
	TECHNICAL SPECIFICATION		Nº: I-ET-0000.00-0000-211-P9U-003
	CLIENT:	PETROBRAS	SHEET: 1 of 18
	JOB:	GENERAL	CC
	ÁREA:	RIGID SUBMARINE PIPELINES	PROJECT:
DP&T	TITLE:	SEAMLESS MOTHER PIPES REQUIREMENTS	 SUB/ES/EISE/EDR



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INDEX OF REVISIONS

REV.	DESCRIPTION AND/OR REVISED SHEETS
0	ORIGINAL EMISSION

	REV. 0	REV. A	REV. B	REV. C	REV. D	REV. E	REV. F	REV. G	REV. H
DATE	25/01/2018								
PROJECT	EISE/EDR								
EXECUTION	RHEL								
CHECK	CWF8								
APPROVAL	CLZ2								

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	TECHNICAL SPECIFICATION	Nº I-ET-0000.00-00-211-P9U-003	REV. 0
	JOB:	GENERAL	
	TITLE:	SEAMLESS MOTHER PIPES REQUIREMENTS	
		SHEET 2 of 18	
		SUB/ES/EISE/EDR	

1 TECHNICAL SPECIFICATION SCOPE

1.1 The objective of this specification is to define the technical requirements for SEAMLESS MOTHER pipes. **SEAMLESS MOTHER pipes manufactured 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) Bends for Spools and other rigid assemblies as part of submarine pipeline systems;
- b) Steel grades: DNV 415MPa to DNV 485MPa;
- c) Coating: Application temperature for parent and field joint coating not exceeding 260°C.

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 MOTHER pipe.

NOTE: This technical specification presents general requirements for SEAMLESS MOTHER 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 system during design life.

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

- 1st – Design Basis
- 2nd – This Technical Specification
- 3rd – DNVGL-ST-F101

1.5 Additional requirements for H₂S operation are presented in Appendix A.

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 requisition by PETROBRAS or SUPPLIER in the purchase order for mother pipe supply.

1.8 SUPPLIER shall, at his expense, perform 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.

1.9 This technical specification was elaborated by PETROBRAS considering comments of the following PETROBRAS internal divisions:

- DP&T/SUB/ES/EISE/EDR;
- DP&T/CENPES/PDISO/TMC;
- DP&T/CENPES/PDDP/TFCM-SEQUI

	TECHNICAL SPECIFICATION	Nº I-ET-0000.00-00-211-P9U-003	REV. 0
	JOB: GENERAL	SHEET 3 of 18	
	TITLE: SEAMLESS MOTHER PIPES REQUIREMENTS		
SUB/ES/EISE/EDR			
2 REFERENCES			
2.1 (1.7.6 - Section 1) Addition - The following references shall also be considered:			
[1]	NACE TM0316 (December 2015)	Four-Point Bend Testing of materials for Oil and Gas	
[2]	BS EN ISO 12737 (December 2010)	Metallic materials - Determination of plane-strain 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.	
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 Pcm – Parameter Crack Measurement			
4 TECHNICAL REQUIREMENTS			
4.1 CARBON STEEL SEAMLESS MOTHERPIPES MANUFACTURING			
4.1.1	(7.1.2.1 - Section 7) Modification – The requirements of this technical specification are applicable for line pipe to be used as mother pipe in a bending process according to item 8.2.3 - section 8 of DNVGL-ST-F101.		
4.1.2	(7.1.4.1 - Section 7) Modification – C-Mn line pipe as mother pipes shall be manufactured according to the following process: Seamless (SMLS).		
4.1.3	(7.1.4.1 - 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.		
4.1.4	(7.1.5.1 - Section 7) Modification – C-Mn line pipe as mother pipes shall meet the supplementary requirements given in Subsection I, for:		
	✓ Sour service, suffix S (see Appendix A of this specification);		
	✓ Fracture arrest properties, suffix F (see 7.9.2);		

