Poseidon Pipeline Project - Offshore Section Update

Specification for Line Pipe

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PROJECT 406010-00159 - SPECIFICATION FOR LINE PIPE

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1 INTRODUCTION

1.1 Background

The Poseidon Pipeline Project, developed by IGI Poseidon S.A., will be designed for the supply of gas from Turkey and the Eastern Mediterranean region to the European market through the interconnection of the Greek and Italian gas networks.

The Poseidon Pipeline consists of two sections:

- An onshore section, stretching from Kipi (north-east of Greece, next to the Greek Turkish border) to the north western coast of Greece (Thesprotia area);
- An offshore section, from the north-western coast of Greece to Italy (Figure 1-1).

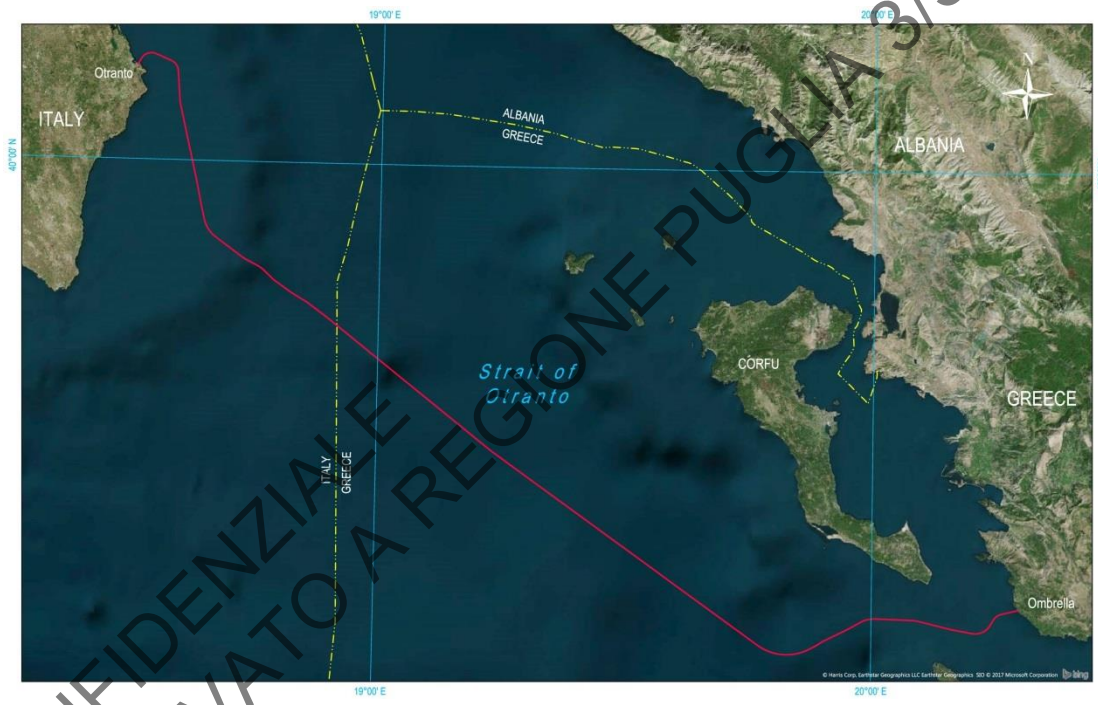


Figure 1-1 Poseidon Pipeline Project – Offshore Section

The offshore section of the Poseidon pipeline comprises:

- A compressor and fiscal metering station next to the Greek landfall (Thesprotia area);
- A deep water offshore pipeline from the Greek landfall to Italy (Otranto, Apulia region). The offshore section (about 200 km, ca. 1,370 m water depth) will cross the Greek shelf, descend the slope into the north Ionian Basin and then ascend the Italian slope, to make landfall east of Otranto;
- A receiving fiscal metering and pressure reduction station in Italy (Otranto, Apulia region);
- Two short buried onshore pipeline sections connecting compressor station in Greece and metering station in Italy to the respective landfalls, including associated scraper launching and receiving facilities.

The FEED phase of the Poseidon Pipeline Project was completed in 2013 and designed for a maximum flow rate of 12 BNCMA of gas (12.66 BSCMA).

INTECSEA's scope of work is named the Poseidon Pipeline Project - Offshore Section Update. It concerns the Design Update to accommodate a maximum flow rate of 20 BSCMA of gas (which represents a potential development of the gas pipeline, not yet authorized, but evaluated for the maximum design capacity and related technical aspects) for the deep water offshore pipeline from the Greek landfall to Italy (Otranto) and the short onshore buried pipelines connecting compressor station in Greece and fiscal metering and pressure reduction station in Italy to the respective landfalls. Updating of FEED specific aspects for the Greek onshore section, such as the geological, geotechnical, route selection and civil design aspects is not included in the scope.

The document numbers for the FEED Revision have a new CTR number (1000 series).

1.2 Document Scope

This document presents the minimum technical requirements for the manufacturing and fabrication of SAWL pipe for the offshore pipeline section of the Poseidon Project, including the short onshore pipeline sections between the landfalls and the onshore stations.

For dimensions and quantities, see Material Take-Off (Doc. No. IGI-1207-10-PL-MTO-001).

2 DEFINITIONS AND ABBREVIATIONS

2.1 Definitions

Definitions applicable to the Project are as follows.

COMPANY	IGI Poseidon (50% EDISON S.p.A. and 50% DEPA)
CONTRACTOR	The Party, which manufactures and/or supplies material, equipment and services to perform the duties as specified in the scope of supply.
May	indicates possible course of action
Shall	indicates mandatory requirement
Should	indicates preferred course of action
Will	indicates an intention of action

2.2 Abbreviations

Abbreviations applicable to the Project are provided below:

API	American Petroleum Institute
ASNT	American Society for Non-Destructive Testing
ASTM	American Society for Testing and Materials
AUT	Automatic Ultrasonic Testing
BOF	Basic Oxygen Furnace
BS	British Standard
CTOD	Crack Tip Opening Displacement
DAC	Distance Amplitude Curve
DNV GL	Det Norske Veritas Germanischer Lloyd
DWTT	Drop Weight Tear Testing
EAF	Electric Arc Furnace
EPC	Engineering, Procurement and Construction
EPIC	Engineering, Procurement, Installation and Construction
FEED	Front End Engineering Design
FL	Fusion Line
FSH	Full Screen Height
HAZ	Heat Affected Zone
ID	Internal Diameter

IGI	Interconnector Greece – Italy
ISO	International Organization for Standardization
JCOE	J-ing, C-ing, O-ing, and Expansion (Pipe Manufacturing Method)
LLI	Long Lead Items
LRF	Ladle Refinery Furnace
MDT	Minimum Design Temperature (specified in the Material Take-Off, Doc. No IGI-1207-10-PL-MTO-001)
MIP	Manufacturing and Inspection Plan
MPQT	Manufacturing Procedure Qualification Test
MPS	Manufacturing Procedure Specification
MTS	Material Testing System
MUT	Manual Ultrasonic Testing
NDE	Non Destructive Evaluation
NDT	Non Destructive Testing
OD	Outside Diameter
OoR	Out-of-Roundness
Pcm	Cracking parameter
PDF	Portable Data Format
PHS	Pipe History System
PQR	Procedure Qualification Record
PRF	Pulse Repetition Frequency
QCP	Quality Control Plan
SAW	Submerged Arc Welding
SAWL	Longitudinally Submerged Arc Welding
SCADA	Supervisory Control and Data Acquisition
SMAW	Shielded Metal Arc Welding
SMYS	Specified Minimum Yield Strength
TMCP	Thermo-Mechanical Control Process
UOE	U-ing O-ing and Expansion (Pipe Manufacturing Method)
UT	Ultrasonic Testing
UTS	Ultimate Tensile Strength
VC	Scanning Velocity

VD	Vacuum Degassing
WM	Weld Metal
YS	Yield Strength

3 CODES AND STANDARDS

The latest issue of the following codes, standards and regulations shall form part of this document unless a specific edition or publication year is given. In the event of conflict between this document and other specifications, data sheets, applicable codes or references, written clarification shall be sought from the COMPANY before proceeding with the work.

3.1 American Petroleum Institute (API)

1. API 5L1 — Recommended Practice for Railroad Transportation of Line Pipe
2. API RP 5LW — Recommended Practice for Transportation of Line Pipe on Barges and Marine Vessels
3. API RP 5L3 — Recommended Practice for Conducting Drop-Weight Tear Tests on Line Pipe

3.2 American Society for Testing and Materials (ASTM)

4. ASTM E 92 — Test Method for Vickers Hardness of Metallic Materials
5. ASTM E 112 — Standard Test Methods for Determining Average Grain Size
6. ASTM E 709 — Standard Guide for Magnetic Particle Examination

3.3 British Standards (BS)

7. BS 7448-1 — Fracture mechanics toughness tests - Part 1: Method for determination of KIC, critical CTOD and critical J values of metallic materials
8. BS 7910 — Guide on methods for assessing the acceptability of flaws in metallic structures

3.4 Det Norske Veritas Germanischer Lloyd (DNV GL)

9. DNVGL-ST-F101 — Submarine Pipeline Systems, 2017

3.5 European Standards

10. EN 1321 — Destructive Test on Welds in Metallic Materials. Macroscopic and Microscopic examination of Welds
11. EN 10204 — Metallic materials. Types of inspection documents

3.6 International Organization for Standardization (ISO)

12. ISO 148 — Steel – Charpy Impact Test (V-Notch)
13. ISO 3690 — Welding and Allied Processes - Determination of Hydrogen Content in Ferritic Steel Arc Weld Metal

14.	ISO 6507-1	Metallic Materials – Hardness test – Vickers Test – Part 1: HV5 to HV10
15.	ISO 6892-1	Metallic materials - Tensile testing Part 1 : Method of test at ambient temperature
16.	ISO / DIS 6892-2	Metallic Materials – Tensile Testing Part 2 : Method of Test at elevated temperature
17.	ISO 9001/9002	Quality systems
18.	ISO 10893-9	Non-destructive testing of steel tubes Part 9: Automated ultrasonic testing for the detection of laminar imperfections in strip/plate used for the manufacture of welded steel tubes

3.7 Poseidon Pipeline Project - Offshore Section Update Project Documents

19.	IGI-1207-10-PL-MTO-001	Material Take-Off
20.	IGI-207-10-PL-SPC-003	Specification for Internal Flow Coating
21.	IGI-207-10-PL-SPC-004	Specification for Anti-Corrosion Coating

3.8 National Regulations

The CONTRACTOR shall also be responsible for ensuring compliance with any Greek and Italian national regulations or requirements.

