PETROBRAS	**TECHNICAL SPECIFICATION**	**N°:**	**I-ET-0000.00-0000-219-P9U-005**
	CLIENT: PETROBRAS		**SHEET:** 1 of 12
	JOB: GENERAL		**CC:**
	AREA: RIGID SUBMARINE PIPELINES		**PROJECT:**
DDP	**TITLE:** **CRA WELD OVERLAY CLAD PIPE REQUIREMENTS FOR RIGID SPOOLS**		**PUBLIC** EDD/EDR

INDEX OF REVISIONS

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1 TECHNICAL SPECIFICATION SCOPE

1.1 The objective of this technical specification is to define the technical requirements for full weld overlay clad pipes. **Weld Overlay Clad Pipes for Rigid Spools fabricated according to this Technical Specification shall be in compliance with all requirements of DNV-ST-F101 ref.[1]**. This document shall be read in conjunction with DNV-ST-F101 ref. [1] and other standards mentioned in item 2 of this technical specification. All additional and modified requirements are mentioned in this technical specification. The DNV-ST-F101 ref. [1] paragraph number is given in square brackets.

1.2 **[7.1.2] Addition -** This technical specification is applicable to the following limits:

a) Outside diameter: from 6” to 20”;
b) Backing steel grade: SMYS from 415MPa to 485MPa;
c) CRA weld overlay cladding covered by this specification is based on the deposition of Alloy 625 in a thickness range of 3.5 to 8 mm. The chemical composition shall be in line with “ASTM B443 Alloy 625”, UNS N06625 ref. [5].
d) Installation Methods: Pull-in;

NOTE: This technical specification shall not be adopted for S-Lay, reel-lay and J-Lay installation method.

e) Coating: Application temperature for parent and field joint coating not exceeding 260ºC;
f) Thickness transitions design demand: equal or smoother than 1:7 transition;

NOTE: The part responsible for design shall establish a smoother transition, if required by one specific project.

g) Forged Straight Pipes, mother pipes for bends and weld test ring made in steel type ASTM A694 Grade F65.

1.3 **[1.5.1] Addition** - Where there is a conflict between the requirements of this specification, the Pipeline Project Design Basis, the referenced DNV and other specific standards, the order of precedence of the documents shall be:

1st – Material Requirements (specific for each Riser and Pipeline project);

2nd – This Technical Specification;

3rd - DNV-ST-F101 ref. [1];

4th – Other specific standards (see references in item 2)

1.4 The Appendix B of this specification presents the necessary information to be informed in the purchase order by PETROBRAS or purchaser for full weld overlay clad pipe supply.

2 REFERENCES

2.1 **[1.5] Addition -** The latest revision of the following documents applies:

[1] DNV-ST-F101 - Submarine Pipeline Systems Edition August 2021 Amended December 2021;

[2] DNV-RP-0034- Steel forgings for subsea applications - technical requirements - Edition November 2020, Amended September 2021;

[3] API STD 2RD - Dynamic Risers for Floating Production Systems;

[4] ASTM E2862 (2018) - Standard Practice for Probability of Detection Analysis for Hit/Miss Data;

[5] ASTM B-443 - Standard Specification for Nickel-Chromium-Molybdenum-Columbium Alloy (UNS N06625) and Nickel-Chromium-Molybdenum-Silicon Alloy (UNS N06219) Plate, Sheet, and Strip;

[6] ASTM G1 (2017) – Standard Practice for Preparing, Cleaning, and Evaluating Corrosion Test Specimens;

[7] BS EN 10204 – Metallic Products – Types of Inspection Documents;

[8] I-ET-0000.00-0000-211-P9U-002 – Seamless (SMLS) Pipes Requirements;

[9] I-ET-0000.00-0000-970-PSQ-001 – Procedure and personnel qualification and certification;

[10] DNVGL Report - JIP Lined and Clad Pipeline Materials, Phase 4 –Guideline for Design and Construction of Lined and Clad Pipelines - Report No.: 2017-3114, Rev. 1.