	TECHNICAL SPECIFICATION	Nº I-ET-0000.00-00-211-P9U-003	REV. 0
	JOB: GENERAL	SHEET 4 of 18	
	TITLE: SEAMLESS MOTHER PIPES REQUIREMENTS	 SUB/ES/EISE/EDR	
<p> ✓ Enhanced dimensional requirements for line pipe, suffix D (see 7.9.4); ✓ Supplementary requirement U - applicable if specified in the purchase order; </p> <p> 4.1.5 (7.1.7.1 - Section 7) Addition – The preliminary MPS shall be part of the required bid documentation dossier. </p> <p> 4.1.6 (7.1.8.1 - Section 7) Addition – If a previously qualified and approved MPQT is presented by SUPPLIER, only FDPT shall be performed as per Tables B-1 and B-2. </p> <p> 4.1.7 (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: </p> <ul style="list-style-type: none"> ✓ Validity of the MPQT; ✓ FDPT and production must reflect the same essential variables used in the qualified and approved MPQT. <p> 4.1.8 (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 pipe production before completion of SSC and 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 pipe wall thickness and D/t ratio to prove that SSC 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. </p> <p> 4.1.9 (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. </p> <p> 4.1.10 (7.1.8.7 - Section 7) Addition – A qualified and approved MPQT may have validity up to 5 years starting with the final validation by PETROBRAS. </p> <p> 4.1.11 (7.2.3.1 and table 7-1 Section 7) Modification – SMLS C-Mn Steel Mother pipe shall be manufactured in accordance with manufacturing route described in table 7-1 for quenched and tempered (QT) pipes. </p> <p> 4.1.12 (8.2.3.2 - Section 8 and table 7.24 of Section 7) Modification – The chemical composition of C-Mn mother pipe, shall be in agreement with the following maximum values (in weight %): C - 0.16 %, Mn - 1.65%, S - 0.002%, P – 0.015%, Mo - 0.35%, Al - 0.06 %, N – 0.008%, Ti - 0.05%, Nb - 0.05% and V - 0.08%. The maximum carbon equivalent (CE) of quenched and tempered or normalized C-Mn steel mother pipe (delivery condition N or Q, respectively) shall be 0.43 for DNV 450 SMLS and 0.44 for DNV 485 SMLS. </p> <p> 4.1.13 (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 920°C and then pipe shall be quenched in water and tempered between 600 to 690°C. 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. </p> <p> 4.1.14 (7.2.3.38 - Section 7) Modification – Pipe ends shall be square cut and be free from burrs. </p> <p> 4.1.15 (7.2.3.40 - Section 7) Modification – Joints are not acceptable. </p>			

4.1.16 (7.2.3.43 - Section 7) **Modification** – If any mechanical tests fail during production of quenched and tempered seamless mother 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, CE variation should be permitted as +0.01/-0.03, where the maximum CE value of the entire supply shall be equal or lower than the maximum CE value specified by SUPPLIER, which shall also be restricted by DNVGL-ST-F101 standard for this product. In case the product analysis measurement during mother pipe production reaches a CE 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 CE value shall be equal or lower than the highest CE value qualified during MPQT.

4.2.2 (7.2.4.8 and 7.9.1.8 - Section 7) **Modification** – The hardness requirements shall be as given in table A-3.

4.2.3 (7.2.4.8 - Section 7 and B.2.10.5 - Appendix B) **Addition** – Hardness testing shall be performed at three different areas, from the mother pipe circumference located 120 degrees apart from each other, for each tested mother pipe in a total of 3 samples. During MPQT and FDPT, for mother pipes with wall thickness greater than 3/4 inch (19 mm), additional hardness measurements shall be performed at 1/4 and 3/4 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 profile 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 3/4 inch (19 mm).