3.8.1 Greece

The requirements as stipulated in Greek Technical Regulation 'Natural Gas Transmission Systems operating at maximum pressure of over 16 Bar', Ministerial Decision D3/A/4303/PE 26510/12 (Gov. Gaz.-603/B/05.03.12) as amended by Ministerial D3/A/8857/2012 (Gov. Gaz. 20126/b/20.06.12) shall be met for the Greek onshore pipeline of the Poseidon Project.

Additional requirements for the manufacturing and fabrication of SAWL pipe are specified in below DESFA Specifications. These Specifications are listed in Annex C of the Greek Technical Regulation 'Natural Gas Transmission Systems operating at maximum pressure of over 16 Bar':

22.	DESFA 171-1	High Pressure (HP) Transmission Systems – Steel Pipe
23.	DESFA 900-3	High Pressure (HP) Transmission Systems – Material Color Coding
24.	DESFA 970-2	High Pressure (HP) Transmission Systems – Shop Inspection for Equipment and Materials for NGT Project
25.	DESFA 970-3	High Pressure (HP) Transmission Systems – Inspection and Test Instructions

3.8.2 Italy

The requirements as stipulated in Decreto del Ministero dello Sviluppo Economico 17 aprile 2008, “Regola technica per la progettazione, costruzione, collaudo, esercizio e sorveglianza delle opere e degli impianti di transporto di gas naturale con densità non superiore a 0,8” shall be met for the Italian onshore pipeline and offshore pipeline within the limits of Italian Territorial Waters.

4 GENERAL REQUIREMENTS

4.1 Quality Assurance and Control

The following documents shall be submitted by the CONTRACTOR to the COMPANY:

- Quality Manual
- Production Schedule
- Manufacturing and Inspection Plan (MIP)
- Manufacturing Procedure Qualification (Final Qualification Report)
- Plate and pipe traceability procedures
- Pipe handling, loading, transportation and packing procedures

The following documents shall be submitted at the bid stage:

- Quality Manual
- Production Schedule (preliminary)
- Manufacturing Procedure Specification (MPS) (preliminary)
- Manufacturing and Inspection Plan (MIP) (preliminary)
- Welding Procedure Specification (preliminary)
- NDT procedures (preliminary)
- Production statistics from previous similar pipe production

A Quality System according to ISO 9000 series shall be implemented by the CONTRACTOR, including the corresponding certification.

The Quality Manual shall show the organization and methods of the quality assurance and quality control systems employed by the CONTRACTOR for manufacture and supply of the line pipe.

All testing and inspection activities shall be indicated in the Manufacturing and Inspection Plan.

A system for traceability of the heat number and the records from all required tests to each individual pipe is to be detailed in a written procedure. Care shall be exercised during storage and handling to preserve the identification of materials.

Three copies of the documentation requirements, as stated in DNVGL-ST-F101, shall be submitted to the COMPANY, for review and acceptance. The final report shall be supplied digitally with all documentation in PDF format.

Pipe tracking data shall be in Microsoft Excel format by ascending pipe number and shall include pipe number, size, weight, height, length, heat number and shipping identifier.

Pipe heat tracking data shall be in Microsoft Excel format and shall include heat number, chemical composition, Pcm, calcium to sulphur ratio and derived mechanical properties.

4.2 Installation and Service Condition

The line pipe to be supplied in accordance with this document shall be SAWL 485 FDU as per DNVGL-ST-F101.

The line pipe supplied in accordance with this document will be used for the construction of onshore and offshore pipelines installed using the S-lay or J-lay installation method (offshore) and traditional cross country construction methods (onshore).

The contents of the pipe will be dry, sweet natural gas.

The line pipe shall meet the following Supplementary Requirements of DNVGL-ST-F101, Section 7, Clause 7.9.2, 7.9.4 and 7.9.5:

- Fracture arrest properties, suffix F
- Dimensional, suffix D
- High Utilization, suffix U.

5 PROCESS OF MANUFACTURE AND MATERIAL

5.1 General

All manufacture shall be carried out in accordance with a pre-qualified Manufacturing Procedure Specification (MPS) and Quality Control Plan (QCP) produced by the CONTRACTOR as stipulated in DNVGL-ST-F101, Section 7.1.7 and 7.1.8, and accepted by the COMPANY. Manufacturing Procedure Qualification Test (MPQT) requirements are detailed in Appendix A.

In addition to the essential variables listed in DNVGL-ST-F101 Section 7.1.7 the following variables also apply:

- Steelmaking and casting route
- Plate rolling sequence
- Chemical composition
- Mechanical expansion ratio
- Welding Procedure Specification
    - any change in consumable trade name, or source of origin
    - any change in wire / flux combination
    - any increase in the number of electrodes used
    - any change in value of heat input, voltage, current or travel speed of more than 10 %
- Plate Mill
- Pipe Mill

Modification of established and qualified essential variables shall not be allowed during pipe production, without appropriate COMPANY accepted re-qualification.

The steel shall be made by the Basic Oxygen Process. The steel shall be fully killed and made to fine grain practice, vacuum degassed and desulfurized. Details of the inclusion shape control treatment shall be included in the MPS.

Slabs shall be produced by the continuous casting process, with precautions to avoid centerline segregation. The methods for mitigating and monitoring segregation shall be included in the MPS. All slab surfaces shall be free of injurious defects and shall be suitable for producing plate for manufacture of coated line pipe.

All plates shall be supplied using the thermo-mechanical control process (TMCP), condition M as per DNVGL-ST-F101. The TMCP definition refers to the use of properly instrumented controlled rolling practices, followed by air cooling or water cooling. Water-cooling may be interrupted or followed by tempering. No skelp (plate) in the plate mill shall be dye stamped.

Pipes shall be fabricated using the UOE, JCOE or three roll bend process and shall be single seam longitudinally double submerged arc welded (SAWL). A low hydrogen electrode shall be used for tack welding. Tack welds must be completely remelted by the Submerged Arc Welding process.

Pipes shall be mechanically cold expanded in accordance with DNVGL-ST-F101 Section 7.2.3.35 determined from the average pipe diameters measured before and after expansion in accordance

with DNVGL-ST-F101, Section 7.2.3.34. If the aim % cold expansion changes by more than 0.002 then a new MPQT is required

Production statistics from previous pipe production of similar size, type, grade, chemical composition and showing histograms of chemical, mechanical, toughness properties and geometrical parameter distributions through the production shall be submitted by the CONTRACTOR. If no such experience or data exists, the CONTRACTOR shall explicitly state this in his proposal.

5.2 Steel and Plate Manufacturing Procedure Variables

The following information shall be included in the MPS supplied with the CONTRACTOR bid documentation. Bid proposals that fail to follow the requirements listed below will not be considered.

- Specific steel production facility and plate rolling mill.
- Specific steel making method or melting practice (EAF-VD, BOF-LRF-VD, etc.), nominal proportions of scrap (by designated scrap grade) and hot metal charge, nominal weight of heat, and any hot metal treatment (degassing, desulfurization, sulfide shape control, etc.) and details of slag free tapping practices.
- Chemical composition control ranges and specific aimed composition (including limits on residual elements) for heat and product analysis.
- Casting details including usage of argon shrouding methods and implementation of soft reduction further down the strand.
- Segregation control procedures and segregation quality control procedures (macro-etching or phosphorus print of slab cross sections) and normal testing frequency for strand-cast product. Note: Sulfur printing is not an acceptable method for monitoring internal quality when sulfur content, as measured during the heat analysis, is equal or less than 0.005 %.
- Slab thickness, width and weight and relationship to final plate thickness.
- Hydrogen flake control methods (bake-out, slow cool, stack, etc.), if applied. Indicate hydrogen content in melt, slab and product.
- Slab reheat temperature and time and computer control of process.
- Finishing mill, controlled rolling start and finish, accelerated cooling start and finish temperatures and control range (including reduction sequence with associated rolling temperatures).
- Total reduction in the finishing mill or during controlled rolling.
- Mother plate size (single or double length, single or double width).
- Tubular forming methods including estimate of normal ID and OD fiber strain imparted during forming operations and expansion.
- Longitudinal seam-welding technique, seam tracking procedure, welding parameters (amperage, voltage, travel speed, and heat input), consumables (wire size, wire and flux manufacturer and brand name), flux handling and all other essential variables as defined in the applicable welding code or standard.
- Methods of non-destructive testing, cold expansion and hydrotest.

- Methods of chemical analysis and use of calibration standards.

5.3 Chemical Properties and Tests

A ladle analysis shall be made on each heat of steel.

A product analysis of both pipe body and weld metal shall be made on two samples per heat or per batch of fifty (50) pipes, whichever is the most frequent. Sample locations shall be ¼ WT or ¾ WT rather than the pipe surface. Analysis shall be performed and reported for all elements covered by this document and the MPS. The Pcm value of the weld metal shall not exceed 0.22.

Ladle and product analyses shall meet the requirements of Table 7-4 of DNVGL-ST-F101 with notes as given in Section 5.4 of this document.

The Pcm value as defined below and by product analysis shall meet the values specified in Section 5.4 of this document.

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

All elements listed in Table 7-4 of DNVGL-ST-F101 shall be measured and reported for each product analysis required by this document. This requirement applies to both residual and intentionally added elements

5.4 Chemical Analysis Requirements

The composition of each heat shall comply with the requirements given in Table 7-4 of DNVGL-ST-F101 including the notes of Table 7-4 of DNVGL-ST-F101 and additional notes given below. The CONTRACTOR shall propose an aimed chemical composition, which shall be subject to COMPANY's acceptance. Once qualified, the aimed chemical composition shall be considered a guaranteed composition for the production.

Additional notes for Table 7-4 of DNVGL-ST-F101:

1 For each reduction of 0.01 % below the specified maximum for carbon, an increase of 0.05 % above the specified maximum for manganese is permissible, up to a maximum increase of 0.10 %.

2 Ti is added to control grain growth, Other methods are subject to COMPANY acceptance

3 Inclusion shape control not required for the required sulfur level.

4 For MPQT Pcm value is essential variables as per DNVGL-ST-F101, Section 7.1.8.8.

5 Al/N ratio is not applicable to Ti killed, low Al steels.

6 No intentional additions of boron, antimony, lead, tin, arsenic, bismuth are allowed.

7 Ca/S ratio shall be greater than 1.5

5.5 Welding Consumables

The chemical composition of welding wires and electrodes within a range more restrictive than the nominal variation used by the consumable manufacturers to ensure consistent weld mechanical properties shall be specified by the CONTRACTOR. The chemical compositions shall be attached to

each applicable Welding Procedure Specification, and shall be provided for COMPANY review and acceptance.