[11] ASME BPVC.IX-2019 - ASME Boiler and Pressure Vessel Code an International Code - SECTION IX Welding, Brazing, and Fusing Qualifications. Qualification Standard for Welding, Brazing, and Fusing Procedures; Welders; Brazers and Welding, Brazing, and Fusing Operators.

[12] ASTM A694 - Standard Specification for Carbon and Alloy Steel Forgings for Pipe Flanges, Fittings, Valves, and Parts for High-Pressure.

3 DEFINITIONS

3.1 **[1.6.1] Modification -** The following verbal forms are applied:

SHALL - Indicates a mandatory requirement (When related to SUPPLIER).
SHOULD - Indicates a preferred course of action.
MAY - Indicates a possible course of action.

3.2 **[1.6.2] Addition -** The following definitions are applied in this document:

PETROBRAS including its employees, inspectors and other authorized representatives;
Purchaser – Refers to EPCI contractors, when they are responsible for full weld overlay clad pipe supply;
SUPPLIER – Weld overlay Clad pipe manufacturer;
BACKING STEEL – The C-Mn pipe in which an internal weld overlay is to be applied;
BACKING STEEL SUPPLIER – Backing steel pipe manufacturer;
CRA WELD OVERLAY CLAD PIPE – C-Mn Pipe to be used in offshore applications with internal (Corrosion Resistant Alloy) layer where the bond between backing steel and cladding material is metallurgical, deposited by welding;

3.3 **[1.6.3] Addition -** The following Abbreviations are also applied:

EDX – Energy Dispersive X-ray

GTAW – Gas Tungsten Arc Welding;

SFC – Steel Forging Class;

PFMECA – Process Failure Modes, Effects and Criticality Analysis

QMS – Quality Management System;

WPQR – Welding Procedure Qualification Report;

QTS - Qualification Test Sample

4 TECHNICAL REQUIREMENTS

4.1 GENERAL REQUIREMENTS:

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

a) General Full Weld Overlay Clad pipe DNV Supplementary Requirements;
b) Supplementary Qualification Testing;

4.1.1.1 The “General Full Weld Overlay Clad pipe DNV Supplementary Requirements” are presented in section 6 of this technical specification. The “Supplementary Qualification Testing” is presented in section 7 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 sections 6 and 7, 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 full weld overlay clad pipe.

The Appendix A of this specification presents additional requirements. These additional requirements shall only be fulfilled by SUPPLIER if required by PETROBRAS or purchasers in the purchase order.

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

4.1.2 **[7.1.7.2] Addition** - Target chemical composition including applicable tolerances, ranges for deliberately added elements and maximum for other elements.

4.1.3 **[7.1.8.7] Modification** - The validity of the MPQT shall be limited to the steelmaking, rolling, and manufacturing/ fabrication facilities used during the qualification of backing material, weld overlay clad pipe and welding procedure specifications based on approved WPQR.

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” [7].

5.2 MANUFACTURING PROCEDURE:

5.2.1 Before MPQT, the following documentation shall be submitted for PETROBRAS evaluation:

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

5.2.2 **[7.1.4] Modification** – The following requirements related to manufacturing procedure shall be considered:

- ✓ Weld overlay clad pipes shall be manufactured from internally deposition of CRA overlay clad on C-Mn backing steel pipe. Weld overlay shall be executed in at least, two welding layers;
- ✓ The weld overlay clad pipes shall be manufactured exclusively by welding.

5.2.3 **[7.4.3.1] Addition** – The following shall be included in the MPS:

For full weld overlay clad pipes

- ✓ The mating and surface preparation procedure of backing steel before weld overlay;
- ✓ Additional mechanical tests regarding the additional requirements of Appendix A (if applicable in accordance with Material Requirements);
- ✓ Weldability testing matrix (if applicable);

5.2.4 **[7.4.3.1] Addition** – SUPPLIER shall submit the detailed MPS of the manufacturing of the full weld overlay clad pipe. MPS shall be subjected to CONTRACTOR validation and shall cover all metallurgical aspects, fabrication tolerances, weld and NDT requirements, dimensional control before and after nickel alloy weld overlay application.

