
 PETROBRAS	TECHNICAL SPECIFICATION		Nº: I-ET-0000.00-0000-211-P9U-001
	CLIENT:	PETROBRAS	SHEET: 1 of 28
	JOB:	GENERAL	CC
	ÁREA:	RIGID SUBMARINE PIPELINES	PROJECT:
DP&T	TITLE: TECHNICAL SPECIFICATION FOR SAWL CARBON MANGANESE STEEL LINEPIPES		 GESTOR: SUB/ES/EISE/EDR

MS Word® - I-ET-0000.00-0000-211-P9U-001=A.doc



INDEX OF REVISIONS

REV.	DESCRIPTION AND/OR REVISED SHEETS
0	ORIGINAL This document supersedes and replaces document I-ET-0000.00-6500-211-P9U-001, rev. A.
A	GENERAL REVISION – IN COMPLIANCE WITH DNVGL-ST-F101 (Oct 2017). REVISED ITEMS WERE HIGHLIGHTED IN YELLOW.

	REV. 0	REV. A	REV. B	REV. C	REV. D	REV. E	REV. F	REV. G	REV. H
DATE	30/11/2017	30/07/2019							
PROJECT	EISE/EDR	EISE/EDR							
EXECUTION	RHEL	RHEL							
CHECK	CWF8	CWF8							
APPROVAL	CLZ2	CLZ2							

THE INFORMATION CONTAINED IN THIS DOCUMENT IS PETROBRAS PROPERTY AND MAY NOT BE USED FOR PURPOSES OTHER THAN THOSE

SPECIFICALLY INDICATED HEREIN. THIS FORM IS PART OF PETROBRAS N-381 REV. L

	TECHNICAL SPECIFICATION	Nº I-ET-0000.00-0000-211-P9U-001	REV. A
	JOB: GENERAL	SHEET 2 of 28	
	TITLE: TECHNICAL SPECIFICATION FOR SAWL CARBON MANGANESE STEEL LINEPIPES	 GESTOR: SUB/ES/EISE/EDR	

1 TECHNICAL SPECIFICATION SCOPE

1.1 The objective of this specification is to define the technical requirements for SAWL C-Mn steel linepipes. **SAWL pipes for use in pipeline transportation systems in the petroleum and natural gas industries, 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 brackets.

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

- Flowlines and dynamic risers for submarine pipeline systems;
- Steel grade: DNV 415MPa to DNV 555MPa;
- Coating: Application temperature for parent and field joint coating not exceeding 260°C;
- 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.3).

1.3 **(7.1.1.3) Addition** - The fatigue resistance of girth welds is not included in the scope of this document. This document is exclusively dedicated to the SAWL pipe. **Pipes manufactured according this technical specification shall not be used as mother pipe for bends.**

NOTE: This technical specification presents general requirements for SAWL line 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) Modification** - Where there is a conflict between the requirements of this specification, the Pipeline Project **Design Basis** and the referenced **DNV GL** Offshore Code, the order of precedence of the documents shall be:

- 1st – **Design Basis (specific for Riser and/or Pipeline project)**
- 2nd – This Technical Specification
- 3rd - **DNVGL-ST-F101**
- 4th - **Other international standards referred**

1.5 Additional requirements for H₂S operation and reeling installation method for riser applications 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 in RM for linepipe 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 **All sub-suppliers (e.g. plate material, welding consumables, NDT supplier, etc.) shall be clearly identified at the bid stage and accepted by the purchaser.**

1.10 This technical specification was elaborated by PETROBRAS considering comments from the following PETROBRAS internal divisions:

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

	TECHNICAL SPECIFICATION	Nº I-ET-0000.00-0000-211-P9U-001	REV. A
	JOB:	GENERAL	
	TITLE:	TECHNICAL SPECIFICATION FOR SAWL CARBON MANGANESE STEEL LINEPIPES	
		SHEET 3 of 28	
		GESTOR: SUB/ES/EISE/EDR	

2 REFERENCES

2.1 **(1.7.6) Addition** - The following references shall also be considered:

[1] DNVGL-ST-F101 (October 2017)	Submarine Pipeline Systems
[2] BS EN ISO 15156-2 (August 2016)	Petroleum and Natural Gas Industries – Materials for Use in H ₂ S containing environments in Oil and Gas Production
[3] NACE TM 0177 (April 2016)	Laboratory testing of metals for resistance to Sulfide Stress Cracking and Stress Corrosion Cracking in H ₂ S environments
[4] NACE TM 0284 (March 2016)	Evaluation of pipeline and pressure vessel steels for resistance to Hydrogen-Induced Cracking
[5] NACE TM 0316 (December 2015)	Four-Point Bend Testing of materials for Oil and Gas
[6] BS EN ISO 12737 (December 2010)	Metallic materials - Determination of plane-strain fracture toughness
[7] BS EN ISO/IEC 17024 (July 2012)	Conformity assessment - General Requirements for Bodies operating Certification of Persons
[8] BS EN ISO/IEC 17025 (June 2017)	General requirements for the competence of testing and calibration laboratories
[9] ABNT NBR 16212 (September 2013)	Pipelines – Storage in uncovered area
[10] ASTM G39 (1999/Reapproved 2016)	Standard practice for preparation and use of bend beam stress corrosion test specimens
[11] I-ET-0000.00-6000-970-PSQ-001	Procedure and personnel qualification and certification.
[12] IOGP S-616	Supplementary Requirements to API Specification 5L and ISO 3183 Line Pipe

3 DEFINITIONS


3.1 **(1.8.2 – Table 1-8) 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 – Table 1-9) Addition** - The following abbreviations are also applied:

AYS	Actual Yield Strength
CR	Computed Radiography
DR	Digital Radiography
FDPT	First Day Production Tests



TECHNICAL SPECIFICATION	Nº I-ET-0000.00-0000-211-P9U-001	REV. A
JOB: GENERAL	SHEET 4 of 28	
TITLE: TECHNICAL SPECIFICATION FOR SAWL CARBON MANGANESE STEEL LINEPIPES	 GESTOR: SUB/ES/EISE/EDR	

FPBT	Four-Point Bend Testing
NCR	Non-Conformance-Report
RM	Requisição de Material – Material Requisition (Document to be included on purchase order)
Pcm	Parameter Crack Measurement
PWC	Preferential Weld Corrosion
T _{Min}	Minimum Design Temperature: The lowest possible temperature in which the component or system may be exposed to during installation and operation. This shall consider local minimum temperature profiles, which may be caused by e.g. sudden shut-downs;
WPC	Welder Performance Control
WPQR	Welding Procedure Qualification Record

4 TECHNICAL REQUIREMENTS

4.1 GENERAL REQUIREMENTS

4.1.1 SUPPLIER shall fulfill all the requirements stated in [1] related to SAWL pipes, as well as the supplementary requirements listed below:

a) Carbon Steel SAWL pipe DNV GL Supplementary Requirements;

4.1.1.1 The “Carbon Steel SAWL pipe DNV GL Supplementary Requirements” are presented in section 6 of this technical specification.



NOTE: The main body of this technical specification presents additional and modified requirements in relation to [1]. In all the referred requirements presented in section 6, the intention is to present more stringent requirements in relation to [1] in order to cope with the lessons learnt from previous projects, as well as update the traditional requirements in accordance with recent research related to SAWL pipe for critical applications.

4.1.1.2 The Appendix A presents additional requirements. These additional requirements shall only be fulfilled by SUPPLIER if required by PETROBRAS or Purchasers in the Purchase Order.

4.1.2 The Appendix B presents testing frequency required by PETROBRAS during MPQT, FDPT and production.

4.1.3 The Appendix C presents the necessary information to be informed in material requisition by PETROBRAS or Purchaser in the purchase order to complement this technical specification, allowing pipe supply.

4.1.4 The Appendix D presents the necessary technical data to be informed in SUPPLIER tendering proposal.

	TECHNICAL SPECIFICATION	Nº I-ET-0000.00-0000-211-P9U-001	REV. A
	JOB: GENERAL	SHEET 5 of 28	
	TITLE: TECHNICAL SPECIFICATION FOR SAWL CARBON MANGANESE STEEL LINEPIPES	 GESTOR: SUB/ES/EISE/EDR	

5 QUALITY ASSURANCE AND QUALITY CONTROL

5.1 GENERAL

5.1.1 All activities to be performed by the supplier or sub-supplier(s) shall be planned, managed and performed under a Quality Management System (QMS) certified to be in compliance with ISO 9001, or equivalent documents validated by PETROBRAS.