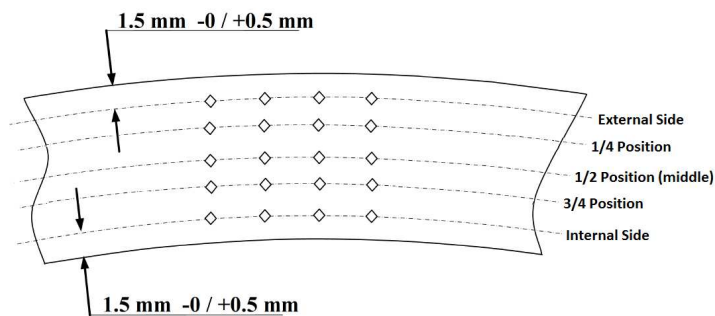


Figure 1 – Hardness profile for MPQT and FDPT for wall thicknesses greater than 3/4 inch (19 mm)



4.2.4 (B.2.10.2 - Appendix B) **Addition** – Microstructure shall be assessed, with a magnification of 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. 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.

4.2.5 (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 the purchase order or Specific Mother Pipe Project Documentation. Specimens shall be removed in the transverse direction.

Table 1 – Absorbed CVN Impact Energy Acceptance Criteria

Material	DNV 450	DNV 485
Impact Energy Average (Minimum) [J]	95 (80)	106 (89)

- 4.2.6 **(7.2.4.9 - Section 7) Addition** – The testing temperature for Charpy V-notch impact test will be informed by PETROBRAS in Design Basis or Specific Mother Pipe Project Documentation.
- 4.2.7 **(B501 Section 7) Modification** – The inspection frequency during production and MPQT shall be as given in Tables B-1 and B-2 of this specification. The remaining inspection tests not mentioned herein shall follow tables 7-7 and 7-8 of DNVGL-ST-F101.
- 4.2.8 **(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 validation. All testing, including the one that failed, shall be reported.
- 4.2.9 **(7.2.5.12 - Section 7) Addition** – Any additional chemical element shall not be added to material without PETROBRAS written validation.
- 4.2.10 **(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.
- 4.2.11 **(7.9.1.10 - Section 7) Modification** – The requirements for HIC testing are given in table A-1 and APPENDIX A of this specification.
- 4.2.12 **(7.9.1.20 - Section 7) Modification** – SSC testing is required unless previous data is presented, which confirms that material is pre-qualified as per table B-1 of ISO 15156-2. In this case track record of supplied mother pipes to hot induction bending manufacturers or to offshore EPCI in order to produce IBS 450 PSL2 or IBS 485 PSL2 shall be presented. Otherwise, SSC requirements in table A-2 and APPENDIX A shall be followed.
- 4.2.13 **(7.9.2.2 - Section 7) Modification** – During MPQT, for quenched and tempered mother pipes with wall thickness higher than 25 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.
- 4.2.14 **(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.
- 4.2.15 **(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 YX plane orientation (through-thickness notch) and with dimensions equal to BxW (where W=2B) as per BS ISO 12737. Wall thickness samples shall be from 13.5 mm up to 28.60 mm. Measured CTOD fracture toughness values shall, as a minimum, be equal or higher than $\delta = 0,40$ mm when tested at $T = -30$ °C for BM locations.

	TECHNICAL SPECIFICATION	Nº I-ET-0000.00-00-211-P9U-003	REV. 0
	JOB: GENERAL	SHEET 7 of 18	
	TITLE: SEAMLESS MOTHER PIPES REQUIREMENTS	 SUB/ES/EISE/EDR	

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

4.2.17 **(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.

4.2.18 **(7.5.1.3 - Section 7) Addition** – Mill test pressure (ph) may be reduced upon written request to PETROBRAS.

4.2.19 **(C.7.3.5 - Appendix C) Addition** - It is not permitted to repair mother 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 validation 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 validation.

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 mother 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** – Mother 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 H400 over a band at least 150 mm inside the location of future welding preparations for girth welds.

