PETROBRAS	**TECHNICAL SPECIFICATION**	N°:	**I-ET-0000.00-0000-211-P9U-002**
	CLIENT: PETROBRAS		SHEET: 1 of 21
	JOB: GENERAL		CC:
	AREA: RIGID SUBMARINE PIPELINES		PROJECT:
DDP	TITLE: **SEAMLESS (SMLS) PIPES REQUIREMENTS**		PUBLIC
			EDR

INDEX OF REVISIONS

REV.	DESCRIPTION AND/OR REVISED SHEETS
0	ORIGINAL EMISSION – THIS SPECIFICATION REPLACES I-ET-0000.00-6500-211-P9U-002=A
A	REVISED ITEMS WERE HIGHLIGTHED IN YELLOW. API 5L 2018 AND IOGP SPECS WERE ALSO CONSIDERED
B	DOCUMENT CLASSIFICATION

	REV. 0	REV. A	REV. B	REV. C	REV. D	REV. E	REV. F	REV. G	REV. H
DATE	28/12/17	07/08/20	11/11/2021						
PROJECT	EISE/EDR	EDD/EDR	EDD/EDR						
EXECUTION	RHEL	CWF8	HXA1						
CHECK	CWF8	HXA1	RVYZ						
APPROVAL	CLZ2	CLZ2	CLZ2						

1 TECHNICAL SPECIFICATION SCOPE

1.1 The objective of this specification is to define the technical requirements for SEAMLESS pipes. **SEAMLESS pipes fabricated according to this Technical Specification shall be in compliance with all requirements of DNVGL-ST-F101 – October 2017**. This document shall be read in conjunction with DNVGL-ST-F101. All additional and modified requirements to DNVGL-ST-F101 are mentioned in this technical specification. The DNVGL-ST-F101 paragraph number is given in parenthesis.

1.2 **(7.1.1.1 - Section 7) Addition -** This technical specification is applicable to the following limits:

a) Flowlines and dynamic risers for submarine pipeline systems;
b) Steel grade: DNV 415MPa to DNV 555MPa;
c) Coating: Application temperature for parent and field joint coating not exceeding 260ºC;
d) Installation Methods: J-lay, S-lay and Towing;

NOTE: This technical specification may be adopted for reel-lay installation method provided that the supplementary requirement P is fulfilled (see Appendix A of this Specification).

1.3 **(7.1.1.3 - Section 7) Addition -** The fatigue resistance of girth welds is not included in the scope of this document. This document is exclusively dedicated to the SEAMLESS pipe.

NOTE: This technical specification presents general requirements for SEAMLESS pipes manufacturing. It is responsibility of the team in charge of the design to insert additional or modified requirements if judged necessary to guarantee the integrity of riser/pipeline during design life.

1.4 **(1.7.1 - Section 1) Modification** - Where there is a conflict between the requirements of this specification, the Design Basis (specific for Riser and Pipeline project) and the referenced DNV Offshore Code, the order of precedence of the documents shall be:

1st – Design Basis (specific for Riser and Pipeline project);

2nd – This Technical Specification;

3rd – DNVGL-ST-F101

1.5 Additional requirements for H_2S operation, reeling installation method, upset end and regarding dimensional requirements for riser applications are presented in Appendix A of this specification.

1.6 Appendix B of this specification presents the requirements and test frequency for the following phases: MPQT, First Day Production Tests (FDPT) and Production.

1.7 Appendix C of this specification presents the necessary information to be informed in material requirements by PETROBRAS in MR for line pipe supply.

1.8 SUPPLIER shall perform, at his expense, all testing precluded in this Technical Specification. SUPPLIER shall consider that, unless otherwise written agreed, PETROBRAS will not accept historical data in order to waive testing or acceptance criteria.

2 REFERENCES

2.1 **(1.7.6 - Section 1) Addition -** The latest revision of the following documents applies:

[1] NACE TM0316 (December 2015)	Four-Point Bend Testing of materials for Oil and Gas Applications
[2] ISO 12135 (November 2016)	Metallic materials — Unified method of test for the determination of quasistatic fracture toughness
[3] BS EN ISO/IEC 17024 (July 2012)	Conformity assessment -- General requirements for bodies operating certification of Persons
[4] ABNT NBR 16212 (September 2013)	Pipelines – Storage in uncovered area
[5] ASTM G39	Standard practice for preparation and use of bend beam stress corrosion test specimens
[6] I-ET-0000.00-0000-970-PSQ-001	Procedure and personnel qualification and certification.
[7] IOGP S-616	Supplementary Requirements to API Specification 5L and ISO 3183 - Line Pipe

3 DEFINITIONS

3.1 **(1.8.2 - Section 1) Addition -** The following definitions are applied in this document:

PETROBRAS	Including its employees, inspectors and other representatives;
SUPPLIER	The firm, organization or person responsible for the provision of goods, materials and/or services specified herein;

3.2 **(1.8.3 - Section 1) Addition -** The following Abbreviations are also applied:

AYS – Actual Yield Strength
FDPT – First Day Production Tests;
FPBT – Four-Point Bend Testing;
MR – Material Requirements (Document issued for each riser and flowline project).
Pcm – Parameter Crack Measurement

4 TECHNICAL REQUIREMENTS

4.1 CARBON STEEL SEAMLESS PIPES MANUFACTURING

4.1.1 **(7.2.3.1 - Section 7) Modification –** C-Mn line pipe shall be manufactured according to the following process: Seamless (SMLS) – rotary piercing.

4.1.2 **(7.2.3.5 - Section 7) Addition –** In case of cold finishing is used during seamless pipe manufacturing, all parameters shall be described in the MPS and it shall be stated in the inspection document.

4.1.3 **(7.1.5.1 - Section 7) Modification –** C-Mn line pipe shall meet the supplementary requirements given in Subsection 7.9, for:

- ✓ Sour service, suffix S (see Appendix A of this specification);
- ✓ Fracture arrest properties, suffix F (see 7.9.2);

- ✓ Enhanced dimensional requirements for line pipe, suffix D (see 7.9.4);
- ✓ Supplementary requirement U - applicable if specified in the MR (Material Requirements);

NOTE: Supplementary Requirement "P" is automatically required if AR R is required (see Appendix A of this specification).

4.1.4 **(7.1.7.1 - Section 7) Addition –** The preliminary MPS shall be part of the required bid documentation dossier;

4.1.5 **(7.1.8.1 - Section 7) Addition –** If a previously qualified and approved MPQT is present by SUPPLIER, only FDPT shall be performed as per Tables B-1, B-2 and B-3 of this specification.

4.1.6 **(7.1.8.1 - Section 7) Addition –** In case of previously qualified and approved MPQT is presented by SUPPLIER, it shall guarantee that the following requirements are complied with:

- ✓ Validity of the MPQT;
- ✓ FDPT and production must reflect the same essential variables used in the qualified and approved MPQT.