5.1.2 During production, the supplier shall make available upon request all material certificates to PETROBRAS and purchaser. All materials shall be certified according to BS EN 10204 Inspection certificate 3.1 "type 3.1".

5.2 MANUFACTURING PROCEDURE

5.2.1 Two months before the date schedule for MPQT, the following documentation shall be submitted by SUPPLIER for PETROBRAS evaluation:

- Quality Plan;
- Manufacture Procedure Specification (MPS) and Inspection Test Plan (ITP) for plates and SAWL pipe, including test requirements and acceptance criteria;
- Manufacturing procedures, including heat treatment;
- Preliminary Welding procedures specifications (pWPS) for SAWL pipe, including procedures for repair welding;
- Non-destructive testing procedures, including defective weld map reference.

5.3 INSPECTION REQUIREMENTS

5.3.1 The inspector employed by SUPPLIER for quality control and quality assurance shall have at least the qualifications as per [11].

5.3.2 SUPPLIER shall consider that PETROBRAS may require at any time full access of the plate and SAWL pipe manufacture to PETROBRAS representatives. This includes access to samples preparation, MPQT and production testing. SUPPLIER shall not deny access to PETROBRAS representatives.

5.3.2.1 PETROBRAS reserve the right to witness all MPQT. Any test not witnessed by PETROBRAS authorized representative for its specific purpose and/or not previously agreed with PETROBRAS will not be considered as a valid test.

5.3.2.2 PETROBRAS reserve the right to witness all production tests and manufacturing. The extension of PETROBRAS inspection will be defined in the comments released by PETROBRAS for "Inspection and Test Plan" document.



5.4 TRACEABILITY (7.2.3.44) Addition

5.4.1 During MPQT traceability of heat number, casting sequence number, casting strand number, billet/slab sequence number, mother billet/slab, mother pipe/plate, heat treatment batch and test unit (pipe) number shall be recorded and demonstrated. The validated traceability system shall be used during production. All records from the required tests, inspections and dimensional reports shall be able to be matched to individual pipe (including individual plate and SAWL pipe) numbers.

5.5 TECHNICAL QUERIES

5.5.1 After contract award, any manufacturer's requests for clarifications or deviations to specifications shall be submitted to the purchaser only through technical queries (TQ) or deviation requests, the format of which shall have prior approval by the purchaser.

5.5.2 Approval given by the purchaser to any manufacturer's work procedures, specifications,

	TECHNICAL SPECIFICATION	Nº I-ET-0000.00-0000-211-P9U-001	REV. A
	JOB: GENERAL	SHEET 6 of 28	
	TITLE: TECHNICAL SPECIFICATION FOR SAWL CARBON MANGANESE STEEL LINEPIPES	 GESTOR: SUB/ES/EISE/EDR	

equipment, etc. shall not release in any way, the manufacturer from their obligation to meet the specifications of the contract.



5.6 NON CONFORMANCE REPORTS

5.6.1 Any part of the supply not in conformance with the requirements of this specification shall be listed in a Non-Conformance Report (NCR) prepared by the supplier and sent to PETROBRAS validation. This NCR shall contain, as a minimum, causes and major concerns, the proposed remedial and mitigation actions with impacts on quality, performance and delivery schedule. The reason for the failure/quality deviation of any test shall be established and the appropriate corrective actions to prevent re-occurrence shall be presented in the NCR.

6 CARBON STEEL SAWL PIPE DNV GL SUPPLEMENTARY REQUIREMENTS

6.1 CARBON STEEL SAWL PIPES MANUFACTURING

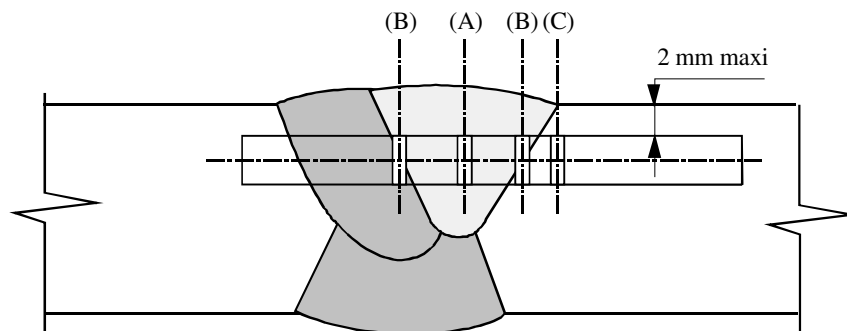
- 6.1.1 **(7.1.4.1) Addition** - SUPPLIER shall submit, with minimum six weeks before pre-production meeting, MPS for plates and linepipe manufacturing, MPQT testing proposal or previously qualified and approved MPQT, NDT procedures and all WPS that will be utilized during linepipe production.
- 6.1.2 **(7.1.4.1) Modification** - SAWL C-Mn steel pipes shall be manufactured using TMCP plates.
- 6.1.3 **(7.1.5.1) Modification** – C-Mn steel pipe shall meet the supplementary requirements given in Subsection 7.9 of DNVGL-ST-F101, for:
- ✓ Sour service, suffix S (see Appendix A of this specification);
 - ✓ Fracture arrest properties, suffix F (see 7.9.2);
 - ✓ Enhanced dimensional requirements for linepipe, suffix D (see 7.9.4);
 - ✓ Supplementary requirement U - applicable if specified in the RM.
- NOTE: Supplementary Requirement "P" is automatically required if AR R is required (see Appendix A.3).
- 6.1.4 **(7.1.7.1) Addition** – The preliminary MPS shall be part of the required bid documentation dossier.
- 6.1.5 **(7.1.8) Addition** - MPQT shall be completed prior to start of linepipe delivery. SUPPLIER shall issue a specific book for MPQT just after it is completed. It shall be issued for each wall thickness including all MPQT documents. This book shall be delivered only in digital format for comments.
- 6.1.6 **(7.1.8.1) Addition** – If a previously qualified and approved MPQT is presented by SUPPLIER, only FDPT shall be performed as per Tables B-1, B-2 and B-3 of this specification.
- 6.1.7 **(7.1.8.1) 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.

	TECHNICAL SPECIFICATION	Nº I-ET-0000.00-0000-211-P9U-001	REV. A
	JOB: GENERAL	SHEET 7 of 28	
	TITLE: TECHNICAL SPECIFICATION FOR SAWL CARBON MANGANESE STEEL LINEPIPES	 GESTOR: SUB/ES/EISE/EDR	
<p>6.1.8 (7.1.8.2) Modification – For C-Mn steels with SMYS equal to 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 linepipe 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.</p> <p>6.1.9 (7.1.8.3) Modification - At least 2 (two) different test units shall be tested (minimum of three pipes, one of each test unit). If production is to be performed at different welding stations, pipes shall be randomly selected from different welding stations to qualify MPQT.</p> <p>6.1.10 (7.1.8.3) Addition - Before start of MPQT and First Day Production Tests, SUPPLIER shall demonstrate effectiveness of the automatic and manual NDT inspection equipment through calibration blocks to detect the inside and outside notches and holes.</p> <p>6.1.11 (7.1.8.6) 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>6.1.12 (C.3.2.4) Addition – For water injection and gas pipeline in carbon steel submitted to the presence of water condensate, welding consumables used for the root and second pass of longitudinal seam weld shall be selected in order to avoid preferential corrosion in weld metal of pipes. The following equation shall be used to determine if the weld metal is cathodic and base metal is not excessively anodic, in comparison with each other:</p> <div style="border: 1px solid black; padding: 5px; margin: 10px 0;"> $\Delta = 3.8*(\%C_{base\ metal} - \%C_{weld\ metal}) + 1.1*(\%Ni_{base\ metal} - \%Ni_{weld\ metal}) + 0.3$ </div> <p>In order to avoid preferential corrosion, Δ is recommended to be between 0.3 and 0.0, and it shall not be above +0.3%. However, PETROBRAS shall be consulted for additional clarifications. [11]</p> <p>6.1.13 (7.1.8.7) Addition – A qualified and approved MPQT may have validity up to 2 years starting with the final approval by PETROBRAS.</p> <p>6.1.14 (7.1.8.8) Modification – For MPQT qualification of SAWL pipes and to support procedure qualification of girth welding, SUPPLIER shall manufacture linepipes at the highest aimed Pcm value. The highest aimed Pcm value shall be specified by SUPPLIER and restricted by DNVGL-ST-F101 standard for each specific product. For First Day Production and production of SAWL pipes, Pcm variation shall be permitted as +0.01/-0.03. In case the product analysis measurement during linepipe production reaches a Pcm value higher than that previous qualified during MPQT, a double check of the heat analysis of the supplied plates 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 aimed Pcm value qualified during MPQT.</p> <p>6.1.15 (7.2.3.15 and 7.2.3.25) Addition - The following requirements shall apply for repair welding:</p> <ul style="list-style-type: none"> • Arc stop/restart: the length between welding arc stop and restart shall be considered as a repair. 			