The mechanical properties of welding consumables shall be certified for each batch, with the exception of welding wires and fluxes which have been certified based on their chemical compositions and if these are considered strict enough to guarantee weld properties as specified and proven during qualification program.

Welding consumables handling procedures shall be adopted by the CONTRACTOR, which shall ensure that moisture pick-up does not occur. The flux handling procedure shall include a moisture check to ensure low hydrogen welds are achieved, i.e., lower than 5 ml/100 g of weld metal. Welding consumables handling procedures shall be provided together with the Welding Procedure Specifications.

Maximum residual moisture content shall not exceed 0.03% for agglomerated type flux. Higher residual moisture contents are acceptable for fused type fluxes. The maximum acceptable residual moisture content shall be established through comparison of glycerine and evaporation tests and the results shall be submitted for COMPANY.

SAW flux moisture shall also be checked for each welding machine at the start of each of the production runs. Flux sampling shall be done at the head of the welding machine Maximum moisture content shall be 0.03% in the case of agglomerated type flux, in accordance with DNVGL-ST-F101 Section 7.2.3.24.

Flux processing and handling procedures shall be submitted by the CONTRACTOR for COMPANY review and acceptance.

5.6 Residual Magnetism

Residual magnetism of the finished pipe shall not exceed an average of 20 gauss or any single value of 25 gauss. Residual Magnetism shall be measured using the procedures specified in Appendix B.

6 MECHANICAL PROPERTIES AND TESTS

All tests specified shall be more stringent or equal to DNVGL-ST-F101 with supplementary requirements for fracture arrest properties (F), dimensions (D), and high utilization (U), unless stated otherwise in this document. The tests shall be carried out on bare material and weld seam of finished pipe.

Inspection frequency is based on 8 hours shifts. For shifts longer than 8 hours the test frequency shall be increased accordingly.

All equipment used for the mechanical testing shall be calibrated and meet the requirements of DNVGL-ST-F101 Appendix B.

Sampling procedure shall be proposed by the CONTRACTOR for COMPANY acceptance. The COMPANY, in any case, reserves the right to select the pipes to be tested and shall witness mechanical testing.

Final samples shall have machined surfaces. Where thermal cutting has been used to remove pipe coupons from which test specimens are prepared, the full extent of the heat affected region shall be removed during final machining.

Test frequency, unless otherwise stated, shall be one pipe out of a lot of fifty (50) produced pipes or one pipe per heat, whichever is smaller. Pipes for testing shall be evenly distributed all through production, rotating among the external welding lines.

If the CONTRACTOR has a mill interruption, which incurs any change in equipment setting (such as production for another customer), one set of production test specimens shall be taken to validate the lot produced after such interruption. Mill interruption is defined as per illustration in Appendix C.

6.1 Tensile Tests

Full thickness longitudinal and transverse specimens taken from parent metal and transverse weld specimens shall be tensile tested in accordance with ISO 6892. The samples from parent metal shall be taken from finished pipe at 180° in transverse direction from the weld seam. Full thickness specimens shall be used for both longitudinal and transverse tests.

The requirements of DNVGL-ST-F101, Section 7.9.5 supplementary requirements, high utilization (U) shall be applied to the transverse testing direction. If the results from the modified testing regime during production meet the requirement SMYS x 1.03, no further testing is required, for results below 500MPa, Section 7.9.5.5 and 7.9.5.6 of DNVGL-ST-F101 shall apply. Tensile test requirements with supplementary requirement U included are summarized in Table 6-1.

Table 6-1 Yield and Tensile Strength Requirements

Steel Grade	Direction	Yield Strength (MPa)		Ultimate Tensile Strength (MPa)		YS/UTS maximum
		Min	Max	Min	Max	
485	Transverse	500	605	570	690	0.90
	Longitudinal	485	605	545	690	0.93

The minimum elongation in 50.8 mm, A_f, shall be 22% as in accordance with the requirements of Table 7-5 of DNVGL-ST-F101 Section 7.

Stress/strain curves in longitudinal and transverse directions shall be recorded during the procedure qualification testing and form part of the final end documentation.

6.2 Hardness Test

One macro-section shall be cut from one end of each pipe selected for testing. It shall be suitably prepared to allow hardness determinations to be made.

The hardness tests shall be made in accordance with ISO 6507-1.

The hardness level shall not be greater than 275 HV10 for the base metal, weld metal and the HAZ.

Distance between readings shall be in accordance with DNVGL-ST-F101, Appendix B, Figure B-10c).

6.3 Charpy Impact Test

Charpy V-notch impact testing shall be performed in accordance with the requirements of DNVGL-ST-F101 and ISO 148. Specimens shall be tested as per Figure B-5 of DNVGL-ST-F101 Appendix B. In addition to the outer diameter sample, samples from internal diameter (ID) and parent pipe at midwall shall be taken. The sample from internal diameter (ID) shall consist of specimens from the weld metal (WM), fusion line (FL), fusion line + 2 mm (FL + 2) and fusion line + 5 mm (FL + 5).

Full Charpy V-notch transition curves for base material are not required during production testing.

Only full size Charpy specimens shall be used for qualification and production testing. The notch line shall be cut through the pipe thickness. All specimens shall be transverse to the pipe axis. Specimen sampling in the weld fusion line area shall be as per DNVGL-ST-F101.

The Charpy impact energy values for base metal shall be 124 J average and 93 J minimum for base material at MDT (-10°C).The minimum Charpy impact energy for the weld metal (WM) and heat affected zone (HAZ) is detailed below:

	Charpy V-notch Energy[1][2]		**Testing Temp.**
Steel Grade (MPa)	**Average (J)**	**Minimum (J)[1]**	**(°C)**
SAWL 485	50	40	-20 ºC

Notes:
1. Only one specimen per set below the average value is allowed
2. The values obtained in the longitudinal direction, when tested, shall be at least 50% higher than the values required in the transverse direction.

6.4 Drop Weight Tear Tests

Base metal DWTT transition curves using full or reduced wall thickness specimens shall be developed for each selected pipe in duplo to define the transition from ductile to brittle behaviour. Minimum five

sets of specimen shall be tested at five different temperatures, including MDT (-10°C) as specified in the Material Take-Off (Doc. No. IGI-1207-10-PL-MTO-001). Each set shall consist of two specimens taken from the same test coupon. The tests shall be performed in accordance with DNVGL-ST-F101, Appendix B.2.7. The specimens tested at MDT (-10°C) shall as a minimum, meet an average of 85% shear area with only one minimum value of 75%.

For qualification (MPQT), as described in Appendix A, two DWTT specimens (a set) shall be tested in accordance with DNVGL-ST-F101 Section 7.9.2.4, and two additional sets shall be tested at the MDT (-10°C) as specified in the Material Take-Off (Doc. No. IGI-1207-10-PL-MTO-001), to produce the full ductile brittle transition curve. These test temperatures may be adjusted by the CONTRACTOR, if necessary, to produce the full ductile brittle transition curve. The test temperature which corresponds to 85% shear shall be reported to the COMPANY. Each set shall be taken from the same joint.

For production, one pipe out of a lot of fifty (50) produced pipes or one pipe per heat, whichever is smaller, shall be tested at the MDT. The specimens shall meet an average of 85% shear area with one minimum value of 75%.

6.5 Guided Bend Test

For each pipe wall thickness, guided bend test in accordance with DNVGL-ST-F101 Appendix B.2.5 shall be carried out during qualification and production. Acceptance criteria shall be as specified in DNVGL-ST-F101 Section 7.2.4.14.

6.6 CTOD Test

For qualification (MPQT) as defined in Appendix A, CTOD tests shall be performed on base metal, weld metal and HAZ. The minimum CTOD requirement is 0.25 mm at MDT (-10°C) for base metal and 0.15 mm at MDT (-10°C) for HAZ and weld metal.

6.7 Metallographic Test

Macro section of the pipe shall be performed in accordance with DNVGL-ST-F101 Appendix B.2.10. This macrograph of the section may be used for the hardness test. Acceptance criteria shall be as specified in DNVGL-ST-F101 Section 7.2.4.16 and 7.2.4.17.

6.8 Ring Splitting Residual Stress Test

Ring splitting residual stress tests shall be performed in accordance with Appendix D. Three ring specimens shall be taken for testing, selected by the COMPANY from the first day's production, representing three heats of steel. Residual stresses shall not exceed 25 % of SMYS.

6.9 Retests

If any pipe fails to conform to the specified requirements of Section 6, retest of two pipes from the same test lot shall be conducted. Before performing the retest, documented information on the origin and extent of the non-conformity (Non Conformity Report) shall be provided to the COMPANY.

Should all retests give acceptable results, then only the pipe which gave the unacceptable result shall be rejected. If one or both re-tests do not meet the specified requirements, the test unit shall be rejected.

If test results are influenced by improper sampling, machining, preparation, treatment of testing, the test sample or specimen, as relevant, is to be replaced by a correctly prepared sample or specimen and a retest performed.

The requirements of re-testing of the line pipe shall be in compliance with DNVGL-ST-F101 Section 7.2.5.6 through 7.2.5.11.

Table 6-2 Summary of Mechanical Test Requirements of Welded Line Pipe

Type of Test	Location	Test Requirements
Tensile Test	Longitudinal, Pipe Body	Q and P
	Transverse, Pipe body	Q and P
	Transverse weld	Q and P
Charpy V-notch Test	Pipe Body	Q and P
	Weld	Q and P
Charpy V-Notch Transition Curve	Pipe Body	Q
Drop Weight Tear Test (DWTT)	Pipe Body	Q and P
DWTT Transition Curve	Pipe Body	Q
Ring Splitting Test	Weld	Q
Bend Test	Weld	Q and P
Hardness Test	Pipe Body	Q and P
	Weld	Q and P
Macro Examination	Weld	Q and P
CTOD Test	Pipe Body and Weld	Q

Notes:
Q = tests required for Qualification of the MPS.
P = tests required during Production.
The location 'weld' may include the Heat Affected Zone (HAZ) as specified in the corresponding Sections (6.1-6.9).

7 HYDROSTATIC TESTING

7.1 Mill Pressure Testing

Each length of pipe shall be hydrostatically tested considering end effect as per DNVGL-ST-F101, Section 7.5.1. The holding time at test pressure shall be minimum 10 seconds as per DNVGL-ST-F101, Section 7.5.1.5. All test records shall be retained on file. In case of ram end loading is used calculations shall be submitted by the CONTRACTOR for COMPANY review and acceptance.