4.1.7 **(7.1.8.2 - Section 7) Addition –** For C-Mn steels with SMYS ≤ 450 MPa, the qualification of the MPS may be performed during production. In this case PETROBRAS may allow the start of line pipe production before completion of SSC and HIC testing and before CTOD testing results at mill risk. PETROBRAS will only consider this option if requested by SUPPLIER four weeks before MPQT start. In this case, SUPPLIER shall present historical data for the same line pipe wall thickness and D/t ratio to prove that SSC, HIC and CTOD testing results (latter carried out at temperature equal to or lower than T_{Min}) will fulfill the specified requirements described herein. Those historical data shall not be used to replace or waive MPQT/ FDPT for a specific project.

4.1.8 **(7.1.8.6 - Section 7) Modification –** Weldability data shall be submitted to PETROBRAS in order to avoid weldability tests. In this case, track record shall be submitted for PETROBRAS review.

4.1.9 **(7.1.8.7 - Section 7) Addition –** A qualified and approved MPQT may have validity up to 5 years starting with the final approval by PETROBRAS.

4.1.10 **(7.2.3.1 and table 7-1 - Section 7) Modification –** SMLS C-Mn Steel shall be manufactured as quenched and tempered (QT) pipes.

4.1.11 **(7.2.3.33 - Section 7) Modification –** Heat treatment procedure of SMLS pipe shall be in accordance with the following definitions: Austenitising temperature shall be around 920ºC and then pipe shall be quenched in water and tempered between 600 to 690ºC. In addition, any recommendations from the material Manufacturer with regard to heating and cooling rates, water temperature and soaking time shall be included in the MPS.

4.1.12 **(7.2.3.38 - Section 7) Modification –** Pipe ends shall be cut square and be free from burrs.

4.1.13 **(7.2.3.40 - Section 7) Modification –** Jointers are not acceptable.

4.1.14 **(7.2.3.43 - Section 7) Modification –** If any mechanical tests fail during production of quenched and tempered seamless pipe, it is acceptable to conduct only one re-quenching and only two re-tempering as re-heat treatment cycle of the entire test unit. All mechanical testing shall be repeated after re-heat treatment and the acceptance criteria defined in this Technical Specification shall be fulfilled.

4.2 TESTING REQUIREMENTS

4.2.1 **(7.1.8.8 - Section 7) Modification –** During MPQT and FDPT qualification and production, Pcm variation should be permitted as +0.01/-0.03, where the maximum Pcm value of the entire project or supply shall be equal or lower than the maximum Pcm value specified by SUPPLIER, which shall also be restricted by DNVGL-ST-F101 standard for this product. In case the product analysis measurement during line pipe production reaches a Pcm value higher than that previous qualified during MPQT, verification of the heat analysis of the supplied billet/ingots with the same heat number may be performed for clearance of the production; however, this new calculated Pcm value shall be equal or lower than the highest Pcm value qualified during MPQT.

4.2.2 **(7.2.4.4 - Section 7) Addition -** To support procedure qualification of girth welding, SUPPLIER shall manufacture and supply the pipes for the MPQT at the highest aimed Pcm value. The delivery of these pipes shall be described in the RM.

4.2.3 **(7.2.4.8 and 7.9.1.8 - Section 7) Modification –** The hardness requirements shall be as given in table A-3 and when applicable table A-4 of this specification.

4.2.4 **(7.2.4.8 - Section 7 and Item B.2.10.5 - Appendix B) Addition –** Hardness testing shall be performed at three different areas, from the line pipe circumference located 120 degrees apart from each other, for each tested pipe in a total of 3 samples. During MPQT and FDPT, for pipes with wall thickness greater than ¾ inch (19 mm), additional hardness measurements shall be performed at ¼ and ¾ of the wall thickness. A minimum of 12 readings at each horizontal line of figure 1 shall be taken at 5 mm intervals. At least on 1 sample an additional hardness prolife shall be taken across the thickness, equally spaced between 0.5 mm – 1.0 mm, and starting at least 1.5 mm away from the outer/inner surface. Figure 1 shows the sketch of hardness profiles for locations for wall thicknesses greater than ¾ inch (19 mm).

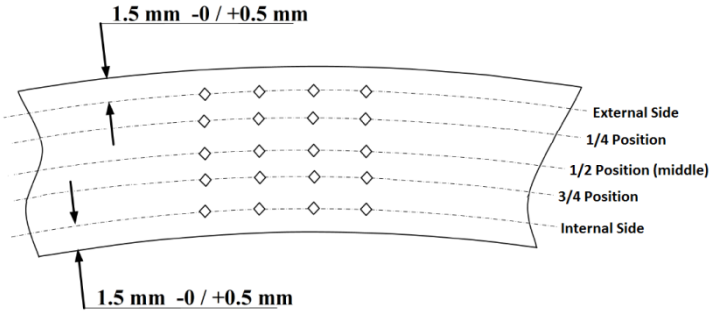


Figure 1 – Hardness profile for MPQT and FDPT for wall thicknesses greater than ¾ inch (19 mm)

4.2.5 **(B.2.10.2 - Appendix B) Addition –** Microstructure shall be assessed, with a magnification of at least 400X, in the internal surface, middle and external surface over the through-thickness, after final heat treatment and only during MPQT and FDPT in the middle and both ends of one single pipe. For each location two test pieces 180° apart shall be taken. During production the microstructure shall be performed and reported at each test unit. 2 Samples from each end shall be removed from one single pipe.

4.2.6 **(7.2.4.9 - Section 7) Modification –** For pipes up to 24” OD absorbed CVN impact energy values shall, as a minimum, meet the values presented in table 1 for full size specimens, unless otherwise specified by PETROBRAS in MR or Specific Pipeline Project Documentation. Specimens shall be removed in the transverse direction.

Table 1 – Absorbed CVN Impact Energy Acceptance Criteria

Material	DNV 450	DNV 485	DNV 555
Impact Energy Average – KVT (Minimum) [J]	95 (80)	106 (89)	134 (112)

4.2.7 **(7.2.4.9 - Section 7) Addition –** The testing temperature for Charpy V-notch impact test will be informed by PETROBRAS in the MR or Specific Pipeline Project Documentation.

4.2.8 **(B.2.4.3 – Appendix B) Modification –** During MPQT, for pipe with t > 20mm and delivered in the QT condition, one additional set of transverse direction CNV test pieces shall be sampled 2 mm above the internal surface. For pipe with t > 35mm (1.38 in.), CVN testing shall be done on specimens taken from ID, mid-wall and OD.

4.2.9 **(7.2.5.1 - Section 7) Modification –** The inspection frequency during production and MPQT shall be as given in Tables B-1 to B-3 of this specification. The remaining inspection tests not mentioned herein shall follow tables 7-7 and 7-8 of DNVGL-ST-F101.

