cr Duplex steels shall be limited to 0.8 – 2.5 KJ/mm. In production welding, the heat input shall not deviate from that qualified by more than +/- 10%. P numbers shall not apply to duplex stainless steels. Each alloy designation shall be separately qualified in accordance with this specification.

5.1.2 Welding consumable qualification tests and welding procedure qualification tests shall be conducted before the start of procurement by employing an approved welding procedure in presence of the Company's Representative. The welding procedure shall be prepared by the Contractor based on the information provided by the Supplier of raw materials and/or electrodes Supplier and approved by the Company. Welding procedure shall be such that it gives maximum hardness on the outer surface of pipe.

All the mills supplying the raw material/pipes etc. shall be required to pass the tests required for procedure qualification testing. Approved procedure shall be common to all the mills.

Laboratory tests shall be performed at an official Laboratory approved by the Company. Sufficient advance notice shall allow the Company to witness all or part of the tests.

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5.1.3 Test Samples

Tests mentioned below shall be performed on welded test pieces and shall include the parent metal, heat affected zone and the weld metal.

5.1.4 Procedure Qualification Tests shall be carried out as given below :

i) Chemical Composition and Microstructure Examination

The ferrite content measurement of test pieces shall be carried out by both the following methods:

- a) Metallographic determination and
- b) Magnegage method (According to Kotecki)

The procedure of ferrite measurement and the calibration of measuring instrument shall bear the approval of the Company before being employed.

ii) Mechanical Properties

These tests shall include tensile testing, impact strength and bend test. Bend tests shall be performed in accordance with ASTM A 370 with a plunger dia equal to 4 times the thickness. No defect shall be visible on bending.

iii) Hardness Tests

Each qualification test shall include a cross sectional hardness survey.

A complete survey of the weld, heat affected zone and the base metal shall be performed according to the following procedure :

- the test method shall be as per ASTM E 18.
- the distance between indentations shall be a maximum of 1 mm.
- the results shall not exceed RC 28.

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iv) Corrosion Tests

a) Intergranular Corrosion Tests (HUEY)

The welds shall be subjected to ASTM A 262 practice C (HUEY Test). Weight loss shall not exceed 3 to 4 mils/month.

b) Chloride Stress Corrosion Cracking Test.

This type of test shall be conducted on the material at 155° C with aeration in 45% MgCl₂ solution as per ASTM G 36. Stress to cause rupture in 500 hours shall exceed 0.35 times the ultimate tensile strength. This test is required to be done per heat for each mill before start of procurement.

c) SSCC Test

Resistance of the material to SSCC shall be tested using :

a) NACE TM 01-77 test solution (Test temp. 24 Deg. C). Minimum stress for cracking in 720 Hrs shall be 350 N/mm².

b) NACE TM 01-77 test solution (test temp. 90 Deg C and total pressure of H₂S = 16 Bars).

Min. stress for cracking in 720 Hrs = 325 N/mm².

v) Radiography

The welds shall be 100% radiographed shall be as per ASME, Section – VIII, Division – I, UW – 51.

vi) Dye Penetrant / MP Testing

All fillet and groove welds other than these radiographed shall be tested by dye penetrant testing or by magnetic particle testing method. No defect shall be accepted.



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vii) Heat Treatment (if required)

Suitable heat treatment procedure shall be established for retaining the Duplex S.S. properties of welded joints which shall be approved by the Company before implementing.

5.2 Welder Qualification Tests

Welders shall be qualified at the fabrication yard / barge employing the qualified welding procedure. The test pieces of each welder shall be subjected to mechanical tests, radiographic examination, DPT/MP Test, microstructure examination and cross-sectional hardness survey with the same test procedure and acceptance criteria as mentioned in 5.1 above.

6.0 FABRICATION

6.1 *No fabrication shall start until the Company has approved the chemistry of the materials, the results of welding procedure qualification tests and welders are qualified as per the approved procedure.*

6.2 Working practices shall be designed to minimize contamination and before welding, internal and external surfaces shall be cleaned for a distance of at least 50mm from the fusion face.

6.2 In production welding the heat input shall be monitored and the same shall not deviate from the qualified WPS by more than +/- 10%.

6.2 Production/Fabrication Tests

Shop/Site Fabrication Tests for each weld shall include :

- Non – destructive hardness tests by portable hardness tester

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- Radiography
- DPI/MP Examination
- Ferrite Measurement by either
 - a) Magnegage method (extended range, according to Kotecki)

OR

- b) Forster Probe Method.

Procedure	Supplier Commercial Name	Typical Chemical Composition in %	Comments
Plasma auto or Manual	Smitweld SW 4462 (Revised Composition)	C:0.010 Mn:1.6 Si:0.25 P:0.20 S:0.008 Cr:23.0 Ni:8.8 Mo:3.1 N:0.012	Filler metal recommended when as welded
	Thyssem	C:0.016 Mn:1.57 Si:0.17 Cr:22.8 Ni:9.18 N:0.04	Very low nitrogen (traces) ferrite level practically identical to 22-6-31.
	Thermanit 22- 09		Excellent results when welded with nitrogen in welding gas.

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SAW	Thyssen Thermanit	C:0.016 Mn:1.57 Si:0.17 Cr:22.8 Ni:9.18 N:0.04	With flux SAP CN 100 – as welded condition gives ferrite range 35- 65%
SMAW	Thermanit 22- 09	C ≤ 0.030 Cr:22.0 to 23.0	
	Sandvik 22- 93LR Smitweld Arosta 4462 Philips Rs 22-9- 3LC Avesta 223 FAL-PW	Ni:9 to 10 Mo ≈ 3, N:0.10 to 0.15	These electrodes even with low heat input, give welds with specified ferrite range.

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