7.2 Calibration

All test equipment shall be calibrated to the satisfaction of the COMPANY. Hydrostatic test pressure shall be verified using the working gauge calibrated against the check gauge at least once per shift. The check gauge shall be calibrated against the master (dead weight) gauge at least once per week. Each hydrotest shall be recorded on a chart, with date, test pressure, test duration and pipe number.

8 DIMENSIONS, WEIGHTS, LENGTHS, DEFECTS AND FINISHES

8.1 General

Dimensional, weight, length, defect and finish requirements shall be measured and checked in accordance with the COMPANY accepted procedures and DNVGL-ST-F101.

Inspection frequency is based on 8 hours shifts. For shifts longer than 8 hours the test frequency shall be increased accordingly.

8.2 Diameter

The pipeline diameter of the Italian offshore section shall have a constant OD of 812.8 mm with varying wall thickness.

For values and quantities, reference is made to Material Take-Off (Doc. No. IGI-1207-10-PL-MTO-001).

Dimensional tolerances on internal diameter over a length of 100 mm from each pipe end measured from the bevel face shall not exceed ± 1.4 mm from the nominal internal diameter. It is preferred that automatic measurement machines with a proven track record are used after COMPANY acceptance. Alternatively, pi diameter tape is acceptable if diameter measurements are done manually.

Note: Nominal ID = Nominal OD - 2 x Nominal WT

Dimensional tolerances on outside diameter in the pipe body shall be ±4.0 mm. If the pipe body diameter is found out of tolerance, then each pipe shall be checked over its full length until the problem has been resolved.

8.3 Wall Thickness

Both ends of each pipe shall be checked for thickness with UT measuring device. Specified thickness shall be guaranteed along the length of the finished pipe and shall be verified along the length by a method to be agreed upon and at a measurement frequency of 100 percent with a recording frequency of six pipes per shift. If less than 6 pipes are produced per shift, all pipes produced during that shift shall be measured. Wall thickness shall be recorded at each end and at the middle of the pipe at a minimum of three positions around the circumference (both sides of the weld and 180° from the weld) for 100% (testing of every pipe).

Wall thickness at any place, including defect areas shall be within ±1.0 mm from the nominal wall thickness (t_{nom} ± 1.0 mm).

The 32-inch line pipe (with a constant OD of 812.8 mm) has wall thicknesses of 20.0 mm and 30.7 mm. For values and quantities, reference is made to the Material Take-Off (Doc. No. IGI-1207-10-PL-MTO-001).

8.4 Weights

Each pipe shall be within -3.5% or +10% of the calculated weight for any pipe and ±1.5% for the average of 50 consecutive pipes. The weight of each pipe shall be recorded in the pipe tally by pipe number and included in the stencil markings.

8.5 Lengths

The pipes shall be supplied in lengths of 11.7 m to 12.5 m, with 12.2 m minimum guaranteed average length per shipment.

8.6 Straightness

The deviation from a straight line shall not exceed 0.15% of the length and 3 mm per meter of pipe.

8.7 Pipe End Preparation and End Squareness

Pipe ends shall be square cut and no bevel end protectors are required unless otherwise especially requested by the COMPANY. The out of squareness is to be measured at a measurement frequency of 5% with a recording frequency of three pipes per shift, and shall meet the requirements of DNVGL-ST-F101, Section 7, Table 7-22.

8.8 Out-of-Roundness

Out-of-roundness measured at any point along the pipe body shall not exceed 1.00% OD for line pipes with a wall thickness smaller than or equal to 30.0 mm and 0.65% OD for line pipes with a wall thickness higher than 30.0 mm as summarized in Table 8-1, and measurements shall be performed as specified in Table 9-1.

The out-of-roundness of pipe ends (over a length of 100 mm from the bevel face) shall not exceed 5 mm for line pipes with a wall thickness smaller than or equal to 30.0 mm and 4.5 mm for line pipes with a wall thickness higher than 30.0 mm as summarized in Table 8-1.

Table 8-1 Maximum Allowable Out of Roundness

Wall thickness	OoR Pipe body	OoR Pipe end
≤30.0 mm	1.00% OD	5 mm
>30.0 mm	0.65% OD	4.5 mm

Out-of-roundness shall be defined as:

$$OoR = D_{max} - D_{min}$$

OoR = Out of roundness in mm

Dmax = The greatest measured inside or outside diameter

Dmin = The smallest measured inside or outside diameter

Note :

- OoR for pipe ends shall be based on inside diameter
- OoR for pipe body shall be based on outside diameter

The out-of-roundness shall be measured using a rod type gauge/external caliper to determine the actual minimum and maximum internal diameter. Alternatively, automatic measurement machines with a proven track record can be used after COMPANY acceptance. As a minimum, all pipe ends shall be measured at four locations in the same plane within the 100 mm from the pipe ends and shall

also be measured next to the weld. The use of a diameter tape is not allowed. Measurements shall be recorded for each pipe for both pipe ends and once per pipe for pipe body.

On all MPQT pipes, OoR measurements shall be taken at 100 mm from each pipe, in addition to ¼, ½, and ¾ length of the pipe (i.e. in total 5 locations along the length of the pipe). The measurements shall be recorded around the circumference with a minimum pitch of 15°. On all production pipes, measurements, as a minimum shall be taken at 15° circumferential intervals at each pipe end and at the middle of pipe length. Pending COMPANY approval and a substantial data base of acceptable results, the circumferential interval may be increased to 45° intervals.

For manual measurements of OoR, the operator shall search for the max and min diameters. Maximum and minimum diameter will typically be at 90° sector intervals. Local OoR (peaking) is not considered as part of the global OoR measurement.

Upon COMPANY request, the MANUFACTURER shall provide a statistical gauge R&R (Repeatability and Reproducibility) study of the OoR measurement system. This GRR shall comply with ISO/TR 12888 following guidance of Annex C.

The procedure for correction of pipe OoR shall be subject to a qualification program and approval by COMPANY.

Peaking and flats (geometric deviations) shall be as per Table 7-22 of DNVGL-ST-F101.

8.9 Longitudinal Seam Welds

Reinforcement of the inside and outside weld seam shall fall within the range of specified in DNVGL-ST-F101, Appendix D, Table D-4. Transition to the base material shall be smooth. Weld bead height shall be measured at a frequency of 5% of pipes per shift.

The reinforcement of the internal weld seam for a distance of at least 150 mm from each pipe end shall be ground to the height of +0.5/-0 mm. The external longitudinal weld seam shall be ground flush with the pipe outside surface over 300 mm from the pipe ends to allow for automated ultrasonic examination during installation. Grinding should be carried out before final NDE inspection.

The radial offset shall be as required by DNVGL-ST-F101, Appendix D, Table D-4. Weld misalignment and offset shall be checked on 10% and recorded on three pipes per shift.

8.10 Additional Quality Requirements

Dents, grooves or gouges that are deeper than 1 mm or extend in any direction more than 5% of the pipe outside diameter shall be considered defects. Dents, grooves or gouges with a sharp bottom shall be ground out regardless of size, but shall not reduce the wall thickness below the minimum value allowed in Section 8.3.

Deviation from circularity in the weld area (peaking) shall not exceed 1.5 mm for 200 mm of the arc of the pipe perimeter over a length of 100 mm from each pipe end. Deviation from circularity shall be measured on the internal surface of the pipe using a gauge having a length of 200 mm and a bending radius equal to the nominal pipe inside radius. There shall be no gap between the gauge and the pipe greater than 1.5 mm; otherwise the pipe shall be rejected. At least 5% of pipes shall be measured with values recorded for six pipes per shift.

Deviation from circularity in the full body of pipe (flatness) shall not exceed 1.5 mm for 200 mm of the arc of the pipe perimeter. Deviation from circularity shall be measured on the external surface of the pipe using a gauge having a length of 200 mm or more and a radius equal to the nominal pipe outside radius. There shall be no gap between the gauge and the pipe greater than 1.5 mm; otherwise the pipe shall be rejected. Measurement shall be taken where indicated by visual inspection.

Weld Linearity - Localized off-seam welds (doglegs) and starved welds are limited to 3.2 mm maximum deviation for weld toe linearity. Each pipe shall be inspected visually for weld linearity on the inside and outside surfaces.

When visual inspection indicates a lack of linearity, the deviation from linearity shall be determined by placing a 300 mm long straight edge against the toe of the weld reinforcement so as to straddle the area in question and measuring the perpendicular distance from the side of the straight edge to the weld toe. Any starved weld or dogleg exposing undercut, lack of fill, inadequate penetration, or unmelted bevel is also cause for temporary rejection (weld repair required).

Hard Spots - Hard spots shall be defined as areas with hardness greater than 300 HV10. Hard spots of any size shall not be acceptable. They shall be repairable only by cut-out the affected area of pipe, unless it is a shallow local hardened area that can be ground off provided that the remaining WT after grinding still meets the minimum WT requirements. Grinding procedure with subsequent inspection shall be approved by COMPANY.

Arc Burns - Arc burns are defined as localized points of surface melting caused by arcing between electrode or ground and the pipe surface or by arcing from any other source such as electromagnetic inspection equipment. Pipe with any arc burn is not acceptable. If doubt exists as to whether a defect is in fact an arc burn, the area may be polished with a wire brush and etched with 5% nital as proof test, or with a COMPANY accepted equivalent. Following any such proof testing, the etched area shall be washed.

Repair of arc burns shall be conducted in accordance with DNVGL-ST-F101 by mechanical removal of affected base material followed by NDT to verify absence of cracks and ultrasonic wall thickness measurements to verify that the remaining material thickness is not below the minimum allowed.

Other Defects - Laminations, seams, undercut cracks or scabs that intersect a weld at any point shall be considered weld defects. Repair shall be made only by cut-out or grinding. All gouges shall be ground out. Gouges with cracks or tears must be removed. The magnetic particle inspection is to be performed only with an AC magnetic yoke; prods shall not be used. All equipment used shall be ground.

The surface quality of the inside and outside surfaces shall be suitable for the application of internal flow-coating and external protective coating without any further grinding.

The internal and external pipe surfaces shall be free from surface laminations, seams, scabs, weld spatter, slivers, pits, etc. These may be ground out, provided that the remaining wall thickness complies with the minimum wall thickness requirements.

Any surface porosity in the weld constitutes a defect and is repairable by cut-out, grinding, or weld repair.