4.2.10 **(7.2.5.7 and 7.2.5.10 - Section 7) Modification –** During MPQT and/or FDPT, if a testing fails to meet the requirements specified herein in this specification, two re-tests shall be performed (for the failed testing only) on samples taken from the same pipe. Both re-testing shall meet the specified requirements for MPQT and/or FDPT qualification approval. All testing, including the one that failed, shall be reported.

4.2.11 **(7.2.5.12 - Section 7) Addition –** Any additional element shall not be added to purchase order without PETROBRAS written validation.

4.2.12 **(7.3.5.8 - Section 7) Addition -** PETROBRAS reserves the right to reject any test unit if failure occurs in CTOD testing or in SSC and/or HIC testing.

4.2.13 **(7.9.1.10 - Section 7) Modification –** The requirements for HIC testing are given in table A-1 and APPENDIX A of this specification.

4.2.14 **(7.9.1.20 - Section 7) Modification –** SSC testing is required unless when used as a backing steel for Mechanically Lined Pipes (MLP). SSC testing shall be performed in accordance with table B-1 of ISO 15156-2 for SSC regions 1, 2 and 3.

4.2.15 (7.9.2.2 - Section 7) Modification – During MPQT, for QT pipes with wall thickness higher than 20 mm, additional CVN transition curves in both original condition and aged condition shall be performed using 5 sets of impact tests (five specimens per set) sampled at ID and tested between -60°C and +20 °C, including T_{Min}, with the distribution to be proposed by SUPPLIER and submitted for PETROBRAS validation.

4.2.16 **(7.9.2.5 - Section 7) Modification -** Minimum value of fractured shear area shall be greater than 85% for CVN impact specimens at the $T_{Min.}$ Acceptance criteria shall be as per table 1 of this specification.

4.2.17 **(7.2.4.15 - Section 7 and B.2.8.13 Appendix B) Addition –** δ fracture toughness testing of the base metal shall be performed using SENB specimens with X-Y plane orientation (through-thickness notch) and with dimensions equal to BxW (where W=2B) as per BS 7448. Wall thickness samples shall be from 13.5 mm up to 28.60 mm. Full thickness rectangular specimens shall be used. Measured CTOD fracture toughness values shall, as a minimum, be equal or higher than δ = 0,40 mm when tested at TMin for BM locations.

4.2.18 **(B.2.8.14 - Appendix B) Addition –** Specimens shall be extracted in the longitudinal direction and shall not be flattened during sample preparation.

4.2.19 **(7.9.2.4 - Section 7) Addition -** When applicable, alternative criteria for inverse (abnormal) fracture evaluation shall be proposed by SUPPLIER and it shall be previously approved by PETROBRAS before start of production.

4.2.20 **(Table 7-29 – Note 2 – Section 7) Addition -** If supplementary requirement P is specified in the project datasheet(s), additional longitudinal tensile testing shall always be performed on proportional samples as per ISO 6892.

4.2.21 **(7.5.1.3 - Section 7) Addition** – Mill test pressure (ph) may be reduced upon written request to PETROBRAS.

4.2.22 **(C.7.3.5 - Appendix C) Addition -** It is not permitted to repair pipe indication/discontinuity by welding.

4.3 NDT REQUIREMENTS

4.3.1 **(D.1.5.1, D.1.5.2 and D.8.1.4 - Appendix D) Modification –** Qualification and certification of NDT inspectors shall be in accordance with the Brazilian System of Personnel Qualification and Certification in NDT – ABENDE, according to standard ISO 9712. NDE personnel qualification to an employer based qualification scheme as SNT-TC-1A may also be accepted only for automatic US inspection and EMI inspection if the Brazilian System of NDE Personnel Qualification does not certify personnel for the intended NDE method on the certification of the Scope of Work (SOW). In this case, only a level 3 as ASNT Level III or ACCP Professional Level III and certified in the applicable method is accepted. For services rendered abroad, qualification and certification shall be according to that established above or by independent international entities that meet requirements in standard BS EN ISO/IEC 17024 and that operate in accordance with standards ISO 9712, whereas in this case PETROBRAS' previous approval is required. In all situations SUPPLIER shall submit a list of the inspectors certified per NDT method, information about the certification standard and name of certification body or authority, with a copy of existing certificates to get PETROBRAS previous approval.

4.3.2 **(D.8.5.1 - Appendix D) Addition –** All pipes shall be inspected for bevel damage, severe corrosion, dent, gouges and other similar defects.

4.3.3 **(D.8.5.30 - Appendix D) Modification –** Magnetic induction, measured at the pipe ends, shall be performed 3 times per shift as a minimum, after all beveling operations and subsequent to any NDT methods that involve the use of a magnetic field (including coating application). Residual magnetic field shall not exceed 20 gauss.

4.3.4 **(D.8.7 - Appendix D) Addition –** Pipe ends shall be tested with wet fluorescent MT for longitudinal and transverse defects, internal and external surfaces, after beveling and machining. MP inspection equipment shall be verified \with specified reference standard at least twice per shift, in the presence of the PETROBRAS representative.

4.3.5 **(D.8.7 - Appendix D) Addition –** All imperfections detected in the MT shall be repaired by grinding and remaining wall thickness will be checked by manual UT.

4.3.6 **(D.8.7.2 and D.8.7.3 - Appendix D) Modification –** Both ends of each pipe shall be tested for laminar imperfections in accordance with ISO 10893-8 and the additional requirements in D.8.1 over a band at least 150 mm inside the location of future welding preparations for girth welds.

4.3.7 **(D.8.7.4 - Appendix D) Modification –** Acceptance criteria shall be according to Table D-12.

4.3.8 **(D.8.8 - Appendix D) Addition –** UT inspection of each pipe body shall be carried out using a helical pattern with at least 25% scanning coverage of the pipe surface.

4.3.9 **(D.8.8.4 - Appendix D) Addition –** It is allowed to perform NDT inspection using the technique of 6.35 mm diameter Flat Bottom Hole in the internal diameter within 50% of the nominal or actual wall thickness can be used. In this case, any equal or greater indication will be cause for rejection.

4.3.10 **(D.8.8.8 - Appendix D) Addition –** Each length of pipe shall be measured full length to measure wall thickness. The pipe SUPPLIER shall submit with his quotation all details of his proposed inspection and the amount of coverage. Ultrasonic thickness testing of the pipe body by scanning along a helical or straight pattern ensuring a minimum pipe surface coverage of 25% shall be achieved by SUPPLIER.

4.3.11 **(D.8.14 - Appendix D) Addition –** UT inspection equipment shall be calibrated with specified reference standard at least twice per shift, in the presence of the PETROBRAS representative. Sensitivity of equipment shall be checked twice per shift, in the dynamic mode, on the reference standard. Should the equipment malfunction during operation the entire amount of pipes tested since the last calibration will require to be re-tested after the equipment has been repaired and its calibration status re-established.