- Shallow repair: typically considered when 10-15% of WT is repaired.
- Deep repair: limited to 70% of wall thickness.
- Repeated repairs in the same area shall be agreed during Pre-Production Meeting.
- When first repair is beyond 50% of wall thickness, repeated repair is forbidden.
- Any repair welding shall be located at least 200 mm away from any **pipe** end.
- When repeated repair is permitted in the same area, it shall be limited to only two repairs.
- Complete removal of the defect before repair welding shall be confirmed either by magnetic particle inspection or by dye penetrant inspection.
- Low Hydrogen welding processes are required. In case of SMAW process is used for repair welding, vacuum packed low hydrogen SMAW welding consumables may be used with a minimum pre-heating of 100°C and interpass temperature and heat input shall be monitored and signed by welding inspector. The vacuum package opening is only allowed at the presence of a PETROBRAS representative who shall immediately sign off on the package, recording the respective package opening time; any opened vacuum package shall be discarded after the maximum time allowed by data-sheet and handling and storage procedure from manufacturer. Closed vacuum package consumables shall be stored in the storage oven with the same requirements of other welding consumables. A Welder Performance Control (WPC) shall be carried out and it shall be presented every week to PETROBRAS representatives.

6.1.16 (7.2.3.26) Addition - Repair welding shall be qualified in a manner realistically simulating the repair situation to be qualified. All repairs shall include a minimum preheating of 100 °C (212 °F), unless the qualification test has shown that a higher temperature is necessary.

6.1.17 (7.2.3.26) Addition - For a partial thickness repair sampling of CVN specimens shall be performed according to with figure 1.



Key

A Weld metal center line

B Fusion line of repair weld to base metal and fusion line of repair to original weld

C Fusion line +2 mm

Figure 1 – Partial Repair Charpy Sampling Location, courtesy of IOGP S616 [12].

6.1.18 (7.2.3.26) Addition - For a partial thickness repair hardness testing (HV10) indentations shall be performed in accordance with figure 2. If repair is located on the cap region, indentations shall be performed in accordance with figure 3. Superficial hardness testing shall also be performed on any repair to the longitudinal weld.

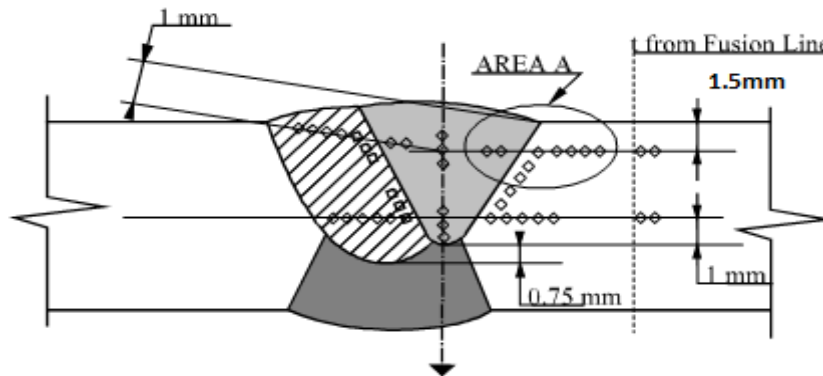


Figure 2 – Partial repair Hardness Indentation Location, courtesy of IOGP S616 [12].

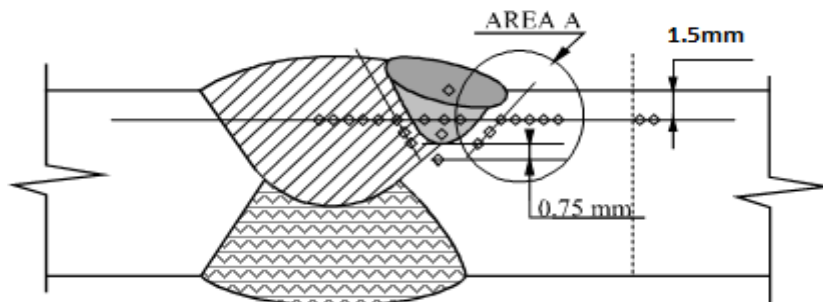



Figure 3 – Cap repair Hardness Indentation Location, courtesy of IOGP S616 [12].

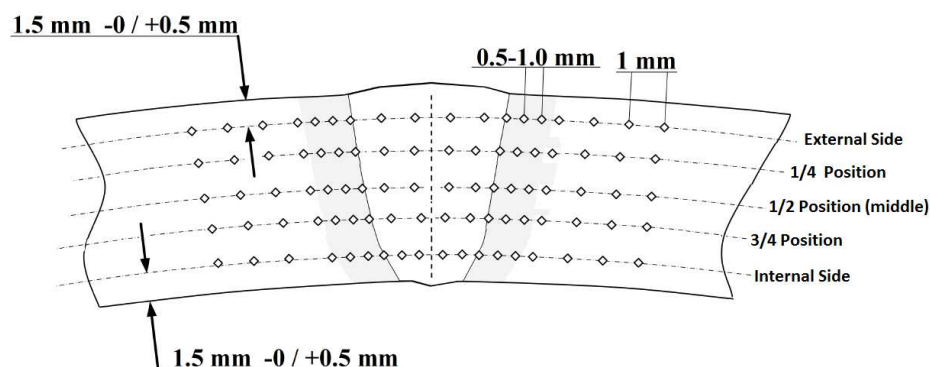
- 6.1.19 **(7.2.3.16) Modification** - Repair of pipe body defects by welding shall not be permitted.
- 6.1.20 **(7.2.3.38) Modification** – Pipe ends shall be cut square and be free from burrs.
- 6.1.21 **(7.2.3.40) Modification** – Jointers are not acceptable.
- 6.1.22 **(Table 7-8) Addition** - SSC **testing** shall be performed for the repair welds when Supplementary Requirement “S” is applicable.
- 6.1.23 **(C.2.2.1) Addition** - SUPPLIER shall perform welding operator qualification for all WPSs. Welding operators shall be qualified before the start of production. If welding operators are not qualified during the MPQT, they shall perform specific welding tests simulating MPQT weld joint. Alternatively, welding operators might be considered qualified considering that it has been welding with the same welding process (i.e. SAW) and have 3 months minimum experience with accepted performance on linepipe welding at the same pipe mill. SUPPLIER shall be responsible to keep a track record of each welding operator to control their individual performances. It is not acceptable to use non-qualified welders and welding operators.
- 6.1.24 **(C.2.2.6) Addition** - Welders for repair weld shall be qualified as per ISO 3183 standard.

TECHNICAL SPECIFICATION	Nº I-ET-0000.00-0000-211-P9U-001	REV. A
JOB: GENERAL	SHEET 10 of 28	
TITLE: TECHNICAL SPECIFICATION FOR SAWL CARBON MANGANESE STEEL LINEPIPES	 GESTOR: SUB/ES/EISE/EDR	

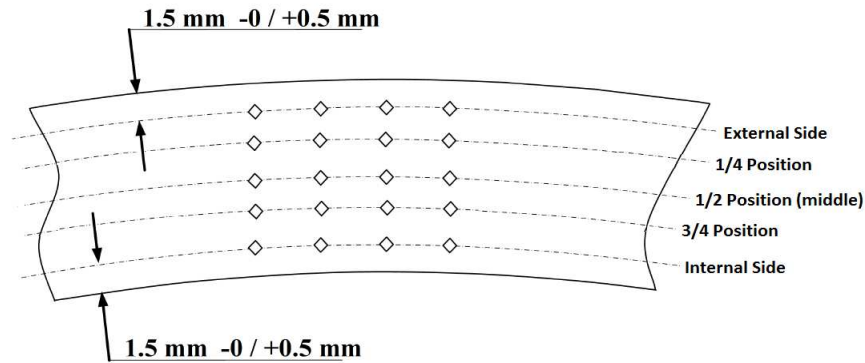
- 6.1.25 **(C.2.2.12) Addition** - In case of failure of a MPQT, welding operator will be treated as non-qualified welding operator and need to be qualified.
- 6.1.26 **(C.2.2.15) Addition** - It shall be recorded the name and number of the welding operator responsible for the MPQT or for the specific welding testing.
- 6.1.27 **(C.2.2.17) Addition** - SUPPLIER shall present, before MPQT or FDPT, qualification plan for welders and welding operators. The list of qualified welders and welding operators shall be available during production.
- 6.1.28 **(C.7.2.8) Addition** - SUPPLIER shall establish tolerances for temperature changes during welding based on the qualified WPS. Minimum pre-heating and/or initial welding temperature shall be established and these variables shall be measured at a distance of 75 mm from the edges of the groove (to be welded).