4.3.7 **(D.8.7.5 - Appendix D) Modification** – Acceptance criteria shall be according to Table D-12.

	TECHNICAL SPECIFICATION	Nº I-ET-0000.00-00-211-P9U-003	REV. 0
	JOB: GENERAL	SHEET 8 of 18	
	TITLE: SEAMLESS MOTHER PIPES REQUIREMENTS		
SUB/ES/EISE/EDR			

- 4.3.8 **(D.8.8 - Appendix D) Addition** – UT inspection of each mother 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 mother pipe shall be measured full length to measure wall thickness. The mother pipe SUPPLIER shall submit with his quotation all details of his proposed inspection and the amount of coverage. Ultrasonic thickness testing of the mother pipe body by scanning along a helical or straight pattern ensuring a minimum mother 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 all the linepipe 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** – Mother pipe shall be furnished with square cut ends according to the purchase order 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 mother pipe rotation, the external Hi-Lo values shall not exceed 1.6 mm and nominal (actual) external diameter at mother 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 mother 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 mother pipe length shall be:
- ✓ 100% of the mother 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 mother pipe lengths shall be inside this range.
- 4.4.6 **(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.
- 4.4.7 **(7.7.3.3 to 7.7.3.6 - Section 7) Modification** – Mother 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 mother 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 mother pipe end ID measurements, including the additional 2 measurements close to the weld toe.

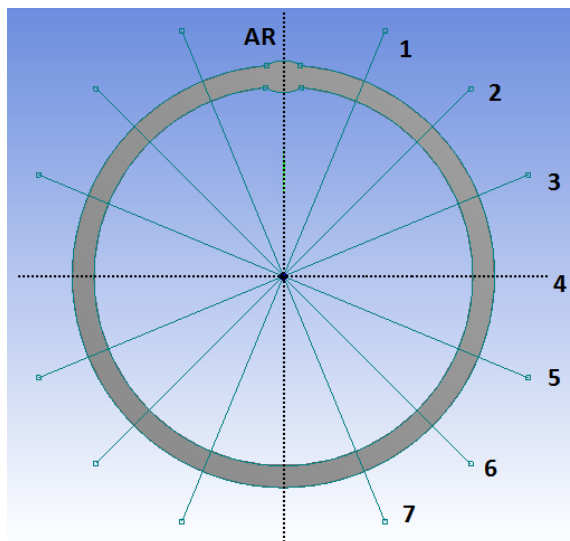




Figure 2 – Example of ID and out-of-roundness measurement positions

- 4.4.8 **(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 No-Go gauge rod calibration certificate period of validity shall be, at most, 6 months.
- 4.4.9 **(Table 7-22 - Section 7) Addition** – Deviation from a straight line shall not exceed 0.15% of the mother pipe length or 13 mm, whichever is less.
- 4.4.10 **(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 mother pipe length, including pipe ends. The mother pipe end straightness shall be measured in, at least, two perpendicular planes. The method of determining straightness shall be subject to PETROBRAS' validation.

	TECHNICAL SPECIFICATION	Nº I-ET-0000.00-00-211-P9U-003	REV. 0
	JOB: GENERAL	SHEET 10 of 18	
	TITLE: SEAMLESS MOTHER PIPES REQUIREMENTS		
SUB/ES/EISE/EDR			

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

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

4.4.12 **(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 mother pipes. For MPQT dimensional inspection of, at least, 5 mother pipes of each test unit shall be recorded. For FDPT dimensional inspection of, at least, 10 mother pipes of each test unit shall be recorded.

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

4.4.14 **(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.

4.5 PIPE MARKING AND TRACEABILITY

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



4.5.2 **(7.8.1.2 - Section 7) Modification** - Marking shall include DNV mother pipe designation as per item 7.2.2 - Section 7. Marking shall reflect the correlation between the product and the respective inspection document.