4.3.12 **(D.8.14 - Appendix D) Addition –** Inclined embedded defects are understood to be inclusions or laminations.

4.3.13 **(D.8.14 - Appendix D) Addition –** Lamination examination sensitivity shall be established using 1/4" diameter flat-bottomed hole with depth ½ wt. All indications resulting in 50% or greater loss in back wall echo shall be rejected. This requirement also exists when square cut ends are specified on MDS. Couplant shall be plain fresh water and equipment shall have audio or visual alarms to denote loss of coupling and signals in excess of acceptance limits.

4.3.14 **(D.8.14.6 - Appendix D) Modification –** As automated ultrasonic testing of girth welds during installation is required to be performed the width of the band shall be extended at least 150 mm inside the location of future welding preparations for girth welds.

4.4 DIMENSIONAL REQUIREMENTS

4.4.1 **(7.7.1 - Section 7) Addition –** Line pipe shall be furnished with square cut ends according to MR definition.

4.4.2 (7.7.2 - Section 7) Addition - All pipes shall be delivered in such a way that after the line-up of two randomly selected pipes, without the need of pipe rotation, the external Hi-Lo values shall not exceed 1.6 mm and nominal (actual) external diameter at pipe ends shall not exceed the tolerance of ± 1.6 mm. The same applies to the internal line-up, where the internal Hi-Lo values shall not exceed 1.4 mm.

4.4.3 **(7.7.2 - Section 7) Addition -** Reference end ID shall be based on the ID average determined by measuring, at least, 30 pipes (60 ends) during the First Day Production.

4.4.4 **(7.7.2.1 and Table 7-17 Section 7) Modification –** ID tolerances for pipe ends shall be according to the following conditions:

- ✓ For ID diameters equal to or less than 254 mm: ± 0.5 mm or ± 0.005 D, whichever is greater, but max. ± 1.0 mm;

- ✓ For ID diameters greater than 254 mm: ± 0.5 mm or ± 0.005 D, whichever is greater, but max. ± 1.4 mm;

4.4.5 **(7.7.2.3 - Section 7) Modification –** The average line pipe length shall be:

- ✓ 100% of the line pipe lengths shall be between 11.9 m - 12.5 m;
- ✓ Average length value shall be between 12.05 m and 12.3 m, where 70% of the line pipe lengths shall be inside this range.

4.4.6 **(7.7.2.3 - Section 7) Addition –** When is required in MR or Specific Pipeline Project Documentation (example, for S-Lay installation method), the requirement for the average line pipe length shall be as below (more stringent since lay vessel layout requires tighter tolerances):

- ✓ 100% of the line pipe lengths shall be between 11.9 m - 12.5 m;
- ✓ Average length value shall be between 12.1 m and 12.3 m, where 70% of the line pipe lengths shall be inside this range.

4.4.7 **(7.7.1.3 - Section 7) Addition –** All measurement devices shall be calibrated in a laboratory registered in RBC (Rede Brasileira de Calibração – INMETRO) or by an equivalent international recognized certifying authority. Additionally, all micrometers shall be checked for calibration at the beginning of each shift.

4.4.8 **(7.7.3.3 to 7.7.3.6 - Section 7) Modification –** Pipe end ID and out-of-roundness shall be measured with automatic equipment (e.g. laser system) in, at least, 8 different internal positions equally spaced around the line pipe circumference. In case of equipment breakdown, measurements may be performed with manual equipment/device. The sketch in the figure 2 presents the methodology of pipe end ID measurements, including the additional 2 measurements close to the weld toe.

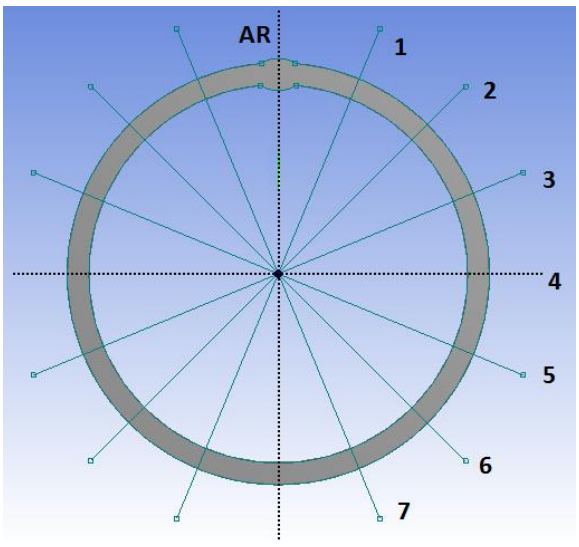


Figure 2 – Example of ID and out-of-roundness measurement positions

4.4.9 **(7.7.3.3 to 7.7.3.6 - Section 7) Addition –** In case of the failure of the laser equipment, the number of positions for ID measurements with manual equipment shall be, at least, the same used during automatic measurements. Laser equipment, micrometer and Go/No-Go gauge rod calibration certificate period of validity shall be, at most, 6 months.

4.4.10 **(Table 7-22 - Section 7) Addition –** Deviation from a straight line shall not exceed 0.15% of the line pipe length or 13 mm, whichever is less.

4.4.11 **(Table 7-22 and 7.7.3.10 Section 7) Addition –** Any local deviation shall be less than 3 mm within any 1 m of line pipe length, including pipe ends. The line pipe end straightness shall be measured in, at least, two perpendicular planes. The method of determining straightness shall be subject to PETROBRAS' validation.

4.4.12 **(Table 7-23 Section 7) Addition –** Pipe end ID and out-of-roundness measurement frequency shall be equal to:

- ✓ 10% of pipes ID shall be measured and recorded using laser equipment or micrometer in case of laser equipment breakdown;
- ✓ 100% of pipes ID shall be controlled by laser or another proper equipment/device in case of laser equipment breakdown.

4.4.13 **(Table 7-23 Section 7) Modification –** Data from dimensional inspection (ID and out of roundness) shall be recorded, at least, in a frequency of 1/10 produced pipes. For MPQT dimensional inspection of, at least, 5 pipes of each test unit shall be recorded. For FDPT dimensional inspection of, at least, 10 pipes of each test unit shall be recorded.

4.4.14 **(Table 7-20 - Section 7) Modification -** The wall thickness tolerance for pipe end shall be equal to ± 0.1 WT, but maximum ± 2.0 mm.

4.4.15 **(Table 7-20 - Section 7) Modification -** The overall wall thickness tolerance at the pipe ends shall not exceed ±2.0 mm. Furthermore, the eccentricity at the pipe ends, i.e. the difference between the maximum and minimum overall wall thickness in one cross-sectional plane shall be limited to 2.0 mm.