6.2 TESTING REQUIREMENTS

- 6.2.1 **(B.2.2) Addition** – SUPPLIER shall carry out chemical heat analysis of each heat of steel used in linepipe manufacturing. Heat analysis can also be performed in the plate mill, with supervision of SUPPLIER representative. SUPPLIER shall be responsible for all product data reported. Samples from, at least, two pipes per heat of steel shall be taken for product analysis during linepipe manufacturing.
- 6.2.2 **(7.2.4.8) Modification** – The hardness requirements shall be as given in table A-3 of this specification.
- 6.2.3 **(7.2.4.8) Addition** – During MPQT and FDPT SUPPLIER shall perform measurements at three different areas, one at the longitudinal weld seam according to figure 4 (a) and two additional measurements according to figure 4-b, located 120° for each side from the weld seam (around 4 and 8 o'clock positions).
- 6.2.4 **(7.2.4.8) Addition** – During MPQT and First Day Production Test, for pipes with wall thickness greater than 3/4 inch (19 mm), a hardness profile shall be taken, with additional lines at 1/4 and 3/4 of the wall thickness. For those lines, a minimum of 18 readings at each line shall be taken. Figure below shows the sketch of hardness profiles for longitudinal weld seam at figure 4-(a) and for base metal at figure 4-(b), located 120° for each side from the weld seam (around 4 and 8 o'clock positions)



(a) Sketch of longitudinal weld seam hardness profile



(b) Sketch of base metal hardness profile

Figure 4 – Hardness profile for MPQT and FDPT for wall thicknesses greater than ¾ inch (19 mm)

6.2.5 **(7.2.4.9) 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 RM 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
Base Metal Impact Energy Average (Minimum) [J]	95 (80)	106 (89)	134 (112)
Weld Metal and HAZ Impact Energy Average (Minimum) [J]	57 (48)	64 (54)	80 (67)

6.2.6 **(7.2.4.9) Addition** – The testing temperature for Charpy V-notch impact test will be informed by PETROBRAS in the RM or Specific Pipeline Project Documentation.

6.2.7 **(7.2.5) Addition** - Project specific Quality Plan and Process Control (Inspection & Testing Plan) shall also be submitted by SUPPLIER and it shall detail all process steps from material supplying up to final linepipe dispatch. This document shall contain details on all physical testing to be carried out including MPQT and First Day Production Testing and it shall detail testing frequencies and acceptance criteria.

6.2.8 **(7.2.5.1) 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**.

6.2.9 **(7.2.5.7 and 7.2.5.10) 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 First Day Production qualification approval. All testing, including the one that failed, shall be reported.

6.2.10 (7.9.1.4) **Modification** – The chemical composition, including allowable ranges of elements, shall be according to Table 2 of this specification.

Table 2 – Chemical composition for welded C-Mn steel pipe with delivery condition M for supplementary requirement, H₂S service

Element	Product Analysis (max. %)	Allowable Range %
C	0.10	0.02
Si	0.45	0.10
Mn	1.65	0.15
P	0.0120	-
S	0.0020	-
Nb	0.05	0.01
Ti	0.025	0.01
V	0.08	0.015
Al	0.060	-
Cu	0.35	0.10
Ni	0.30	0.10
Cr	0.30	0.10
Mo	0.15	0.05
B	0.0005	-
N	0.012	-
Pcm	0.21	0.021
Al/N	≥ 2:1	-
Nb+Ti+V	0.10	-
Ca/S	≥ 1.5*	-

Note 1: (Allowable range: Target CE Pcm ±0.010)


6.2.11 (7.2.5.12) **Addition** – Any additional chemical element shall not be added to material without PETROBRAS written approval.

6.2.12 (7.3.5.8) **Addition** - PETROBRAS reserves the right to reject any test unit if failure occurs in CTOD testing or in SSC and/or HIC testing.

6.2.13 (7.9.1.10) **Modification** – The requirements and acceptance criteria for the HIC testing shall be as per Table A-1 of Appendix A.2 of this Technical Specification.

6.2.14 (7.9.1.20) **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. Otherwise, SSC requirements in table A-2 and Appendix A.2 of this Technical Specification shall be followed. SSC testing shall be performed on BM either by FPBT method described at ASTM G39, NACE TM 0316 or by method A of standard NACE TM 0177. BM specimens shall be removed in the linepipe longitudinal direction. SSC testing shall be performed on longitudinal weld seam by FPBT method described at ASTM G39 or NACE TM 0316. WM specimens shall be removed transversally to the weld direction. SSC test specimens shall be taken as close as possible from the internal surface of the linepipe. A macro examination record shall be reported in order to confirm position of sample removal.

6.2.15 (7.9.2.2) **Modification** – During MPQT, CVN transition curves in both original condition and

TECHNICAL SPECIFICATION	Nº I-ET-0000.00-0000-211-P9U-001	REV. A
JOB: GENERAL	SHEET 13 of 28	
TITLE: TECHNICAL SPECIFICATION FOR SAWL CARBON MANGANESE STEEL LINEPIPES	 GESTOR: SUB/ES/EISE/EDR	

aged condition shall be recorded using 5 sets of impact tests (five specimens per set) tested between -60°C and +20 °C, including T_{Min} , with the distribution to be proposed by SUPPLIER and submitted for PETROBRAS approval.

- 6.2.16 **(7.9.2.5) 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.
- 6.2.17 **(B.2.8.7) Addition** - For HAZ qualification (fracture toughness testing), specimens shall be extracted in the transverse direction and shall be tested according to BS EN ISO 15653, with NP plane orientation (through-thickness notch). Fatigue pre-crack tip shall be located at 25% WM_{ext} /50% HAZ/ 25% WM_{int} as illustrated on **figure 5**.

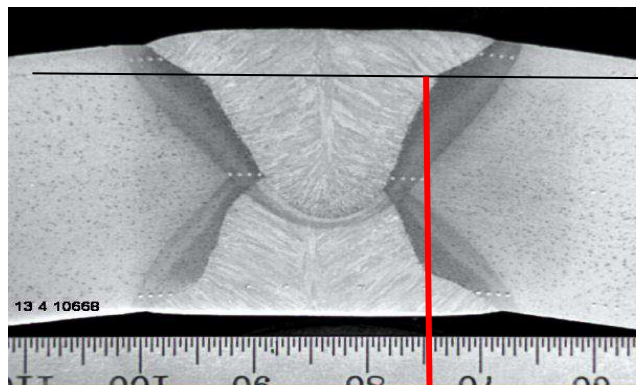







Figure 5 – Example of HAZ notch location (red line) for CTOD testing

- 6.2.18 **(B.2.8.13) Addition** – CTOD fracture toughness testing shall be performed on the frequency established in Table B-1 and Table B-3 of this Technical Specification. CTOD fracture toughness testing of the base metal shall be performed using SENB specimens with YX plane orientation (through-thickness notch) as per BS ISO 12737. Each set of CTOD test specimens shall be composed by three (3) specimens. CTOD specimens shall be tested with maximum thickness possible considering the linepipe geometry. Weld area shall not be flattened during sample preparation. 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 $\delta = 0,30$ mm when tested at T_{Min} for WM and HAZ. For BM locations values shall, as a minimum, be equal or higher than $\delta = 0,40$ mm when tested at $T = -30$ °C.
- 6.2.19 **(B.2.7) Addition** – As a minimum, DWTT during MPQT, FDPT and production shall be performed on the frequency established in Table B-1 of this Technical Specification. When applicable, DWTT specimens shall reflect Supplementary Requirement “P” as per RM, i.e. specimens shall be also tested in the strained and aged condition. 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.
- 6.2.20 **(B.2.5) Addition** - As a minimum, Guided Bend testing during MPQT, FDPT and production shall be performed on the frequency established in Table B-1 of this Technical Specification. Guided Bend testing shall be performed in the following orientations: root bend and face bend.
- 6.2.21 **(C.2.3.1) Addition** - Samples for HIC shall be obtained in the longitudinal direction of linepipe, for BM, and in the transversal direction of linepipe for the WM.
- 6.2.22 **(7.9.1.9) Addition** - If any hard spot outside the MPQT hardness acceptance criteria value for the SSC region of environmental severity ‘1’ and ‘2’ is detected during FDPT and