9 QUALITY CONTROL REQUIREMENTS

9.1 General

The work shall be inspected in accordance with DNVGL-ST-F101 and the accepted Manufacturing and Inspection Plan. This shall include, but not be limited to, the following clauses. The procedure for these examinations shall be included in the MPS for acceptance by the COMPANY.

9.2 Visual Inspection

The entire length of each pipe shall be visually inspected externally and internally for surface defects.

9.3 Dimensional Inspection

All specified dimensions (in accordance with Section 8) shall be checked at the frequency specified in Table 9-1 and Table 9-2.

Table 9-1 Frequency of Dimensional Checks

Dimensional Parameter	Section	Measurement Frequency (pipes/shift)	Recording Frequency (pipes/shift)
Internal Diameter	8.2	100%	100%
Outside Diameter	8.2	5%(1)	5%
Wall Thickness at Pipe Ends	8.3	100%	100%
Wall Thickness along Pipe Body	8.3	100%	6
Weight	8.4	100%	100%
Length	8.5	100%	100%
Out-of-Roundness at Pipe Ends	8.8	100%	100%
Out-of-Roundness along Pipe Body	8.8	5%(1)	100%
Peaking	8.10	see Table 9-2	see Table 9-2
Straightness	8.6	5%(1)	6
Ends Squareness	8.7	5%(1)	3
Weld Bead Height	8.9	5%	6
Weld Misalignment	8.9	10%	3
Radial Offset	8.9	10%	3
Note: (1) The minimum frequency shall be 4 pipes per 8-hours shift			

Table 9-2 Frequency of Peaking Checks

Location	MPQT/Production	Tool	OD/ID	Measurement Frequency	Recording Frequency
Pipe end	Production	200 mm template	ID	10%	6 pipes/shift
Pipe end	MPQT	200 mm template	ID	100%, both ends	100%, both ends
Pipe Body	MPQT	150 mm dial gauge	OD	100% at centre	100% at centre

The frequency of random checks may be increased up to 100% upon request of the COMPANY, if deviations from the specified values occur. The checking frequency will be reduced to the initial frequency after consistent acceptable results. Recording shall include traceability to pipe number.

10 NON-DESTRUCTIVE TESTING

10.1 General

All NDT shall be performed in accordance with DNVGL-ST-F101, Section 7.6.2 and the requirements of this document.

All NDT shall be performed in accordance with written procedures and shall be subject to COMPANY acceptance.

Inspection frequency is based on 8 hours shifts. For shifts longer than 8 hours the test frequency shall be increased accordingly. The written procedures as a minimum include the information as written in in DNVGL-ST-F101 Appendix D.8.1.3.

Reported indications shall be classified for the type of imperfections. In case the occurrence per type of imperfection would be higher than the agreed mill standard, an investigation shall be agreed and will be carried out by the CONTRACTOR under strict control of the COMPANY, and quality corrective action shall be taken.

10.2 NDT of plates

100% automatic ultrasonic inspection of all plates shall be carried out for detection of laminar imperfection through the entire wall thickness in accordance with ISO 10893-9. Alternative codes may be used with prior COMPANY acceptance.

Manual ultrasonic testing of the areas reported during automated ultrasonic testing equipment shall cover a square of minimum 250 mm x 250 mm centered on the reported indication. The equipment shall be calibrated against maximum 6 mm diameter flat bottom holes, machined 4 mm below each surface and at mid thickness and the DAC curve established with the maximum response set to 80% of full screen height. For dimensional evaluation, the half-value-drop method shall be used.

Acceptance criteria shall be in accordance with DNVGL-ST-F101, Appendix D, Table D-12, with the following additions:

In the examination of the longitudinal edges, an allowance in the area width shall be made to cover possible oversized plates and later edge milling and end bevelling.

Acceptance criteria for plate edges shall also be valid for the plate ends (i.e., on the future pipe ends) and shall be in accordance with DNVGL-ST-F101 Appendix D.8.14.6.

10.3 Automated Ultrasonic Testing of Longitudinal Weld Seam

100% of all longitudinal weld seams shall be tested by means of an automated scanning device for detection of defects oriented predominantly parallel to and/or at right angles to the weld seam. In both cases, testing shall be carried out in two opposing directions of beam travel.

The equipment and the documentation thereof shall meet all requirements given in DNVGL-ST-F101, Appendix D.8.6.

A full description of the equipment shall be submitted and shall include, as a minimum, the information required by DNVGL-ST-F101, Appendix D.8.1.3.

The description of the equipment shall state:

- The number and position of probes dedicated for detection of longitudinal defects and the operational mode (pulse-echo and/or through transmission).
- Probes firing sequence
- The number of probes dedicated for detection of transverse defects, their orientation given in degrees relative to the weld axis and the operational mode (pulse-echo and/or through transmission).
- For each probe, the following information shall be provided:
- The probe type and dimensions
- The frequency
- The probe angle
- The chosen number of skips
- The distance from the weld centerline to the probe index point
- The angle between the ultrasound beam direction and the weld axis.

Full weld coverage shall be sketched both for longitudinal and transverse inspection, adopting the beam properties documented by the probe manufacturers' data sheets.

The equipment shall include devices for weld tracking and provide checks of adequate coupling for each individual probe.

The total automated ultrasonic system shall have a documentation of calibration not older than 6 months at the start of production.

For all probes, the noise shall be at least 8 dB weaker than the signal from the reference reflector (used for sensitivity setting) at the target distance.

10.3.1 Reference Standard

The reference standard shall be a project specific piece of pipe in accordance with DNVGL-ST-F101 Appendix D.8.4. The reference standard shall contain a typical production weld. The weld surface shall be ground flush with the original pipe contour in an area around each reference reflector sufficient to obtain signals without interference from unground weld reinforcements. The reference standard shall contain at least the following artificial reflectors sufficiently separated (with a minimum of 150 mm) from each other so that clearly distinguishable signal indications are obtained:

A. 1.6 mm dia. through drilled hole at the weld centerline (target)

B. 1.6 mm dia. radial drilled holes up to about mid thickness at the weld centerline, inside and outside (targets)

C. 3.0 mm dia. side drilled hole parallel to the weld axis at the weld centre, 1/3WT, and 2/3WT (target)

D. N5 notches parallel to the weld at both sides of the weld toe edge, inside and outside (sensitivity setting)

E. 3.0 mm dia. radial drilled holes in the pipe material 10 mm outside the weld toe edge at both sides (gate setting). Two reflectors Ø 1.6 mm, through drilled holes at the edge of the weld from both sides for transverse indications.

The length of the N5 notch shall be 1.5 times the probe element size or 20 mm, whichever is shorter. The length does not include any rounded corners. The width of the N5 notches shall not exceed 1 mm. Depth shall be 1.5 mm (± 15%).

Additional reflectors with Ø3 mm through drilled holes to verify uninspected area at the pipe ends shall be performed.

Other additional reflectors and calibration methods may be suggested by the CONTRACTOR, if needed, due to the specific equipment set-up.

10.3.2 Static Calibration

The longitudinal outside and inside probes shall be targeted at the A reflector and the sensitivity for all probes shall be set to 80% of FSH of the echo of the D reflector in the area of interest giving the lowest response. The alarm level shall be set 6 dB below the sensitivity level.

The longitudinal weld centre probes shall be targeted at the C reflector and the sensitivity shall be set as the response from the C reflector to 80% of FSH for all probes. The alarm level shall be set 6 dB below the sensitivity level.

The transverse probes shall be targeted at the B reflectors such that the difference in amplitude when the largest echo is set to 80% of FSH is no more than 3 dB. Sensitivity shall be set as 80% of FSH of the echo of the B reflector in the area of interest giving the lowest response. The alarm level shall be set 3 dB below the sensitivity level.

The variation in sensitivity between the probes in any pair shall be minimized.

The echo height from the target and sensitivity reflectors shall be recorded for each probe without any changes to the amplification, soundpath lengths, or position of the probes. All settings, angles, and offsets from the weld centerline to the probe index point shall be recorded for each probe.

During the static calibration, it shall be verified that each A, B, C and D reflector are detected by both probes in the pair covering the area of interest.

The gates for the longitudinal probes only shall start at the near side E reflector and end at the far side E reflector. Only if geometrical echoes from the weld reinforcement exceed the echo from the far side D reflectors, the gate may end at a maximum of 15 mm from the far side E reflector.

The documented tolerance of the weld tracking device and the allowed asymmetrical bead shall be considered when setting the gates. All gate settings shall be recorded.

The maximum allowable scanning velocity (V_C) shall be determined according to:

$$V_C \leq W_C \bullet PRF/3$$

where W_C is the narrowest –6 dB beam width at the appropriate operating distance of all probes in the array and PRF is the effective pulse repetition frequency per probe.

10.3.3 Dynamic Calibration

A check of the static calibration shall be performed in the dynamic mode. After each static calibration, the reference standard shall be passed through the ultrasonic testing equipment 3 times at the operational scanning velocity. If a change in gain is required in order to maintain the recorded percentage for the probes when aimed at their respective reference reflectors (used for sensitivity

setting), these values shall be recorded as an average of the 3 dynamic check results. This average gain, if any, shall be added to the primary gain for each probe during production testing.

Variation of gate setting should not be above the tolerance of the weld tracking device.

Dynamic checks shall be undertaken by passing the reference standard through the ultrasonic testing equipment at the operational scanning velocity. The dynamic check shall be repeated at least once every 4 hours during production or once per every 10 pipes tested, whichever is the longer time period and:

- the start and end of each shift
- at any change of equipment operator
- whenever a malfunction of the equipment is suspected

The equipment shall be deemed to be out of calibration if:

- The response from target and sensitivity setting reflectors during the dynamic check falls 3 dB below the recorded value from the reference dynamic check.
- The gate setting during the dynamic check is changed by more than $\pm$ 1.5 mm from the recorded value from the static calibration.
- If any of the parameters which were used during the initial static calibration, are changed.
- A change of component affecting the sensitivity and/or alarm settings

If the equipment is deemed out of calibration it shall be re-calibrated in accordance with Section 10.3.2 and 10.3.3 of this document and all pipes tested since the last successful dynamic check shall be re-tested.

Insufficient coupling shall be deemed to occur if the transmission signal deteriorates more than 10 dB.

For production testing, the gain for each probe shall be increased by 3 dB: the total gain will thus be the gain required to set the echo at 80% of FSH + added gain from dynamic check (if any) + the added 3 dB for production testing. This 3 dB increased gain may be removed during production, subject to acceptance, if excessive number of false indications would appear during actual inspection. In addition, this gain increase shall be removed during dynamic check.