4.5.3 **(7.8.1.3 - Section 7) Addition** - Each mother pipe shall be marked with a unique number to allow tracking of pipes throughout manufacturing, coating, welding and installation. Not only mother pipes shall have a traceable unique number but also each sample obtained for tests and inspections.

4.5.4 **(7.8.1.3 - Section 7) Addition** - Mother pipe unique number shall be cold die stamped on both ends.

4.5.5 **(7.8.1 - Section 7) Addition** - SUPPLIER shall submit for PETROBRAS' validation the layout of marking. Mother pipe marking shall have, at least the information stated in Section 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.

	TECHNICAL SPECIFICATION	Nº I-ET-0000.00-00-211-P9U-003	REV. 0
	JOB: GENERAL	SHEET 11 of 18	
	TITLE: SEAMLESS MOTHER PIPES REQUIREMENTS	 SUB/ES/EISE/EDR	

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 the purchase order 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 mother 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 mother 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 ABNT NBR 16212 standard shall be fulfilled.

4.6.3 **(7.8.4 - Section 7 and 12.3.1 - 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 validation. 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 validation.



TECHNICAL SPECIFICATION	Nº I-ET-0000.00-00-211-P9U-003	REV. 0
	JOB: GENERAL	SHEET 12 of 18
	TITLE: SEAMLESS MOTHER PIPES REQUIREMENTS	NP-1 SUB/ES/EISE/EDR

APPENDIX A - ADDITIONAL REQUIREMENTS

A.1 GENERAL

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

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 H₂S effects on Sour Service operation of rigid pipelines.

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

A.2 - AR SS – ADDITIONAL REQUIREMENTS FOR H₂S SERVICE.

A.2.1 – (Items 7.9.1.10 and 7.9.1.11 - Section 7) Modification - According to the SSC region of environmental severity defined in the purchase order and Specific Mother Pipe 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-2, when applicable.

Table A -1 – HIC Testing Requirements

Test Solution for H₂S service operation and acceptance criteria

SSC REGION OF ENVIRONMENTAL 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 H₂S 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 ₂ S/ 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 H₂S Service Operation

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 the purchase order.

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 the purchase order 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 the purchase order:

- 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 $\delta = 0,35$ mm when tested at T_{Min} for BM locations;
- b) Testing environment: solution with dissolved H₂S 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 H₂S gas.

	TECHNICAL SPECIFICATION	Nº I-ET-0000.00-00-211-P9U-003	REV. 0
	JOB: GENERAL	SHEET 14 of 18	
	TITLE: SEAMLESS MOTHER PIPES REQUIREMENTS	 SUB/ES/EISE/EDR	

A.3 - AR HL – ADDITIONAL REQUIREMENTS FOR HI-LO CONTROL OF MOTHERPIPES

A.3.1 - The additional requirement AR HL allows the consideration of a better hi-lo of mother pipe ends in pipeline and riser design. The aimed Hi-Lo shall be specified in the purchase order 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 mother 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 mother 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 mother pipe ends shall not exceed the tolerance of ± 0.5 mm.

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

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

A.3.2 – (Table 7-22 - Section 7) Addition - Total deviation from a straight line, over the entire mother pipe length, shall be less than 13 mm of the whole mother pipe length. At mother pipe end, the local deviation from a straight line within 1m length shall be less than 3 mm.

A.3.3 – When required per purchase order or specific pipeline project documentation, SUPPLIER shall classify mother pipes according to the Hi-Lo requirement.