	TECHNICAL SPECIFICATION	Nº I-ET-0000.00-0000-211-P9U-001	REV. A
	JOB: GENERAL	SHEET 14 of 28	
	TITLE: TECHNICAL SPECIFICATION FOR SAWL CARBON MANGANESE STEEL LINEPIPES	 GESTOR: SUB/ES/EISE/EDR	
<p>production, SUPPLIER shall perform SSC testing in one set of 3 samples of the same plate heat. All tests shall be approved. For SSC region of environmental severity '3', if any hard spot, outside the MPQT hardness accepted value is detected, even during re-testing, all heat shall be discharged.</p> <p>6.2.23 (B.2.10.2) Addition - As a minimum, metallographic examination during MPQT, FDPT and production shall be performed on the frequency established in Table B-2. Metallographic examination at WM, HAZ and BM locations with a magnification of 400X shall be performed in order to verify the typical microstructure.</p> <p>6.2.24 (7.5.1.1) Addition - Pressure gauging devices shall be calibrated prior to the start of production and verified, at least, weekly thereafter. Pressure chart shall be verified against the manometer. Verification against a master gage and/or recalibration is also required either (1) after sudden depressurization caused by hydrostatic failure of seals of linepipe or (2) with change of wall thickness or grade. Chart records and calibration certificates shall be available at any time when requested by PETROBRAS or their representative and they shall be part of the Manufacturing Record Book.</p> <p>6.2.25 (7.5.1.6) Modification - SUPPLIER shall disregard this item.</p> <p>6.2.26 (7.5.1.3) Addition – Mill test pressure (ph) may be reduced upon written request to PETROBRAS.</p> <p>6.3 NDT REQUIREMENTS</p> <p>6.3.1 (D.1.5.1, D.1.5.2 and D.8.1.4) 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 standards 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.</p> <p>6.3.2 (D.2.5.11) Addition - The fluorescent MT method shall be considered herein as non-destructive surface method to detect imperfections in the weld.</p> <p>6.3.3 (D.2.6.1) Modification - During MPQT and FDPT, all produced linepipes shall be non-destructive inspected after 48hrs.</p> <p>6.3.4 (D.3.5.1) Addition - If the supply of linepipes will be coated by the linepipe supplier, it is acceptable that residual magnetism measurement is carried out after the coating application since all coating activities are properly controlled as per coating specification and qualified procedure.</p> <p>6.3.5 (D.7) and (D.8.5.24) Addition - No hard spots with hardness value measured on the plate surface shall exceed 220 HV10 for Sour Service Severity Steel Class "3".</p>			

	TECHNICAL SPECIFICATION	Nº I-ET-0000.00-0000-211-P9U-001	REV. A
	JOB: GENERAL	SHEET 15 of 28	
	TITLE: TECHNICAL SPECIFICATION FOR SAWL CARBON MANGANESE STEEL LINEPIPES	 GESTOR: SUB/ES/EISE/EDR	
<p>6.3.6 (D.7) Addition - Eddy current technique shall be used for 100% TMCP plate surface inspection of hard surface layer. Inspection shall be performed on the up side surface of plates. Any blind zone shall be inspected by portable hardness tester following a grid pattern. Grid dimensions are to be agreed upon at bid stage. Alternatively, blind zones shall be cropped.</p> <p>6.3.7 (D.8.3.8) Addition - All pipe body imperfections detected in the visual inspection shall be repaired by cosmetic grinding and local remaining pipe wall thickness shall be checked by manual UT (ultrasonic thickness gage). For cosmetic grinding, flap wheels shall be used with minimum 80 grit size. Only flap wheels shall be used.</p> <p>6.3.8 (D.8.4.17) Addition - Sensitivity of automatic NDT inspection equipment shall be checked twice per shift in the presence of the PETROBRAS' representative, in the dynamic mode on the reference standard. If the automatic NDT inspection equipment shows malfunction during operation, all linepipe tested since the last calibration shall be re-tested after equipment has been repaired and its calibration status checked through the established standard. All NDT procedures shall be prepared and signed up by level 3 certified inspectors.</p> <p>6.3.9 (D.8.5.2) Addition – All pipes shall be inspected for bevel damage, severe corrosion, dent, gouges and other similar defects. All defects discovered shall be recorded by SUPPLIER against linepipe serial number.</p> <p>6.3.10 (D.8.5.30) 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. All linepipes produced between the defective and the last acceptable linepipe shall be individually measured. Any linepipe exceeding this limit is not acceptable unless full length demagnetized to a level less than 20 Gauss. Measurements shall be taken on square cut end face of finished linepipe.</p> <p>6.3.11 (D.8.7) Addition – Pipe ends shall be tested with wet fluorescent MT for longitudinal and transverse defects, internal and external surfaces, after beveling and machining. MT equipment shall be verified with specified reference standard at least twice per shift, in the presence of the PETROBRAS representative.</p> <p>6.3.12 (D.8.7) Addition – All imperfections detected in the MT shall be repaired by grinding and remaining wall thickness will be checked by manual UT.</p> <p>6.3.13 (D.8.7.2 and D.8.7.3) Modification – Both ends of each pipe shall be tested for laminar imperfections in accordance with ISO 10893-8 and the additional requirements in D.8.4 over a band at least 150 mm inside the location of future welding preparations for girth welds. For MPQT and FDPT, manual or automatic UT for laminar imperfections in the BM shall be performed at least 150 mm of pipe ends.</p> <p>6.3.14 (D.8.13) Addition - Imperfections that are not classified as defects but that are repeatedly distributed in the weld over the longitudinal weld seam length shall be considered as systematic imperfections. Systematic imperfections shall be reported. The source of the imperfections shall be investigated and corrected to ensure they do not lead to defects in subsequent production.</p> <p>6.3.15 (D.8.13.8) Addition – All MPQT, FDPT and production linepipes approved by AUT shall have its weld seam ends inspected by manual UT in a length of, at least, 300mm.</p>			



TECHNICAL SPECIFICATION	Nº I-ET-0000.00-0000-211-P9U-001		REV. A
	JOB: GENERAL		SHEET 16 of 28
	TITLE: TECHNICAL SPECIFICATION FOR SAWL CARBON MANGANESE STEEL LINEPIPES		 GESTOR: SUB/ES/EISE/EDR

6.3.16 **(D.8.14.6) 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.

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

6.3.18 **(D.8.14) Addition** – Lamination examination sensitivity on pipe ends shall be established using 1/4" diameter flat-bottomed hole with depth of 1/2 WT. All indications resulting in 50% or greater loss in Back Wall Echo technique shall be rejected. This requirement also exists when square cut ends are specified at linepipe MPS. Couplant shall be plain fresh water and inspection equipment shall have audio and/or visual alarms to denote loss of coupling and signals in excess of acceptance limits.

6.3.19 **(Table D-12) Modification** – Acceptance Criteria for Laminar Imperfections shall be in accordance with the following table. Individual laminations or lamination densities exceeding the specified acceptance limits for sour service in Table 3, shall be classified as defects.

Table 3 – Acceptance Criteria for Laminar Imperfections

Service Condition	Maximum Individual Imperfection		Minimum Imperfection Size Considered			Maximum Population Density ^a
	Area mm ² (in. ²)	Length mm (in.)	Area mm ² (in. ²)	Length mm (in.)	Width mm (in.)	
Pipe Body (or strip/plate body)						
SCC Level 0: Non Sour	1000 (1.6)	Not specified	300 (0.5)	35 (1.4)	8 (0.3)	10 [per 1.0 m (3.3 ft) × 1.0 m (3.3 ft) square]
SCC Levels 1 & 2 : Sour	500 (0.8)		150 (0.2)	15 (0.6)	8 (0.3)	10 [per 500 mm (1.6 ft) × 500 mm (1.6 ft) square] ^c
SCC Level 3 : Sour	50		30 (0.05)	5 (0.2)	5 (0.2)	5 [per 500 mm (1.6 ft) × 500 mm (1.6 ft) square] ^c
Strip/Plate Edges or Areas Adjacent to the Weld Seam ^d						
Sour, fatigue, offshore or longitudinal plastic strain capacity	32	6.4	—	6.4	—	3 [per 1.0 m (3.3 ft) length]

NOTE 1 For an imperfection to be larger than the minimum imperfection size, each of the minimum area, minimum length and minimum width given for the pipe body (or strip/plate body) have to be exceeded.