The alarm level for each probe shall be set not higher than the sensitivity setting of the reflector in the area of interest giving the lowest response during static calibration/first dynamic check. Alarm level for transverse probes shall be set for B reflectors.

Anti-noise suppression shall be set to the lower practical level to be established before production.

Indications triggered by the alarm shall be investigated by MUT according to Section 10.5 of this document. AUT with automatic paint spray system shall be used to provide marking on the location of the indications. The procedure of the automatic paint spray system shall be submitted to the COMPANY for acceptance. The use of RT is only allowed as an additional inspection tool to complement UT inspection; final acceptance of defects by RT is not permitted. If the presence of a flaw is not confirmed by MUT, then the area is considered acceptable. Flaws that are confirmed by MUT and exceed the acceptance criteria in Section 10.5.2 of this document shall be rejected.

10.4 Radiographic Testing

Radiographic testing may be used to complement UT inspection. However, final acceptance of defects by RT shall not be permitted. Pipe ends shall be inspected by radiographic testing as per DNVGL-ST-F101 Section 7 Table 7-16 and Appendix D.

10.5 Additional Ultrasonic Testing

Additional Ultrasonic Testing shall be performed on the following areas:

- Pipe Ends (Lamination)
- Part of the longitudinal weld at each pipe end not covered by AUT
- Testing for delayed hydrogen cracking weld repairs
- If required by Section 9.3 of this document

Probes with beam angles of 0°, 45°, 60°, 65°, 70° and 75° and frequencies between 2 and 5 MHz shall be available for manual ultrasonic testing. The use of the highest frequency probes shall be preferred. Calibration blocks for manual UT shall be made from a section of project pipe.

The calibration block shall be as specified in Section 10.5.2.

10.5.1 Pipe Ends Circumferential UT

Ultrasonic testing shall be performed over a 150 mm wide band at each pipe end shall consist of scanning for the detection of laminations and through thickness planar defects. The 150 mm band shall be from the future weld preparation and an allowance shall be made for later end beveling.

Manual ultrasonic testing, semi-automated, or automated equipment may be used.

For detection of laminations, calibration shall be performed according to ISO 10893-9. For dimensional evaluation, the half-value-drop method shall be used.

No laminations wider than 6 mm or with a maximum area of 100 mm^2 are acceptable.

For detection of through thickness planar defects, calibration shall be performed on a rectangular notch with a depth 3% of the pipe thickness. A DAC curve consisting of 3 points shall be established for all probes. Scanning shall be performed on both circumferential directions. ASTM A577 shall apply.

Indications exceeding 20% of DAC curve, while scanning for through thickness planar defects, shall be further investigated and the amplitude maximized using probes with different angles.

Acceptance criteria for through thickness planar flaws are:

- No maximized indications exceeding the DAC curve are acceptable.
- No flaws intersecting the inside or outside surface of the pipe are acceptable.
- No cracks are allowed.
- Defects may be repaired by grinding, within the wall thickness tolerance, or by cutting pipe.

10.5.2 Manual Ultrasonic Testing (MUT) of Weld Seam

Manual ultrasonic testing (MUT) of welds shall be performed in accordance with DNVGL-ST-F101, Appendix D.2.3, and the following requirements.

Calibration shall be against a project specific reference standard with a 1.6 mm dia. through drilled hole. A DAC curve consisting of 3 points shall be established for all probes. Indications exceeding 20% of DAC curve shall be further investigated and the amplitude maximized using probes with smaller and larger angles.

All maximized indications exceeding 25% of DAC curve shall be reported.

The scanning speed shall not exceed 100 mm/second. Scanning of areas indicated by AUT and weld repaired portions shall be performed transverse to the longitudinal axis of the weld with 100% overlap on scan lines. The scanning shall include a check along the weld with a 0^{o} probe for laminar defects that may interfere with the testing. Scanning for transverse defects shall be included.

Acceptance criteria are:

- No cracks.
- All indications exceeding 33% and less than 100% of DAC shall be investigated for maximized amplitude. Length of flaw shall be assessed using 6 dB drop method. In accordance with DNVGL-ST-F101, Appendix D, Table D-5, flaw length over t/2 mm is not acceptable.

10.6 Magnetic Particle Testing

Magnetic particle inspection shall be performed on all ends of each finished pipe for a minimum length of 50 mm, on the external seam and on all weld repairs to confirm complete removal of the defect.

Magnetic particle inspection shall also be carried out on the full length of the longitudinal weld as required in DNVGL-ST-F101, Section 7, Table 7-16.

Magnetic particle testing shall be performed with the wet method in accordance with DNVGL-ST-F101, Appendix D.2.5.

Fluorescent particles shall be preferred. The ambient visible light shall not exceed 20 lux at the place of examination when fluorescent particles are used.

Manual magnetic particle testing shall be performed by AC yoke.

Acceptance criteria for pipe ends are:

- Any indication exceeding 5 mm in length is unacceptable and shall be removed by machining and re-examined.

Acceptance criteria for the longitudinal weld, including weld ends, are:

- DNVGL-ST-F101, Appendix D.8.14.
- No laminations, laps, or cracks are allowed.

10.7 Liquid Penetrant Testing

Liquid penetrant testing of ferro-magnetic materials shall not be accepted as a substitute for magnetic particle testing, but may be used as a supplement.

Liquid penetrant testing shall be in accordance with DNVGL-ST-F101, Appendix D.2.6.

10.8 Other Acceptance Limits

In addition to the requirements of DNVGL-ST-F101, the following shall be applicable:

- Any imperfection that reduces the wall thickness below the specified minimum shall be considered a defect and the pipe shall be discarded.
- Surface laps, shells, slivers, laminations and all sharp edged imperfections, e.g., gouges, are unacceptable defects. Surface finish and surface defects shall also comply with the requirements specified in Section 8.10 of this document.

10.9 Personnel Qualifications

All personnel performing NDT and interpretation of results shall be qualified in line with DNVGL-ST-F101 Appendix D.1.5.

COMPANY shall reserve the right to reject any NDT operator who is not performing the work in compliance with the accepted procedures.

All MUT operators shall demonstrate to be familiar with and be able to document experience with the applicable NDT technique. The COMPANY reserves the right to qualify each operator for the specific applicable technique.

11 WORKMANSHIP AND DEFECT REPAIR

11.1 Workmanship

All pipe defects shall be assessed and accepted or rejected in accordance with DNVGL-ST-F101 and Sections 8.10 and 10.2 through 10.8 of this document.

The pipe surfaces shall be free from scale or any other defects that may interfere with the application of the selected coating system. Scale is defined as something that cannot be normally removed by a blasting operation.

11.2 Repair of Defects

11.2.1 Pipe Body Repairs

No repairs by welding shall be made to the pipe body.

11.2.2 Weld Defect Repairs

All repairs to welds shall be reported to the COMPANY.

Weld defects (other than cracks) may be treated only by grinding, weld repair, or cut-out. Any defect within 150 mm of the original pipe end shall be repaired by cut off. Any defect in the weld area (weld and heat affected zone) located more than 150 mm from the original pipe end, whether found by visual, ultrasonic, radiological or electromagnetic methods of inspection is cause for removal of the joint. If defect occurs near the pipe ends, the defective pipe section may be cut if the remaining length is within the specified pipe length range.

If any welding defects are detected, documentation shall be presented regarding the origin of the defect, with the appropriate corrective actions, to the COMPANY in a shortest possible time period.

Repairs by grinding necessitate non-destructive re-inspection, except for visually detected undercut. A local magnetic particle examination shall be carried out according to ASTM E709 to ensure that the defect is completely removed and the repair is acceptable. Ultrasonic wall thickness checks shall be required after grinding.

11.2.3 Weld Repair Limitations

Repairs to welded seams shall be made using shielded metal arc welding (SMAW), or other COMPANY accepted welding processes.

No repairs by welding are permitted after expansion. No repairs of weld repairs shall be acceptable. Each weld repair shall consist of minimum 2 passes. The minimum length of repair is 150 mm. The minimum distance between two repairs shall be 200 mm. Repair welds shall be no closer than 150 mm to the pipe ends.

Manual repair welds shall be ground smoothly to the original weld contour.

If the total (cumulative) length of the weld repair on a pipe exceeds 1 m, or the number of the places to be welded exceeds three, the pipe shall not be repaired without specific authorization of the COMPANY. Full or partial length re-welding is not allowed.

The requirements of repair welding shall be in compliance with DNVGL-ST-F101 Appendix C.7.3.

11.2.4 Arc Stop / Restart

Arc stop/restart is always considered as a repair and subject to weld repair qualification.

11.2.5 Weld Defect Removal

If carbon arc gouging is used for defect removal, at least 3.2 mm additional metal shall be removed by chipping or grinding to completely remove the carburized area.

12 LINE PIPE MARKING

The following data shall be paint stencilled clearly on the internal surface of both ends of each pipe:

- Manufacturer's Name
- Project and COMPANY Name
- Contract Number and Item Number
- DNVGL-ST-F101
- Grade and Type of Steel, including the manufacturing process
- Size (Diameter, Wall Thickness, Length)
- Weight
- Heat Number and Unique Pipe Number
- Supplementary Requirements FDU

The pipe number shall be cold die stamped on the bevel at both pipe ends at about 10 mm from the weld. Cold or hot die stamping of the pipe body is prohibited.

The mill assigned Heat and Pipe Number shall be unique and not repeated throughout the qualification and/or production.

Unless otherwise specified, the pipe surface shall be suitable for application of the specified coatings by being free from oil and grease as well as surface defects.

Permanently rejected pipe shall be yellow-banded.

A sketch of marking shall be included in the MPS.

13 COATING FOR TEMPORARY PROTECTION

Unless otherwise specified in the Material Take-Off (Doc. No. IGI-1207-10-PL-MTO-001), the pipes shall be delivered in bare condition. Requirements for special protective coatings and/or linings shall be agreed at the time of order.

The pipe external and internal surfaces shall be free from oil and dirt.

14 HANDLING, STORAGE AND TRANSPORTATION

Detailed handling, storage, and transportation procedures including, but not limited to, detailed material traceability system procedures and detailed repair procedures shall be submitted for COMPANY acceptance.

All pipes shall be handled, stored and transported in accordance with the requirements specified in this document in order to prevent damage to any of the pipes.

14.1 Handling

End hooks with suitable radius and lined with plastic or similar accepted material, or a fork lift with suitably padded forks shall be used to pick up pipe. A spreader bar shall be used between lifting lines. During handling the pipe shall be protected from impacts or jars.

The COMPANY shall be advised of any pipe suffering impact or jars. Lifting equipment shall be COMPANY accepted. Wire ropes shall not be used in direct contact with lift pipes.