Note 1: For special applications (risers, jumpers, dynamic pipelines, etc), the more stringent requirements of the Appendix C of this specification shall be used. This condition shall be clearly described in the MR or specific Pipeline Project Documentation.

Note 2: In the end of the SMLS pipes manufacturing process, in case of machining is to be performed on each pipe end to be supplied as a backing steel for lined pipe (MLP), the pipe end shall be machined to fit the specified target, which shall be agreed between MLP manufacturer and purchaser.

4.5 PIPE MARKING AND TRACEBILITY

4.5.1 **(7.8.1.1 - Section 7) Addition** - When required as per RM, color identification shall be in accordance with ISO 3183 standard. Color identification shall be used herein for grouping pipes from different wall thicknesses, dimensional tolerances and specific additional requirements.

4.5.1.1 **(7.8.1.2 - Section 7) Modification -** Marking shall include DNV line pipe designation as per item 7.2.2 - Section 7. Marking shall reflect the correlation between the product and the respective inspection document.

4.5.1.2 **(7.8.1.3 - Section 7) Addition -** Each pipe shall be marked with a unique number to allow tracking of pipes throughout manufacturing, coating, welding and installation. Not only pipes shall have a traceable unique number but also each sample obtained for tests and inspections.

4.5.1.3 **(7.8.1.3 - Section 7) Addition –** Line pipes shall be supplied with square cut – non beveled ends. Pipe unique number shall be cold die stamped on both ends.

4.5.1.4 **(7.8.1 - Section 7) Addition -** SUPPLIER shall submit for PETROBRAS' approval the layout of marking. Pipe marking shall have, at least the information stated in item 11.2.1 of ISO 3183 standard. Additional information to be marked are expressed below:

- ✓ Heat and ITP Number;
- ✓ Sour Service Severity Steel Class;
- ✓ Mark of PETROBRAS inspection representative, if applicable.

4.6 DELIVERY CONDITION AND DOCUMENTATION REQUIREMENTS

4.6.1 **(7.8.3 - Section 7) Addition –** When applicable, the use of end caps in order to preserve the integrity of the bevel codification and avoid dirt and water entrance may be required in MR or specific project documentation. The end protections shall be able to be installed and re-installed manually in pipe end during coating application, and shall also allow line pipe lifting without their removal.

4.6.2 **(7.8.3 - Section 7) Addition –** SUPPLIER shall submit 8 weeks prior to initial load out all instructions and diagrams related to line pipe loading by all kinds of transportation manners, i.e. by truck, train or vessel. Loading instructions Works shall be reviewed and approved by PETROBRAS. Storage requirements of [4] shall be fulfilled.

4.6.3 **(7.8.4 - Section 7 and 12.3.1.1 - Section 12) Addition** - The documentation to be submitted for review prior to start or during start-up of manufacturing shall be submitted for PETROBRAS evaluation by SUPPLIER two months before the date schedule for MPQT.

Note 1: PETROBRAS will release comments 14 days after the submission of documentation for PETROBRAS evaluation. SUPPLIER shall resubmit the document with the implemented comments up to 14 days after the comments release. The revision cycle will only be finished when all comments made by PETROBRAS and/or purchaser are implemented by SUPPLIER.

Note 2: MPQT shall not begin until the all documents are approved by PETROBRAS and purchaser.

Note 3: Before starting production, SUPPLIER shall release the remaining documents stated in clause C101, section 12 of DNV plus the Inspection Test Plan (ITP) for PETROBRAS or purchaser appreciation. The revision cycle deadline presented in Note 1 above is still applicable for production purposes.

Note 4: The quality of documentation shall allow PETROBRAS or purchaser approval. PETROBRAS or purchaser to reserve the right to reject the documentation in case of lack of clarity, poor quality documentation, deviation to this technical specification and the absence of the information requested in this section.

4.6.4 **(12.3.1.2 - Section 12) Addition -** The complete statistics of chemical composition, mechanical properties and dimension (out of roundness) for the quantity delivered shall be released per batch manufactured, one month after each batch manufactured. Information of measured properties such as chemical composition, yield and ultimate strength and wall thickness shall be clearly presented for each batch.

4.6.5 **(12.3.1.2 - Section 12) Addition -** All documentation shall be available in electronic data files one month after manufacture finishes. All electronic data files shall be delivered in PDF format. All files shall be clearly presented in folders in a logical index to be proposed by SUPPLIER and submitted to PETROBRAS or purchaser approval.

APPENDIX A - ADDITIONAL REQUIREMENTS

A.1 GENERAL

A.1 - This appendix presents the additional requirements for manufacturing and testing of SMLS pipes. These additional requirements are applicable if required by PETROBRAS or the purchaser on RM.

A.1.2 - The following additional requirements are envisaged in this appendix:

AR SS: This additional requirement is applicable when designer intends to take into account the H_2S effects on Sour Service operation of riser/ pipeline;

AR RL: This additional requirement is necessary when SMLS pipes manufactured are intended to constitute risers or pipelines installed by Reel-Lay method;

AR HL: This additional requirement is applicable when designer intends to take into account the Hi-Lo control on riser/ pipeline design;

AR UE: This additional requirement is applicable when designer intends to take into account the Upset End effects on riser/ pipeline design;

A.2 - AR SS – ADDITIONAL REQUIREMENTS FOR H_2S SERVICE.

A.2.1 – (7.9.1.10 and 7.9.1.11 - Section 7) Modification - According to the SSC region of environmental severity defined in MR and Specific Pipeline Project Documentation, SUPPLIER shall conduct HIC and SSC testing in compliance with the requirements and acceptance criteria presented in Tables A-1 and A-2 below.

A.2.2 - Inspection frequency of testing is defined in Table B-1 and Table B-3, when applicable.

Table A -1* – HIC *Testing Requirements

Test Solution for H_2S service operation and acceptance criteria

SSC REGION OF ENVRONMENTAL SEVERITY	HIC TEST SOLUTION	ACCEPTANCE CRITERIA		
		CLR (%)	CTR (%)	CSR (%)
0	N.A.	N.A.	N.A.	N.A.
1	Solution B of standard NACE TM 0284	15	3	1
2	Solution B of standard NACE TM 0177	15	5	2
3	Solution A of standard NACE TM 0284	15	5	2

Table A-2 – SSC Testing Requirements

Test Solution for H_2S service operation and acceptance criteria

SSC REGION OF ENVIRONMENTAL SEVERITY	SSC TESTING SOLUTION	ACCEPTANCE CRITERIA
0	N.A.	N.A.
1	Solution B of standard NACE TM 0284 with 10% of H_2S/ 90% CO_2	No cracks
2	Solution B of standard NACE TM 0284	No cracks
3	Solution A of standard NACE TM 0177	No cracks

Table A-3 – Maximum Hardness Values for H_2S Service Operation

Requirements not considering Reel Lay Installation

SSC REGION OF ENVIRONMENTAL SEVERITY	MAXIMUM HARDNESS VALUES	
	INTERNAL and MIDDLE SURFACE	EXTERNAL SURFACE
0	**275HV10**	**300HV10**
1	**250HV10**	**275HV10**
2	**250HV10**	**255HV10**
3	**230HV10**	**250HV10**

A.2.3 – (B.3.3.1 and B.3.3.2 - Appendix B) Modification - HIC test specimen shall be prepared as per NACE TM 0284. Acceptance criteria and testing conditions (solution) for the HIC testing shall be as per above Table A-1 complying with the SSC region of environmental severity defined in RM.