NOTE 2 For the purpose of determining the extent of suspect area, adjacent suspect areas separated by less than the smaller of two minor axes of the areas shall be considered as one area.

^a Number of imperfections smaller than the maximum and greater than the minimum imperfection size.

^b The maximum imperfection area of edges is the product of the maximum imperfection length, where length is the dimension parallel to the material edge and the transverse dimension; an imperfection is considered to be larger than the maximum imperfection size if either the length or the transverse dimension is exceeded.

6.4 DIMENSIONAL REQUIREMENTS

- 6.4.1 **(7.7.1) Addition** - Linepipe shall be furnished with square cut ends according to RM definition. Square cut end faces shall not be brought into tolerance by welding or grinding; repair shall only be made by re-machining the entire end face.
- 6.4.2 **(7.9.4.1) Modification** - Dimensional Requirements shall be performed at the frequencies specified in Table B.1 of Appendix B of this Technical Specification.
- 6.4.3 **(7.2.3.39) Modification** - Internal and external weld bead grinding removal shall be at least 300mm at both pipe ends. Transition between BM and WM shall be smooth and the height of the remaining weld beads shall not extend above the adjacent linepipe surface by more than 0.5 mm as per **figure 6**.

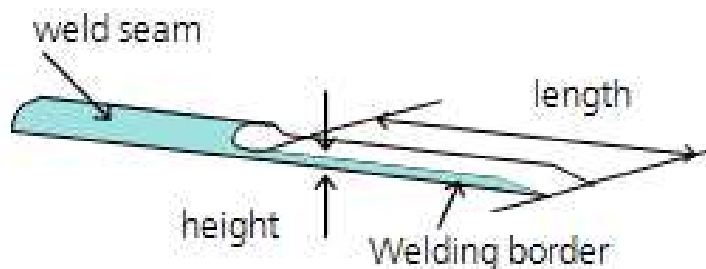


Figure 6 – Pipe end grinding

- 6.4.4 **(7.7.2) Addition** - All pipes shall be delivered in such a way that after the line-up of two randomly selected pipes, without the need of linepipe 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.
- 6.4.5 **(7.7.2.1 and Table 7.18) 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.
- 6.4.6 **(7.7.2.3) Modification** – The average linepipe length shall be:
- ✓ 100% of the linepipe 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 linepipe lengths shall be inside this range.
- 6.4.7 **(7.7.2.3) Addition** – When is required in RM or Specific Pipeline Project Documentation (example, for S-Lay installation method), the requirement for the average linepipe length shall be as below (more stringent since lay vessel layout requires tighter tolerances):
- ✓ 100% of the linepipe 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 linepipe lengths shall be inside this range.
- 6.4.8 **(7.7.1.3) 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 [8]. Additionally, all micrometers shall be checked for calibration at the beginning of each shift.

6.4.9 **(7.7.3.3 to 7.7.3.7) Modification** – pipe end ID shall be measured with automatic equipment (e.g. laser system) in, at least, 7 different internal diameter positions equally spaced. Additional to those measurements, in the weld area, at least two internal diameter measurements at the distance of 50 mm shall be performed close to the weld toe. In case of equipment breakdown, pipe end ID may be measured with manual equipment/device. The sketch in the figure 7 presents the methodology of pipe end ID measurements, including the additional 2 measurements close to the weld toe.

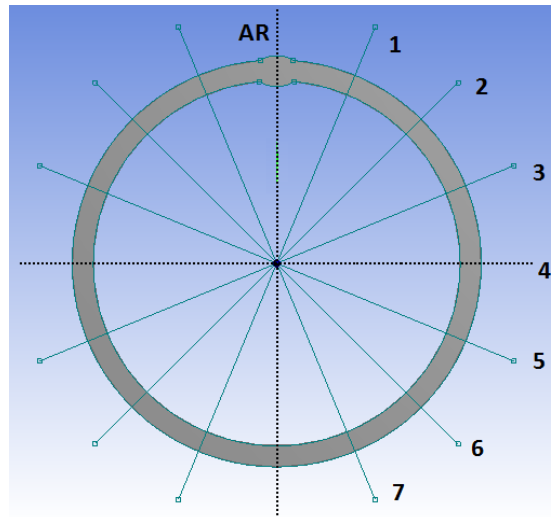






Figure 7 – Sketch of ID and out-of-roundness measurement positions


- 6.4.10 **(7.7.3.3 to 7.7.3.7) 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 gauge rod calibration certificate period of validity shall be, at most, 6 months.
- 6.4.11 **(Table 7-22) Addition** – Deviation from a straight line shall not exceed 0.15% of the linepipe length or 13 mm, whichever is less.
- 6.4.12 **(Table 7-22 and 7.7.3.10) Addition** – Any local deviation shall be less than 3mm within any 1 m of linepipe length, including pipe ends. The pipe 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.
- 6.4.13 **(Table 7-23 and 7.7.3.2) Addition** – Pipe end ID and out-of-roundness measurement frequency shall be equal to:
- ✓ 10% of linepipes 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.
- 6.4.14 **(Table 7-23 and 7.7.3.2) Modification** – Data from dimensional inspection (ID and out of roundness) shall be recorded, as per figure 4, at least, in a frequency of 1/10 produced linepipes. For MPQT dimensional inspection of, at least, 5 linepipes of each test unit shall be recorded. For FDPT dimensional inspection of, at least, 10 linepipes of each test unit shall be recorded.

	TECHNICAL SPECIFICATION	Nº I-ET-0000.00-0000-211-P9U-001	REV. A
	JOB: GENERAL	SHEET 19 of 28	
	TITLE: TECHNICAL SPECIFICATION FOR SAWL CARBON MANGANESE STEEL LINEPIPES	 GESTOR: SUB/ES/EISE/EDR	
<p>6.4.15 (Tables 7-18, 7-19, 7-22 and 7-23) Modification - For special applications (risers, jumpers, dynamic pipelines, etc), the below requirements shall be used. This condition may be clearly detailed in the RM or specific Pipeline Project Documentation.</p> <ul style="list-style-type: none"> ✓ Maximum end ID variations shall be less than 1.0 mm or 0.5 mm; ✓ ID and out-of-roundness measurement frequency shall be equal to 100% of pipes ends measured and recorded by laser equipment; ✓ Pipe body out of roundness measurement frequency shall be equal to 100% of pipes controlled by proper device. <p>6.5 PIPE MARKING AND TRACEABILITY</p> <p>6.5.1.1 (7.2.3.44) Addition - Linepipe markings and mill certificates shall be checked to ensure correct identification and traceability of the production. This data shall be used as a basis for monitoring product movement from the time of receipt until the delivery of coated linepipe to SUPPLIER.</p> <p>6.5.1.2 (7.8.1.2) Modification - Marking shall include DNV GL linepipe designation as per item 7.2.2. Marking shall reflect the correlation between the product and the respective inspection document.</p> <p>6.5.1.3 (7.8.1.1) Modification - All marking shall be easily identifiable and in such a condition that it is readable during the subsequent activities. Cold die stamped shall be used in both linepipe cut ends only. When required as per RM, color identification shall be in accordance with ISO 3183 standard. Color identification shall be used herein for grouping linepipes from different wall thicknesses, dimensional tolerances and specific additional requirements. SUPPLIER shall guarantee adequate color identification traceability as per RM.</p> <p>6.5.1.4 (7.8.1.3) Addition - Each linepipe shall be marked with a unique number to allow tracking of pipes throughout manufacturing, coating, welding and installation. Not only linepipes shall have a traceable unique number but also each sample obtained for tests and inspections. For linepipe intended to be subsequent external coating, external marking shall be done at coating facility rather than the linepipe mill. However, SUPPLIER shall guarantee that traceability from linepipe mill to coating facility will be assured.</p> <p>6.5.1.5 (7.8.1) Addition - SUPPLIER shall submit for PETROBRAS' approval the layout of marking. Linepipe 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:</p> <ul style="list-style-type: none"> ✓ Heat and ITP Number; ✓ Sour Service Severity Steel Class; ✓ Mark of PETROBRAS inspection representative, if applicable; ✓ DNV GL Linepipe Designation; ✓ Purchase Order Number. <p>6.6 DELIVERY CONDITION AND DOCUMENTATION REQUIREMENTS</p> <p>6.6.1 (7.8.3) 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 RM 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 linepipe lifting without their removal.</p>			