All pipes shall be visually inspected for damage, dents, gouges, bevel burrs, imperfections, out-of-roundness and straightness after each handling stage.

14.2 Storage

Yard surface shall be wide enough to allow safe handling and storing of pipe.

Pipe shall be stacked in accordance with stacking arrangements submitted, including stacking heights, to the COMPANY for review.

All pipes shall be stacked on level ground free from foreign materials, stones and vegetation and on supports of a proven load bearing capacity. Pipes shall be suitably spaced from the soil (minimum 150 mm) to prevent any contact with the ground and to prevent surface water from entering during the entire storage period. Pipe shall be prevented from exposure to salt spray.

Separation between coated pipe joints shall be provided by use of strips of soft rubber, rope or other material which will prevent damage to the coating. Pipe stacks shall be of the same diameter, wall thickness and, if applicable, grade of pipe and shall be clearly marked.

Slings or non-metallic straps shall be used for securing loads during transportation and shall be suitably padded at contact points with the pipe.

14.3 Transportation

All pipes shall be transported using the best industry practices for land and marine transport in accordance with the appropriate requirements of API RP 5L1 and API RP 5LW, as applicable.

15 DOCUMENTATION AND CERTIFICATION

The following documentation shall be delivered by the CONTRACTOR.

15.1 Mill certificates

1. The inspection test certificate required to support the delivered pipes shall be 3.1 according to EN 10204 Std. Mill certificate shall be established by the pipe Manufacturer.
2. Mill certificates shall make reference to DNVGL-ST-F101 together with this document.
3. Mill certificates shall show the following:
    - Rolling technique/heat treatment of base material (e.g. normalized, TMCP with/without accelerated cooling, etc.)
    - Manufacturing process (e.g. UOE, JCOE, Bending Roll, Press Bending)
    - Ladle analysis, including Pcm
    - Pipe no. with reference to heat no. (and slab no., where possible)
    - Mechanical test results and product chemical analysis (including Pcm) with reference to pipe no.
    - Dimensional inspections with results
    - Non-Destructive Tests performed with results
    - Any supplementary tests and inspections carried out
    - Certificate no. and date of issue.
4. Format of Mill certificates and the number of copies shall be agreed with the COMPANY prior to pipe production.

15.2 When the bids are submitted

- Manufacturer and mill names.
- A preliminary Pipe Manufacturing Procedure Specification (including plate manufacturing procedure specification) giving the main features and characteristics of proposed base materials and pipes.
- Description of the proposed bevel protectors (if any)
- Handling, transport and storage procedure for pipes (typical)
- Quality Assurance certification (ISO 9000 series)
- Quality Control Plan (typical)
- Pipe supply track record as well as histograms of chemical and mechanical test (including impact tests on base metal and weld seam) results from previous orders of the same pipe grade and similar dimensions, as proofs of capability to produce pipes according to this document
- Details of offered fabrication Pipe History System (PHS) (if any)

- At CONTRACTOR's option, any other pertinent technical information relating to the proposed pipe supply
- The CONTRACTOR’s deviations/qualifications to this document. Where no deviations are stated in the bid, then the potential CONTRACTOR shall be considered as fully accepting the requirements of this document.

15.3 Upon completion of pipe production

A close-out production dossier shall be established by the CONTRACTOR and submitted to the COMPANY. It shall include, but not be limited to, the information and documents stated hereafter:

- Steel making process and plate Manufacturing Procedure Specification
- Non-Destructive Testing reports of steel plates
- Mill test certificates of plates
- Pipe Manufacturing Procedure Specification
- Mill certificates of pipes
- Reports of pipe manufacturing procedure qualification tests, including WPS and WPQR
- Reports of NDT procedure qualification tests
- Reports of production tests made on pipes
- Reports of all dimensional and NDT made on pipes
- Mill hydrostatic test certificate of compliance
- Quality Control Plan
- Report of weldability tests (if any) and CONTRACTOR’s recommendations or guidance for site welding of supplied pipes
- List of heat numbers showing pipe numbers, individual length and weight, total length and eight produced per heat
- Pipe list with sequential numbers of produced pipes related to heat numbers
- Pipe list of shipments
- Histogram of production test results (chemical and mechanical) and dimensions of pipes (length, as a minimum),
- Fabrication Pipe History System (if any)
- Compilation of concessions/deviations, if any, granted by the COMPANY.

The number of originals and copies of Mill certificates and the close-out production report which are to be supplied to the COMPANY shall be proposed by the CONTRACTOR.

The Inspector shall stamp (rubber-stamp), sign and date the original documentation. The copies shall be stamped (as a minimum) by the Inspector.

Appendix A Manufacturing Procedure Qualification

A.1. General

Manufacturing Procedure Qualification Testing (MPQT) shall be carried out prior to the start of production and shall meet the requirements in DNVGL-ST-F101. MPQT shall be witnessed by the COMPANY and MPQT results will be submitted to the COMPANY for review and acceptance prior to the start of production. A manufacturing procedure shall be established for each combination of steel slab source, steelmaking and casting method, target chemistry, plate manufacturing route, pipe forming procedure, seam welding procedure, hydrostatic test procedure, mechanical testing and NDT procedures. Care shall be taken to ensure that the pipe forming method used to produce the qualification pipe(s) produces metallurgical results, strains, and stresses that are identical to the production pipe.

- It shall be guaranteed that, during production, the following are in compliance with those used in the MPQ. Any variation shall be qualified.
- The manufacturing process and/or the control procedures
- Used plants and equipment
- The testing and measuring equipment

During the MPQT, the CONTRACTOR shall be subject to a process audit by the COMPANY in order to evaluate:

- Application of the Quality System
- Application and compliance with the MIP
- CONTRACTOR's ability to keep under control the characteristic process parameters
- The operating characteristics of the non-destructive test equipment in conformity with the requirements of Section 10, of this document
- Traceability

A minimum of twenty pipes shall be manufactured from two different heats (10 pipes/heat). All the pipes shall be subject to the visual, dimensional and NDT inspection, as required by this document. All pipes produced during MPQT shall be subjected to 100% dimensional control and all results shall be recorded for the MPQT report.

Two pipes per heat (four pipes in total) shall be selected for MPQT and subjected to all of the tests and inspections required during production and those required below to qualify each manufacturing procedure. Table A.1 of this document provides a summary of the tests required for manufacturing procedure qualification.

Destructive tests shall be carried out after final NDT, visual and dimensional controls.

The results of all the tests will be evaluated by the COMPANY who will authorize the mill to produce line pipes, if they fully comply with the requirements of this document.

A.2 .Tests on Base Material

Tensile tests shall be done, both in longitudinal and transverse direction in accordance with ISO 6892-1 with strain measured up to maximum load. Stress- strain curve up to the maximum load shall be reported.

High temperature tensile tests according to ISO 6892-2 shall be performed on both ends of the pipes subjected to testing (8 specimens in total). Tests shall be done at 50 ºC in the longitudinal direction. Yield and ultimate tensile strength, elongation at fracture and yield ratio shall be reported for information. Stress-strain curve up to maximum load shall also be reported.

Base metal Charpy V transition curves shall be plotted for each selected pipe for the base metal in accordance with the requirements of DNVGL-ST-F101, Section 7.9.2. Test temperatures selected shall produce the full ductile brittle transition curve. The test temperatures may be adjusted by CONTRACTOR, if necessary, to produce the full ductile brittle transition curve. The minimum absorbed energy at MDT (-10°C) shall exceed 124 J (average) and 93 J (single).

Base metal DWTT transition curves using full or reduced wall thickness specimens shall be developed for each selected pipe by duplicate tests to define the transition from ductile to brittle behaviour. Minimum five sets of specimen shall be tested at different temperatures, including MDT (-10°C) as specified in the Material Take-Off (Doc. No. IGI-1207-10-PL-MTO-001). Each set shall consist of two specimens taken from the same test coupon. The tests shall be performed in accordance with DNVGL-ST-F101, Appendix B.2.7. The specimens tested at MDT (-10°C) shall as a minimum, meet an average of 85% shear area with only one minimum value of 75%.

A.2.1. CTOD

Fracture toughness testing of the base material shall be carried out at MDT (-10°C) as per BS 7448, on Bx2B through-thickness notched specimens. The measured fracture toughness shall, as a minimum, have a CTOD value of 0.25 mm.

One set of samples shall be prepared from each pipe, i.e. in total 4 sets of samples for the MPQT. Each set consists of three samples taken from the base metal.

A.3. Tests on Weld Seam

At the start of MPQT, the diffusible hydrogen contents of SAW longitudinal weld shall be checked in accordance with ISO 3690 and shall be lower than 5 ml/100 g of weld metal. The details of the testing per ISO 3690 will be mutually agreed prior to the MPQT. Hydrogen Measurement shall be based on Gas Chromatographic Method.

SAW flux moisture shall also be checked for each welding machine. Maximum moisture content shall be 0.03% in the case of agglomerated type flux (see Section 5.5 of this document).

The following tests are required for each of the pipes to be tested:

- Two transverse weld tensile (see Section 6.1 of this document) and two all-weld metal tensile tests (inside and outside weld) as per DNVGL-ST-F101, Appendix B.2.3.
- Four side bend tests (see Section 6.5 of this document).
- Two transverse macro specimens.
- Two hardness surveys.
- Weld Charpy specimens from the same locations as in Section 6.3 of this document.

All weld metal tensile tests shall satisfy criteria set for SMYS and SMTS in base metal circumferential direction. Transverse weld tensile tests to satisfy criteria set for SMYS and SMTS of base metal. SMYS and SMTS criteria are stipulated in Table 6-1 of this document.

The transverse macro specimen shall be polished, etched, and examined. The weld, as examined on the macro specimen, shall be sound and free from cracks, undercuts and other defects. The section shall show full penetration and fusion at the root.

Vickers Hardness surveys shall be carried out in accordance with ISO 6507-1, using a 10 kg load. The hardness testing shall be performed in accordance with DNVGL-ST-F101 Appendix B Figure B-10c). The hardness shall not exceed the values given in Section 6.2.

Charpy tests shall consist of three specimens removed from each of the locations detailed in DNVGL-ST-F101 Appendix B Figure B-5. All specimens for procedure qualification shall be individually etched prior to notching and the locations agreed with the COMPANY.

A.3.1. CTOD

Fracture toughness testing of the weld material and the coarse grained HAZ of the longitudinal weld shall be carried out at MDT (-10°C), as per BS 7448, on Bx2B through-thickness notched specimens. The HAZ notch shall sample as much of the coarse grained zone as possible. The measured fracture toughness shall, as a minimum, have a CTOD value of 0.15 mm.