A.2.4 – (B.3.4.6 - Appendix B) Modification - SSC testing shall be performed on BM either by FPBT method described at ASTM G39, NACE TM0316 or by method A of standard NACE TM 0177. BM specimens shall be removed in the line pipe longitudinal direction. SSC testing solution shall be selected according to Table A-2 considering the SSC region of environmental severity defined in MR or Specific Pipeline Project Documentation. Applied loading during SSC testing shall be minimum 80% of AYS. Testing duration shall be, at least, 720 hours.

A.2.5 - (7.9.1.11 - Section 7) Modification – Visual examination of the tested surface shall be carried out with a low power microscope (10X magnification) to prove that there are no surface breaking fissures or cracks as a result of SSC damage mechanism. Further metallographic examination can also be performed in case of visual examination does not provide any conclusion. Visual and/or metallographic examination report shall include pictures of the tested surfaces for each SSC specimen.

A.2.6 - (7.9.3.4 - Section 7) Addition - The following testing shall also be conducted when required by PETROBRAS in RM:

a) CTOD testing carried out considering hydrogen effects in the material toughness. In this case, measured CTOD fracture toughness values shall, as a minimum, be equal or higher than δ = 0,35 mm when tested at T_{Min} for BM locations;

b) Testing environment: solution with dissolved H_2S gas; procedure for hydrogen charging is similar to HIC test as per NACE TM0284. The bath used to charge SENB shall be the solution A of NACE TM0177 standard. The minimum time of hydrogen charging for each specimen shall be, at least, 96 hours. The specimens shall be washed after been taken out of the bath and the CTOD test shall be carried out as soon as possible as per BS 7448; during testing, environment of the chamber shall be air or another solution without dissolved H_2S gas.

A.3 - AR RL – ADDITIONAL REQUIREMENT FOR REEL-LAY INSTALLATION

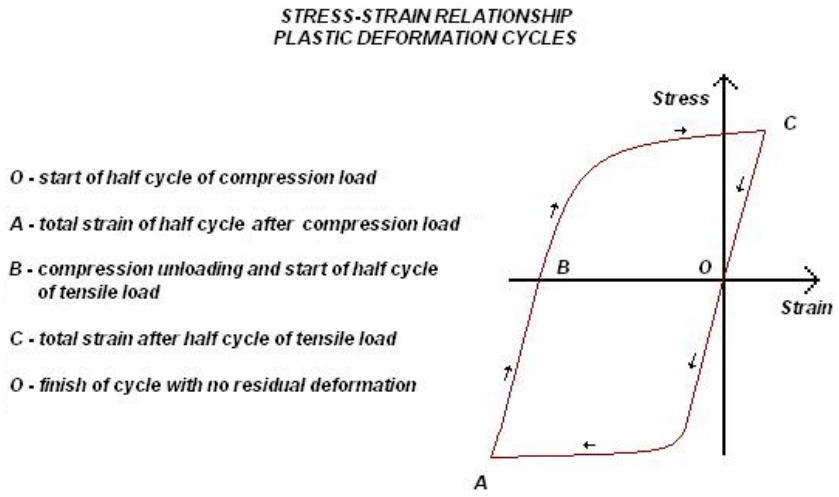
A.3.1 - The additional requirement AR R allows the utilization of SMLS pipes for risers or pipelines installed by reel-lay method, under the following limits in addition to item 1.2.

a) Reel-lay drum and aligner radius: Equal or higher than 7.5m;
b) Bending cycles: No more than 4 reeling cycles.

A.3.2 – (7.9.3.6 - Section 7) Modification – As part of qualification of the line pipe material, the finished pipe shall be deformed by simulated deformation according to the following straining cycles:

- ✓ 1st cycle: compression to -D/(15000+D) % and tension to 0.0% (closed loop OABCO);
- ✓ 2nd cycle: compression to -D/(15000+D) % and tension to 0.0% (closed loop OABCO);
- ✓ 3nd cycle: compression to -D/(15000+D) % and tension to 0.0% (closed loop OABCO);
- ✓ 4rd cycle: compression to -D/(15000+D) % + 0,2%[1] and tension to 0.0% (closed loop OABCO).

Where, D is the line pipe outside nominal diameter, in millimeters.



[2] Based on practical experience, an increase of 0,2% of compressive load is required to achieve final sample with no residual plastic deformation.

Figure A.1 – Straining cycles (closed loop).

[1] For production, no straining and ageing is required.

A.3.3 – (7.9.3.4 - Section 7) Addition - The following testing shall also be conducted for AR R fulfillment:

a) Pre-strained and aged samples shall be used for SSC corrosion testing on the inner surface.

b) CTOD specimens with wall thickness from 13.5 mm up to 28.60 mm, for reel-lay installation method shall be pre-strained considering 4 reeling cycles described in item A.3.2 and aged at 250ºC for 1 hour before testing. Measured CTOD fracture toughness values shall, as a minimum, be equal or higher than δ = 0,40 mm when tested at T_{Min} for BM locations.

Table A-4 – Maximum Hardness Values after straining and ageing for H_2S Service Operation

Requirements considering Supplementary Requirement "P" (after straining and ageing)

SSC REGION OF ENVIRONMENTAL SEVERITY	MAXIMUM HARDNESS VALUES	
	INTERNAL and MIDDLE SURFACE	EXTERNAL SURFACE
0	275HV10	300HV10
1	250HV10	275HV10
2	250HV10	255HV10
3	250HV10	250HV10

A.3.4 – (7.9.3.7 - Section 7) Addition - When Supplementary Requirement "P" is required as per MR SSC testing shall be performed on samples that are removed, strained and artificially aged according to figure A.1 of this specification. SSC testing condition shall comply with table A-2 for the SSC region of environmental severity defined in RM. In addition to the 3 strained and artificially aged samples tested at 80% AYS, another sample shall be prepared to be tested at 90% AYS. The result of this additional sample shall be described and reported as pass or fail, for information only.

A.3.5 - (7.2.4.9 - Section 7) Modification - In addition to the 3 CVN KVT (transverse direction specimens), another set of 3 CVN KVL (longitudinal direction specimens) shall be prepared to be tested at testing temperature. The required KVL values shall be 50% higher than the required KVT values.