	TECHNICAL SPECIFICATION	Nº I-ET-0000.00-0000-211-P9U-001	REV. A
	JOB: GENERAL	SHEET 20 of 28	
	TITLE: TECHNICAL SPECIFICATION FOR SAWL CARBON MANGANESE STEEL LINEPIPES	 GESTOR: SUB/ES/EISE/EDR	

- 6.6.2 **(7.8.3) Addition** – SUPPLIER shall submit 8 weeks prior to initial load out all instructions and diagrams related to linepipe 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.
- 6.6.3 **(7.8.4 and 12.3.1.1) 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 **12.3.1.1** of plus the Inspection Test Plan (ITP) for PETROBRAS or purchaser appreciation. The revision cycle deadline presented in Note 1 above (in section 4.6.3) is still applicable for production purposes.
- Note 4: The quality of documentation shall allow PETROBRAS or purchaser approval. PETROBRAS or purchaser 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.
- 6.6.4 **(12.3.1.2) Addition** - The “complete statistics of chemical composition, mechanical properties and dimension 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.
- 6.6.5 **(12.3.1.2) Addition** - All documentation shall be available in electronic data files one month after manufacture ends. 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.
- 6.6.6 **(12.3.1) Addition** - All documentation generated during fabrication of linepipes (NDE reports, weld reports, weld repair reports, WPSs, non-conform reports, out-of-roundness control, welder performance control, list of short pipes, tally lists, etc..) shall be available at any time at pipe mill, and shall be presented to PETROBRAS when requested by their representative.



TECHNICAL SPECIFICATION ^{Nº} I-ET-0000.00-0000-211-P9U-001 REV. A	JOB: GENERAL	SHEET 21 of 28
	TITLE: TECHNICAL SPECIFICATION FOR SAWL CARBON MANGANESE STEEL LINEPIPES	
	 GESTOR: SUB/ES/EISE/EDR	

APPENDIX A - ADDITIONAL REQUIREMENTS

A.1 GENERAL

A.1.1 - This appendix presents the additional requirements for manufacturing and testing of SAWL 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 H₂S effects on Sour Service operation of riser/ pipeline;

AR RL: This additional requirement is necessary when SAWL pipes manufactured are intended to constitute risers or pipelines installed by reel-lay method.

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

A.2.1 – (7.9.1.10 and 7.9.1.11) Modification - According to the SSC region of environmental severity defined in RM 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. Detailed drawings of test specimens sampling for MPQT and production tests shall be issued by SUPPLIER and submitted (in PDF format) for the purchaser's approval, as part of the MPS.

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 H₂S service operation and acceptance criteria

SSC REGION OF ENVIRONMENTAL SEVERITY	HIC TEST SOLUTION	ACCEPTANCE CRITERIA ¹		
		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

Note 1: crack area ratio (CAR) = 5 % maximum of the specimen area, per specimen. The CAR shall include all cracks and all laminations whether they are associated with cracks or not.

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 – Hardness values for SAWL pipes

SSC REGION OF ENVIRONMENTAL SEVERITY	MAXIMUM HARDNESS (VICKERS HV10)			
	BASE METAL	WELD METAL	HAZ EXTERNAL	HAZ INTERNAL
0	250	275	275	275
1	240	250	275	250
2	240	250	275	250
3	230	240	240	240

A.2.3 – (B.3.3.1 and B.3.3.2) 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) Modification - SSC testing shall be performed on BM either by FPBT method described at ASTM G39, NACE TM 0316 or by method A of standard NACE TM 0177. BM specimens shall be removed in the linepipe longitudinal direction. SSC testing solution shall be selected according to Table A-2 considering the SSC region of environmental severity defined in RM 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 – (B.3.4.6) Modification - SSC testing shall be performed on WM and HAZ either by FPBT method described at ASTM G39 or NACE TM 0316. Specimens shall be removed in the weld seam transversal direction. SSC testing solution shall be selected according to Table A-2 considering the SSC region of environmental severity defined in RM 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.2.6 - (7.9.1.11) Modification – Visual examination of the tested surface shall be carried out with a low power microscope (10 and 100x 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.2.7 - (7.9.3.4) 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 $\delta = 0,35$ mm when tested at T_{Min} for BM locations and $\delta = 0,15$ for WM and HAZ;
- b) Testing environment: solution with dissolved H₂S gas; procedure for hydrogen charging is similar to HIC test as per NACE TM 0284. The bath used to charge SENB shall be the solution A of NACE TM 0177 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 ISO 12737; during testing, environment of the chamber shall be air or another solution without dissolved H₂S gas.

TECHNICAL SPECIFICATION	Nº	I-ET-0000.00-0000-211-P9U-001	REV.	A
	JOB:	GENERAL		SHEET 23 of 28
	TITLE:	TECHNICAL SPECIFICATION FOR SAWL CARBON MANGANESE STEEL LINEPIPES		 GESTOR: SUB/ES/EISE/EDR

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

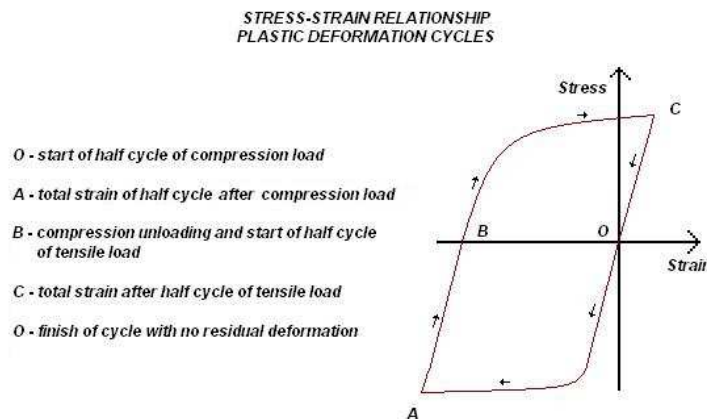
A.3.1 - The additional requirement AR RL allows the utilization of SAWL pipes for risers or pipelines installed by reel-lay method, under the following limits in addition to clause 1.2 of this specification.

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

A.3.2 – (7.9.3.6) Modification – As part of qualification of the linepipe 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);
- ✓ 3rd cycle: compression to $-D/(15000+D)$ % and tension to 0.0% (closed loop OABCO);
- ✓ 4rd cycle: compression to $-D/(15000+D)$ % + 0,2% and tension to 0.0% (closed loop OABCO);

Where, D is the linepipe outside nominal diameter, in millimeters.



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).

A.3.3 – (7.9.3.6) Addition – After straining, linepipe material shall be subject to ageing heat treatment at the temperature of 250 °C for, at least, 1 (one) hour.

A.3.4 – (7.9.3.4) Addition - The following testing shall also be conducted for AR R fulfillment:

- Pre-strained and aged samples shall be used for SSC corrosion testing on the inner surface;
- 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 250°C for 1 hour before testing. Measured CTOD fracture toughness values shall, as a minimum, be equal or higher than $\delta = 0,15$ mm when tested at T_{Min} for BM locations.

A.3.5 – (7.9.3.7) Addition - When Supplementary Requirement “P” is required as per RM SSC 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.