One set of samples shall be prepared from each pipe, i.e. in total 4 sets of samples for the MPQT. Each set consists of three samples for each location. Two locations shall be used, the weld centre line and coarse grained HAZ.

A.4. Welding Procedure Qualification

Welding procedures for the longitudinal seam and for repair welds shall be qualified in accordance with the applicable clauses of DNVGL-ST-F101, Appendix C, unless obviously applicable only to girth welding, and require COMPANY acceptance. The welding procedure qualification may be performed as part of the first day's production at CONTRACTOR's risk.

Welding Procedure Specification for the longitudinal seams and repair welds shall include, as a minimum, information detailed in DNVGL-ST-F101 Appendix C.4.

The material used for the test shall be the same steel grade, target chemistry, manufacturing method and size as that used in production. The test shall be carried out using the same or equivalent equipment as that used in production. All production stages, which may affect material properties, shall be incorporated including compressive reduction in the O'ing press and cold expansion.

Repair welding procedures shall be qualified by a simulated repair welded joint. A suitably long excavation shall be gouged out to full depth, sufficient to perform the required mechanical testing and re-welded using SMAW. Only one repair attempt per location shall be allowed.

Simulated repair shall include:

- Shallow repair
- Deep repair (75% of the weld thickness)
- Arc stop/restart.

The weld procedure qualification tests shall include 100% radiography, magnetic particle inspection, and ultrasonic testing (including on-bead examination) at least 48 hours after weld completion in accordance with this document.

All the mechanical testing requirements for the weld seam as described in Section A.3 of this document shall also be part of the WPQ.

The PQR (Procedure Qualification Record) shall include as a minimum the following documentation:

- A record of all welding parameters used in the test, incl. weld bead map
- All test results (including photomacrographs)
- NDT reports
- Third party approved mill certificates for materials used in the test
- Heat treatment records (if applicable)
- Consumable batch test certificates
- Applicable Welding Procedure Specification (WPS).

A.5. Essential Variables

The limitations of essential variables shall be as per DNVGL-ST-F101, Appendix C, Table C-2, with additional requirements as stated below. Changes in any of the essential variables shall require a new Welding Procedure Specification and qualification.

- Any change in base materials target chemical analysis or heat treatment condition.
- Any change in material thickness.
- Any change in consumable trade name, grade, classification, or source of origin.
- Any change in wire/flux combination.
- Any increase in electrode size.
- Any increase in the number of electrodes used.
- Any change in heat input, current, voltage, or welding speed of more than ± 10%.
- The time taken for the procedure weld shall be no more than 1.25 x the time taken for a weld of similar length and thickness in production.
- Any change in root treatment.

A.6. Residual Stress Measurement

Residual stress measurement shall be provided for similar grade, diameter and wall thickness data for COMPANY review and acceptance. If data is not available, ring splitting tests shall be performed in accordance with COMPANY accepted procedures.

A.7. Presentation of Results

At the completion of all the MPQ tests, a final report shall be prepared by the CONTRACTOR. The report shall contain complete documentation regarding the test conditions and results.

Table A-1 Summary of Manufacturing Procedure Qualification Test Requirements

Type of Tests	Testing Requirements
Chemical Analysis	1 analysis on Ladle and 1 on each selected pipe, as per Section 5.4.
Hydrostatic	Section 7
Dimensional	Section 8
Wall Thickness Measurement	At 1 m internal along 3 longitudinal planes displayed by 90°, as per Section 8.3
Visual	Section 9.2
Ultrasonic	Sections 10.3 and 10.5
Radiography	Section 10.4
Magnetic Particle	Both pipe ends and longitudinal weld seam, as per Section 10.6
Tensile	1 longitudinal/transverse as per Section 6.1
Hardness	Section 6.2 and DNVGL-ST-F101 Appendix B Fig B-10c)
Charpy V-Notch	Section 6.3
DWTT	Section 6.4
Guided Bend Test	Section 6.5
Ring Splitting Test	Section 6.8 and Appendix D
Charpy V-Transition Curves	Section A.2
DWTT- Transition Curves	Section A.2
CTOD Tests	Sections A.2.1, A.3.1 and A.6

Appendix B Measurement of Residual Magnetism

Measurements shall be made using a Hall-effect gaussmeter or other type of calibrated instrument accepted by the COMPANY. The gaussmeter shall be operated in accordance with written instructions demonstrated to give accurate results. The accuracy shall be verified at least once each day that the gaussmeter is used.

Measurements shall be made on each end of at least three pipes per working shift. One pipe shall be taken from the beginning of the shift, one from near the middle and one from the end of the shift. The results shall be recorded.

The measurement method shall be compatible to be used after anti-corrosion coating has been applied. The testing frequency and responsibility of the residual magnetism after application of internal and external anti-corrosion coating shall be in agreement with the COMPANY.

Pipe shall be measured subsequent to inspection and handling with electromagnetic equipment, and prior to shipment from CONTRACTOR's facility.

As a minimum, four readings 90 degrees apart shall be taken around the circumference of each end of the pipe. The average of the four readings shall not exceed 20 gauss and no single reading shall exceed 25 gauss with a Hall-effect gaussmeter, or equivalent values with other types of instruments.

Any pipe that does not meet the above requirements shall be considered defective. In addition, all pipes produced between the defective pipe and the last acceptable pipe shall be measured. Alternatively, if the pipe production sequence is documented, pipe may be measured in reverse sequence beginning with the pipe prior to the defective pipe until at least three consecutive pipes meet the requirements. Pipe produced prior to the three acceptable pipes need not be measured. Pipe produced after the defective pipe shall be measured until at least three consecutive pipes meet the requirements.

All defective pipes shall be degaussed full length and remeasured, or rejected.

Appendix C Mill Interruption – Mechanical Test Frequency

Case 1 --- No additional test specimen be taken

Work Shift (8 hrs) Shift 1 Shift 2 Shift 3 Shift 4 Shift 5 Shift 6

If production for COMPANY were to be discontinued due to mill production line maintenance (no change in the equipment settings) and recommence its production for project contract but only for a small quantity, this shall be considered as "continuous" as long as no change in the production setting and no production were to occur in between the two production shifts as described.

Case 2 --- Additional test specimen be taken

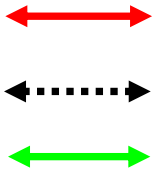
Work Shift (8 hrs) Shift 1 Shift 2 Shift 3 Shift 4 Shift 5 Shift 6

If production for the COMPANY were to be interrupted with any change in equipment, setting to occur (including production for another customer, etc.) additional test specimens shall be taken, even from the small lot production.

COMPANY Production

No Production

Production for other customer (s)



Appendix D Ring Splitting Test

Residual stress tests shall be performed on rings approximately 12-inches long.

Manufacturer shall:

1. Mark one end of the 12-inch specimen with punch marks at 11 o'clock and 1 o'clock positions.
2. Using micrometer calipers, measure:
    a) the distance between punch marks (M1), and
    b) the diameter of the pipe (D)
3. Cut the specimen through the centerline of the longitudinal weld and parallel to the longitudinal axis.
4. Repeat the measurements from step 2a (M2).
5. Referencing the equation below, M1 and M2 shall be reported to the COMPANY and calculate and report the residual stress as:

$$s = \frac{Et}{1-m^2}\,\frac{M2-M1}{D^2\pi}$$

Where,

s = Circumferential Residual Stress

E = Young's Modulus (Assumed 210 MPa)

t = Average wall thickness (mm.)

m = Poisson's Ratio (assumed = 0.3)

D = Average Pipe Diameter (mm)

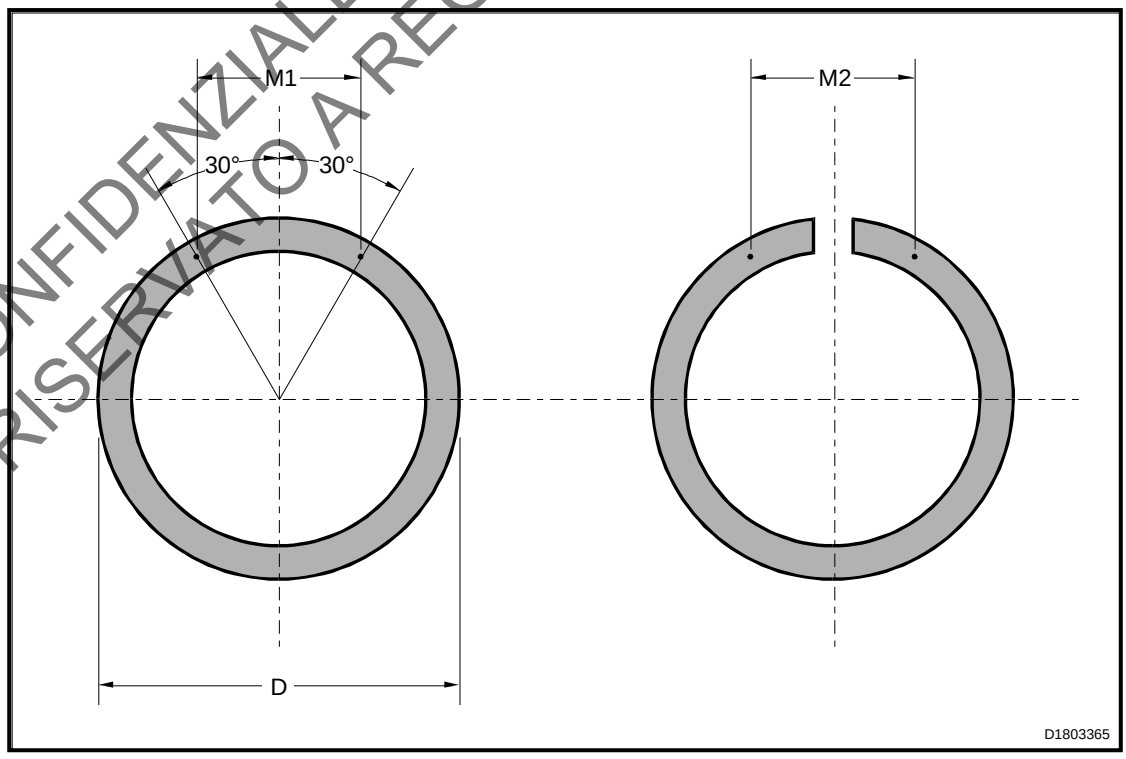


Figure D-1: Ring Splitting Residual Stress Test