A.4 - AR HL – ADDITIONAL REQUIREMENTS FOR HI-LO CONTROL OF LINEPIPES

A.4.1 - The additional requirement AR HL allows the consideration of a better hi-lo of pipe ends in pipeline and riser design. Riser application class shall be specified in the MR or specific Pipeline Project Documentation, according to this definition SUPPLIER shall consider one of the following requirements:

a) Normal (Low) Hi-Lo requirement: ± 1.4 mm; full or partial machining shall be permitted; nominal (actual) internal diameter tolerance at pipe ends shall not exceed ± 1.4 mm;

b) Medium Hi-Lo requirement: ± 0.8 mm; only full internal machining shall be performed; full or partial external machining shall be permitted; nominal (actual) internal diameter at pipe ends shall not exceed the tolerance of ± 0.8 mm;

c) High Hi-Lo requirement: ± 0.5 mm; only full internal machining shall be performed; full or partial external machining shall be permitted; nominal (actual) internal diameter at pipe ends shall not exceed the tolerance of ± 0.5 mm.

For external diameter the following requirements shall be considered according to MR definitions:

a) External hi-lo shall not exceed 1.4 mm for critical sections or actual external tolerance diameter at pipe ends shall not exceed ± 1.4 mm;
b) External hi-lo shall not exceed 1.6 mm for non-critical sections or actual external tolerance diameter at pipe ends shall not exceed ± 1.6 mm.

A.4.2 – (Table 7-22 - Section 7) Addition - Total deviation from a straight line, over the entire line pipe length, shall be less than 13 mm of the whole line pipe length. At pipe end, the local deviation from a straight line within 1m length shall be less than 3 mm.

A.4.3 – When required per MR or specific pipeline project documentation, SUPPLIER shall classify Line pipes according to the Hi-Lo requirement. Pipes shall be produced in a manner that pipe sorting or matching shall be not necessary during pipeline construction.

A.4.4 – Machining activities shall be performed by automatic equipment able to provide the specified level of eccentricity in the machined pipe end in order to assure the specified Hi-Lo requirement for a specific project. The following requirements shall be fulfilled:

- ✓ Each machining step shall be executed with a CNC machine. CNC machines shall be monitored for dimensional accuracy at least once per shift. Automatic measurement systems shall be calibrated once a year;
- ✓ Surface finishing after end machining shall provide Ra roughness lower than 3.2 µm and a maximum Rt roughness equal to 40 µm for internal surface. Roughness in the external surface shall not be controlled in the line pipe mill unless it is specified in the MR or specific Pipeline Project Documentation;
- ✓ Cylindrical machined section in the internal and external pipe ends shall be extended to, at least, 150 mm up to tapered transition area. Unless otherwise agreed, a 7:1 tapered transition shall be considered to assure a smooth transition between the cylindrical machined section and the “as manufactured” internal side. No sharp edges shall be kept in the division line between cylindrical/tapered transition area and tapered transition/“as manufactured” internal side;
- ✓ The machining after pipe end machining, both internal and external machined section may be finish by flap disc grinding device to enhance surface roughness. Finishing may be also extended beyond the tapered transition area in a length equal or higher than 150mm. Flap disc grit shall, as minimum, be equal to 80;
- ✓ The roughness of the cylindrical machined internal section, after machining and finishing, shall be measured in 100% of pipe ends by a RMS comparator in, at least, two longitudinal lines on the cylindrical machined surface;
- ✓ Machined internal section at the pipe end shall be as parallel as possible to external surface in order to avoid NDT difficulties (exception is considered for taper transition). Conical machining profile is not accepted.

A.4.5. - Pipe end machined section shall be inspected considering, at least, the requirements expressed below:

a) Visual inspection shall be performed on 100% of pipe ends, in order to verify the existence of grooves, scars or any other stress concentrator. Finished extension beyond the tapered transition shall be verified;

b) ID inspection shall be performed on 100% of pipe ends, including minimum of 8 different internal diameter positions equally spaced along the circumference. The inspection shall be done by laser equipment and in case of breakdown of the automatic system, by manual measurement device approved by PETROBRAS. All data shall be properly recorded guaranteeing line pipe traceability;

c) Wall thickness measurement in, at least, 16 locations equally spaced around pipe end circumference shall be executed for every 10 pipes. The inspection shall be performed by internal micrometer, UT measurement equipment or any other device previously approved by PETROBRAS.

A.4.6 - The end straightness shall be measured in, at least, two perpendicular planes. The method of determining straightness shall be subject to PETROBRAS approval and a minimum of three measurements per shift shall be recorded at both pipe ends (minimum of three pipes per shift).

NOTE: All measurement devices shall be calibrated in a laboratory registered in RBC (Rede Brasileira de Calibração – INMETRO) or internationally recognized equivalent institution and shall have calibration certificates available for verification. Additionally, all measurement devices shall be checked for calibration at the beginning of each shift.

A.5 - AR UE – ADDITIONAL REQUIREMENTS FOR UPSET END EFFECTS.

A.5.1 - The additional requirement AR UE allows the consideration of a better hi-lo of pipe ends in pipeline and riser design.

A.5.2 – When allowed in RM, SUPPLIER may offer end machined seamless pipes, previously upset at the pipe extremity and full body heat-treated, ideal for limiting Stress Concentration Factors.

A.5.3 – Pipes shall be ID and OD machined to achieve the requested tight inner and outer diameter tolerances. The machining of the pipe end shall be performed with automated CNC equipment to the original nominal wall thickness. The resulting machined pipe ends and associated transition zones to the pipe body shall be fully inspected by UT and MT.

A.5.4 – Roughness on machined surfaces shall be Ra 10µm maximum.

A.5.5 – A comparative study shall be performed between upset end pipe and pipe body, in order to confirm that upsetting operation in the pipe manufacturing flow have no impact, on the mechanical and microstructural properties of the finished pipe ends.