A.3.4 – Machining activities shall be performed by automatic equipment able to provide the specified level of eccentricity in the machined mother 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 $3.2 \mu\text{m}$ and a maximum Rt roughness equal to $40 \mu\text{m}$ for internal surface. Roughness in the external surface shall not be controlled in the mother pipe mill unless it is specified in the purchase order or specific Pipeline Project Documentation;
- ✓ Cylindrical machined section in the mother pipe internal and external end 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 mother 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;



TECHNICAL SPECIFICATION	Nº I-ET-0000.00-00-211-P9U-003	REV. 0
JOB: GENERAL	SHEET 15 of 18	
TITLE: SEAMLESS MOTHER PIPES REQUIREMENTS	NP-1	
	SUB/ES/EISE/EDR	

- ✓ The roughness of the cylindrical machined internal section, after machining and finishing, shall be measured in 100% of mother pipe ends by a RMS comparator in, at least, two longitudinal lines on the cylindrical machined surface;
- ✓ Machined internal section at the mother 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.3.5. – Mother pipe end machined section shall be inspected considering, at least, the requirements expressed below:

- a) Visual inspection shall be performed on 100% of mother 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) Internal diameter inspection shall be performed on 100% of mother 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 mother pipe traceability;
- c) Wall thickness measurement in, at least, 16 locations equally spaced around mother pipe end circumference shall be executed for every 10 mother pipes. The inspection shall be performed by internal micrometer, UT measurement equipment or any other device previously approved by PETROBRAS.

A.3.6 - The end straightness shall be measured in, at least, two perpendicular planes. The method of determining straightness shall be subject to PETROBRAS validation and a minimum of three measurements per shift shall be recorded at both mother pipe ends (minimum of three mother 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.



TECHNICAL SPECIFICATION JOB: GENERAL TITLE: SEAMLESS MOTHER PIPES REQUIREMENTS	Nº I-ET-0000.00-00-211-P9U-003	REV. 0
	SHEET 16 of 18	



SUB/ES/EISE/EDR

APPENDIX B – TEST MATRIX – ACCEPTANCE CRITERIA AND FREQUENCIES:

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

Table B-1 – Testing Frequency

TEST/ CONTROL	REQUIREMENT	TEST FREQUENCY		
		MPQT	FDPT	PRODUCTION
Pipe Dimensional Check				
Pipe 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
Materials 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 mother pipes)
Tensile Testing at mother pipe 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 10 lengths of mother 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 20 lengths of mother pipe.
Hardness Testing	According to Table A-3 for BM.	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 10 lengths of mother pipe.
Transverse CVN Transition Curve	As per clauses 4.2.5, 4.2.6, 4.2.13, 4.2.14 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 4.2.5, 4.2.6, 4.2.13, 4.2.14 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.

	TECHNICAL SPECIFICATION		Nº I-ET-0000.00-00-211-P9U-003	REV. 0
	JOB: GENERAL			SHEET 17 of 18
	TITLE: SEAMLESS MOTHER PIPES REQUIREMENTS			 SUB/ES/EISE/EDR

CTOD Testing	@ -30 ⁰ C CTOD (transversal, Bx2B) shall be as per Clause 4.2.15. of this specification	1 set (3 spec) 1 pipe for each test unit and for each thickness.	N.A.	N.A.
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TEST/CONTROL	REQUIREMENT	TEST FREQUENCY		
		MPQT	FDPT	PRODUCTION
Materials 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.

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 operation shift.
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 4.2.18 of this specification	All pipes.	All pipes.	All pipes.



TECHNICAL SPECIFICATION	Nº I-ET-0000.00-00-211-P9U-003	REV. 0
JOB: GENERAL	SHEET 18 of 18	
TITLE: SEAMLESS MOTHER PIPES REQUIREMENTS	NP-1	
	SUB/ES/EISE/EDR	

APPENDIX C – ADDITIONAL INFORMATION TO ALLOW MOTHER PIPE SUPPLY:

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

Type and quantity data:

- Mother pipe diameter;
- Mother pipe nominal thickness;
- Specified Minimum Yield Strength;
- 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 HL;
- Supplementary Requirement U of DNVGL-ST-F101.

Process:

- Minimum design temperature.

Commercial:

- Delivery point.

Third Party Inspection:

- Third party inspection coverage (if applicable).