TECHNICAL SPECIFICATION	Nº I-ET-0000.00-0000-211-P9U-001	REV. A
JOB: GENERAL	SHEET 24 of 28	
TITLE: TECHNICAL SPECIFICATION FOR SAWL CARBON MANGANESE STEEL LINEPIPES	 GESTOR: SUB/ES/EISE/EDR	

APPENDIX B – TEST MATRIX – ACCEPTANCE CRITERIA AND FREQUENCIES

This appendix presents the acceptance criteria and testing frequencies for SAWL linepipes on the following tables:

Table B-1 – Testing Frequency

TEST/ CONTROL	REQUIREMENT	TEST FREQUENCY		
		MPQT	FDPT	PRODUCTION
Linepipe Dimensional Check				
Linepipe Dimensional Check	According to Tables 7-18, 7-19, 7-22 and 7-23 of DNVGL-ST-F101 and modifications required in clause 6.4 of this technical specification	For, at least, 5 pipes for each test unit	For 10 pipes produced, for each test unit	Clause 6.4 of this technical specification
Materials Requirements				
Product Analysis	According to Tables 7-4 and 7-25 of DNVGL-ST-F101	Two analyses per test unit	Two analyses per test unit	Two analyses per heat of steel (from separated pipes)
Tensile Testing at pipe body	According to Table 7-5 of DNVGL-ST-F101.	1 set ¹ of test per test unit with the same cold-expansion ratio	1 set of test per test unit with the same cold-expansion ratio	1 set of test per 50 lengths of pipe with the same cold-expansion ratio
Tensile Testing (Cross Weld)	According to Table 7-5 of DNVGL-ST-F101. For transverse weld tensile testing, the ultimate tensile strength shall be at least equal to the SMYS	1 set of transversal test per heat unit with the same cold expansion ratio and centred on the weld	1 set of test per test unit with the same cold expansion ratio and centred on the weld	1 set of test per 50 lengths of pipe with the same cold expansion ratio and centred on the weld
All-Weld Tensile Testing	According to Table 7-5 of DNVGL-ST-F101	1 test for each pipe provided	1 test for each test unit provided	N.A.
CVN Impact Testing (BM, WM and HAZ)	As per clauses 6.2.5, 6.2.6, 6.2.16 and Table 1 of this specification	1 set per pipe for each region (BM, WM and HAZ [FL and FL + 2 mm]) per test unit	1 set per pipe for each region (BM, WM and HAZ [FL and FL + 2mm]) per test unit	1 set of test per 50 lengths of pipe with the same cold expansion ratio
Hardness Testing	According to Table A-3, clauses 6.2.3 and 6.2.4 of this specification for BM, WM and HAZ	3 sets of test per pipe 1 as per figure 1(a) and 2 as per figure 1(b) per test unit	Same as MPQT	3 sets of test per pipe 1 (as per figure 1(a) and 2 as per figure 1(b)) per 50 lengths of pipe
Transverse CVN Transition Curves	As per clauses 6.2.5, 6.2.6, 6.2.15, 6.2.16 and Table 1 of this specification	5 sets (5 specimens/set) between -60°C and +20 °C for BM per test unit	N.A.	N.A.
Transverse CVN Transition Curves -Aged Condition	As per clauses 6.2.5, 6.2.6, 6.2.15, 6.2.16 and Table 1 of this specification	5 sets (5 specimens/set) between -60°C and +20 °C for BM per test unit	N.A.	N.A.

	TECHNICAL SPECIFICATION		Nº I-ET-0000.00-0000-211-P9U-001	REV. A
	JOB: GENERAL			SHEET 25 of 28
	TITLE: TECHNICAL SPECIFICATION FOR SAWL CARBON MANGANESE STEEL LINEPIPES			 GESTOR: SUB/ES/EISE/EDR

CTOD Testing	As per clauses 6.2.17 and 6.2.18 of this specification and A.2.7 (when required)	As per clauses 6.2.17 and 6.2.18 of this specification and A.2.7 (when required)	N.A.	N.A.
Drop Weight Tear Testing (For BM only)	As per clause 6.2.19 and Clause 7.9.2.4 of DNVGL-ST-F101	5 sets (2 spec./set) of specimens between -60°C and +20 °C per test unit	1 set (2 spec./set) specimens at the minimum design temperature per test unit	1 set (2 spec./set) of test per 50 lengths of pipe with the same cold expansion ratio
Guided Bend Test	As per clause 6.2.20 of this technical specification and Clause 7.2.4.14 of DNVGL-ST-F101	1 set (2 spec./set) per test unit (root and face)	1 set (2 spec./set) per test unit	1 set (2 spec./set) of test per 50 lengths of pipe with the same cold expansion ratio
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 and different regions (BM and WM) from different test units and welding procedures	N.A.	N.A.

*1 set of tensile test: 1 longitudinal specimen 90° from weld seam and 1 transversal specimen 180° from weld seam.

Table B-2 – Inspection Testing Frequency

TEST/CONTROL	REQUIREMENT	TEST FREQUENCY		
		MPQT	FDPT	PRODUCTION
Macrographic	According to Clauses 7.2.4.16, 7.2.4.17, and B.2.10. of DNVGL-ST-F101	Once per test unit	Once per test unit	Once per operation shift
Metallographic Examination (microstructure)	As per Clause 6.2.23 of this specification and Clause 7.2.5.15 of DNVGL-ST-F101	Once per test unit	Once per test unit	Once per operation shift
NDT Inspection	According to Table 7-16 and Appendix D of DNVGL-ST-F101	All pipes	All pipes	All pipes
Hydrostatic Testing	As per items between 7.5.1.1 and 7.5.1.5 of DNVGL-ST-F101	All pipes	All pipes	All pipes




TECHNICAL SPECIFICATION	Nº I-ET-0000.00-0000-211-P9U-001	REV. A
JOB: GENERAL	SHEET 26 of 28	
TITLE: TECHNICAL SPECIFICATION FOR SAWL CARBON MANGANESE STEEL LINEPIPES	 GESTOR: SUB/ES/EISE/EDR	

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 with the same cold-expansion ratio. Acceptance criteria as per Table 7-29 of DNVGL-ST-F101	1 set of test per test unit with same the cold-expansion ratio. Acceptance criteria as per Table 7-29 of DNVGL-ST-F101 standard	1 set of test per 50 lengths of pipe with the same cold-expansion ratio. Acceptance criteria as per Table 7-29 of DNVGL-ST-F101 ²
All-Weld Tensile Testing	According to Table 7-29 of DNVGL-ST-F101 . For transverse weld tensile testing, the ultimate tensile strength shall be at least equal to the SMTS.	1 test for each pipe provided for MPQT	N.A.	N.A.
BM Hardness Testing	According to Table A-3 of this specification for BM, WM and HAZ	1 set of test per pipe BM per test unit	N.A.	N.A.
WM Hardness Testing	According to Table A-3 of this specification for BM, WM and HAZ	1 set of test per pipe for BM and WM per test unit	N.A.	N.A.
CVN Impact Testing transition curve (BM)	As per clauses 6.2.15 and 6.2.16	5 sets (5 specimens/set) between -60°C and +20 °C for BM per test unit	N.A.	N.A.
CVN Impact Testing (WM, HAZ)	According to additional requirement as per Table 1 of this specification for WM and HAZ at the minimum design temperature	1 set per pipe for WM and HAZ [FL and FL + 2 mm] per test unit	N.A.	N.A.
CTOD Testing	@ Tmin 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.

² For production, no straining and ageing is required.



TECHNICAL SPECIFICATION	Nº I-ET-0000.00-0000-211-P9U-001	REV. A
JOB: GENERAL	SHEET 27 of 28	
TITLE: TECHNICAL SPECIFICATION FOR SAWL CARBON MANGANESE STEEL LINEPIPES	NP-1	
	GESTOR: SUB/ES/EISE/EDR	

APPENDIX C– ADDITIONAL INFORMATION TO ALLOW LINEPIPE SUPPLY

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

Type and quantity data:

- Linepipe diameter;
- Linepipe 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 RL;
- Supplementary Requirement U of **DNVGL-ST-F101 standard**.

Process:



- Minimum design temperature.

Commercial:

- Delivery point.

Third Party Inspection:

- Third party inspection coverage (if applicable).

	TECHNICAL SPECIFICATION	Nº I-ET-0000.00-0000-211-P9U-001	REV. A
	JOB: GENERAL	SHEET 28 of 28	
	TITLE: TECHNICAL SPECIFICATION FOR SAWL CARBON MANGANESE STEEL LINEPIPES		
		GESTOR: SUB/ES/EISE/EDR	

APPENDIX D – REQUESTED TECHNICAL DATA FOR TENDERING PHASE

D.1 GENERAL

D.1.1 This appendix presents the minimum necessary information to be supplied by the companies tendering to be the SUPPLIER of SAWL pipes. It means that all information requested in this appendix shall be supplied during tendering phase.

D.1.2 The objective of the technical evaluation is to detect the technical risk of a particular company, participating from the tendering, to not fulfill the technical requirements of this technical specification.

D.2 REQUESTED TECHNICAL DATA

D.2.1 The following information shall be delivered for PETROBRAS evaluation:

- a) Statement of compliance with all requirements of this technical specification with no exceptions or deviations;
- b) Certification of SAWL pipe manufacturing for offshore industry using DNVGL-ST-F101 or API 5L;
- c) MPQT results, validation program or pre-qualification trials under witness (by PETROBRAS representatives or agreed third-party inspection) based on Quality Management System, SAWL pipe fabrication and inspection process validation, PFMECA, material and product evaluation;