APPENDIX B – TEST MATRIX – ACCEPTANCE CRITERIA AND FREQUENCIES:

This appendix presents the acceptance criteria and tenting frequencies for SMLS pipes on the following tables:

Table B-1 – Testing Frequency

TEST/ CONTROL	REQUIREMENT	TEST FREQUENCY		
		MPQT	FDPT	PRODUCTION
Line pipe Dimensional Check				
Linepipe Dimensional Check	According to Tables 7-17, 7-19, 7-22 and Table 7-23 of DNVGL-ST-F101 standard and modifications required in clause 4.4 of this technical specification	For, at least, 5 pipes for each test unit.	For 10 pipes produced, for each test unit.	Clause 4.4 of this technical specification
Material Requirements				
Product Analysis	According to Tables 7-3 and 7-24 of DNVGL-ST-F101 standard.	Two analyses per test unit.	Two analyses per test unit.	Two analyses per heat of steel (from separated pipes)
Tensile Testing at linepipe body	According to Table 7-5 of DNVGL-ST-F101.	1 set of test per test unit.	1 set of test per test unit.	1 set of test per 50 lengths of pipe.
CVN Impact Testing of the BM	According to Table 7-27 of DNVGL-ST-F101 for BM (See clauses 4.2.6, 4.2.7 and table 1 of this specification)	1 set per pipe for BM per test unit.	1 set per pipe for BM per test unit.	1 set of test per 50 lengths of pipe.
Hardness Testing	According to Table A-3 for BM of this specification	1 set of test per pipe for BM per test unit.	1 set per pipe for BM per test unit.	1 set of test for BM per 50 lengths of pipe.
Transverse CVN Transition Curve	As per clauses 4.2.6, 4.2.7, 4.2.14, 4.2.15 and Table 1 of this specification	5 sets (5 samples/set) from -60°C to +20 °C per test unit.	N.A.	N.A.
Transverse CVN Transition Curve – Aged Condition	As per clauses 4.2.6, 4.2.7, 4.2.14, 4.2.15 and Table 1 of this specification	5 sets (5 samples/set) from -60°C to +20 °C per test unit.	N.A.	N.A.
Drop Weight Tear Test	According to Clause 7.9.2.4 of Section 7 DNVGL-ST-F101 standard.	5 sets (2 samples/set) from -60°C to +20 °C per test unit.	N.A.	N.A.
CTOD Testing	@ -30^{0}C CTOD (transversal, Bx2B) shall be as per Clause 4.2.16. of this specification	1 set (3 spec) 1 pipe for each test unit and for each thickness.	N.A.	N.A.

TEST/ CONTROL	REQUIREMENT	TEST FREQUENCY		
		MPQT	FDPT	PRODUCTION
Material Requirements				
HIC Testing	According to NACE TM 0284 requirements and Appendix A.2 of this specification.	1 set (3 samples) of test for each pipe from different test units.	1 set (3 samples) of test for pipe from the 3 first test units.	1 set (3 samples) of test per casting sequence of not more than ten (10) heats.
SSC Testing	According to NACE TM 0177 requirements and Appendix A.2 of this specification.	2 sets (3 samples/set) for each pipe for different test units.	N.A.	N.A.
Additional Testing for Upset Ends				
Hardness Testing	According to Table A-3 of this specification	1 set of test per pipe per test unit.	N.A.	N.A.
Transverse CVN Transition Curves	As per clauses 4.2.14 and 4.2.15 of this specification	5 sets (5 specimens/set) between -60°C and +20 °C per test unit.	N.A.	N.A.
Transverse CVN Transition Curves – Aged Condition	As per clauses 4.2.14 and 4.2.15 of this specification	5 sets (5 specimens/set) between -60°C and +20 °C per test unit.	N.A.	N.A.
SSC Testing	According to NACE TM 0177 requirements and Appendix A.2 of this specification.	2 sets (3 samples/set) for each pipe for different test units.	N.A.	N.A.

Table B-2 – Inspection Testing Frequency

TEST/ CONTROL	REQUIREMENT	TEST FREQUENCY		
		MPQT	FDPT	PRODUCTION
Metallographic Examination (microstructure)	As per Clause 4.2.5 of this specification and Clause 7.2.5.15 of Section 7 DNVGL-ST-F101	Once per test unit.	Once per test unit.	Once per 10 test units.
NDT Inspection	According to Table 7-16 of Section 7 DNVGL-ST-F101 and Table D-12 of Appendix D -DNVGL-ST-F101	All pipes.	All pipes.	All pipes.
Hydrostatic Testing	As per items of 7.5.1 of Section 7 DNVGL-ST-F101 and clause 4.2.19 of this specification	All pipes.	All pipes.	All pipes.

Table B-3 – Installation Requirements

Supplementary Requirement "P" – DNVGL-ST-F101

TEST/ CONTROL	REQUIREMENT	TEST FREQUENCY		
		MPQT	FDPT	PRODUCTION
BM Longitudinal Tensile Testing (proportional specimens)	According to Table 7-29 of DNVGL-ST-F101.	1 set of test per test unit. Modification – UEL>5% Elongation > 18%	1 set of test per test unit. Modification – UEL>5% Elongation > 18%	1 set of test per 50 lengths of pipe. Modification – UEL>5%.[1] Elongation > 18%
BM Transverse Tensile Testing (ASTM A370)	According to Table 7-29 of DNVGL-ST-F101.	1 set of test per test unit. From the opposite end of MPQT pipe in which longitudinal specimen was obtained Modification – Elongation > 18%	N.A	N.A
Hardness Testing	According to Table A-4 of this specification for BM.	1 set of test per pipe per test unit.	1 set of test per pipe per test unit.	N.A
CVN Impact Testing	As per clauses 4.2.14, 4.2.15 and A.3.5 of this specification	1 set (3KVT) and 1 set (3KVL) per pipe per test unit.	1 set (3KVT) and 1 set (3KVL) per pipe per test unit.	N.A
CVN Impact Testing transition curve (BM)	As per clauses 4.2.14 and 4.2.15 of this specification	5 sets (5 specimens/set) between -60°C and +20 °C per test unit	N.A.	N.A.
CTOD Testing	@ T_{Min} CTOD (transversal, Bx2B) shall be as per Clause A.3.4 of this specification.	1 set (3 spec) 1 pipe for each test unit and for each thickness.	N.A.	N.A.
HIC Testing	According to NACE TM 0284 requirements and Appendix A.2 of this specification.	1 set of test for each pipe from different test units.	1 set of test for each pipe from different test units.	N.A
SSC Testing	According to NACE TM 0177 requirements and Appendix A.2 of this specification.	2 sets for each pipe for BM from different test units.	2 sets for each pipe for BM from different test units.	N.A
Metallographic Examination (microstructure)	At least 400x Clause B.2.10 of Section 7 DNVGL-ST-F101	1 S&A sample per test unit.	1 S&A sample per test unit.	N.A

APPENDIX C– ADDITIONAL INFORMATION TO ALLOW LINEPIPE SUPPLY:

This technical specification shall be supplemented by PETROBRAS or purchaser in order to allow line pipe supply. The following additional information shall be supplied:

Type and quantity data:

- Pipe diameter;
- Pipe nominal thickness;
- Specified Minimum Yield Strength;
- Pipe Length.

NOTE: In order to determine length to be acquired, bear in mind to include contingency and the amount necessary to execute installation, welding , NDT and coating tests;

Additional requirements (If applicable):

- AR SS;
- AR RL;
- AR HL;
- AR UE;
- Supplementary Requirement U of DNVGL-ST-F101.

Process:

- Minimum design temperature.

Application:

- As backing steel of Mechanically Lined Pipes (MLP).

Commercial:

- Delivery point.

Third Party Inspection:

- Third party inspection coverage (if applicable).