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 [9].

6 GENERAL WELD OVERLAY CLAD PIPE DNV SUPPLEMENTARY REQUIREMENTS

6.1 BACKING STEEL REQUIREMENTS:

6.1.1 **[7.1.4.1] Modification** – The backing steel of the full weld overlay clad pipe shall be manufactured as SMLS pipe according to ref. [8] or as Quenched and Tempered forged pipes manufactured according to ref. [3].

6.1.2 **[7.1.5] Modification** – The applicable supplementary requirements given in subsection I of [1] are listed in [8]. The project specific conditions will be defined by PETROBRAS or purchaser (see Appendix B).

NOTE: Supplementary Requirement “P” is not applicable.

6.1.3 **[7.1.5] Addition** – Additional requirements AR SE of [8] may be selected depending on the project specific conditions.

6.1.4 **[7.2.3.39] Addition** - The ID pipe roughness shall be checked in backing steel supplier facility prior to shipping. Acceptance criteria shall be in the weld overlay clad pipe MPS.

6.1.5 **[7.4.1.2] Addition** – No repair of the backing steel by weld overlay is permitted.

6.1.6 **[8.2.3.2] Addition** – Supplier shall perform metallurgical design of mother pipe in order to comply with final bends required mechanical properties.

6.1.7 [**Table 8-2] Modification -** C, CE and Pcm values for backing steel shall be in accordance with the following: C max. = 0.16 % and CEmax = 0.42 or Pcm max = 0.22.

6.1.8 **[8.2.3.5] Modification** – CRA Mechanically Lined pipe and Hot Roll bonded CRA Clad pipe shall not be used as mother pipes.

6.1.9 **[8.2.3.2] Addition** –. DNV SMLS 360 (X52) mother pipe is allowed to be used as input backing steel material grade for induction bend mother pipes fabrication if the final product specification of IB 450-PSL2 is achieved.

6.2 WELD OVERLAY CLAD PIPE MANUFACTURING REQUIREMENTS

6.2.1 **[7.4.2] Addition** - In addition to the designation of the backing material (see [7.1.4]) Weld overlay clad pipe shall be designated with:

— WO, for Weld overlay;
— UNS N06625 (for Alloy 625 as cladding material).

6.2.2 **[7.4.4] Addition** - Overlay welding shall be performed according to qualified welding procedures meeting the requirements of Appendix C of DNV-ST-F101 [1].

6.2.3 **[C.5.4.1] Modification** – Weld overlay shall be performed with pulsed GTAW mechanized process or GMAW mechanized process.

6.2.4 **[C.8.1] Addition** - For full weld overlay clad pipes using Alloy 625 as CRA, welding consumables shall be in accordance with UNS N06625.

6.2.5 **[C.5.4] Addition** - The qualification of welding procedures, including the whole qualification tests and requirements, for full weld overlay clad pipes shall be in accordance with sub-sections C.5.4 and C.6.4 of [1] added by the requirements of this specification. The essential variables of the respective welding process from ASME BPVC Section IX [11] shall be complied with. The qualified range shall be according to that code.

6.2.6 **[C.5.4] Addition** - The clad weld shall be executed in several welding passes in order to limit an eventual flaw height and weld metal dilution. At least, two welding layers are required. After final pass, a machining at pipe ends shall be executed.

6.2.7 **[7.4.7] Addition** - Mechanical and Corrosion Testing shall, at least, comply with DNV-ST-F101 requirements of Appendixes B, C and D. Exceptions to the stated requirements may be provided on this Technical Specification or in the Material Requirement specification.

6.2.8 **[7.4.4.1] Addition** – Pickling shall be performed. The pickling solution to be applied shall fulfill the requirements of Item C.6.1, Table A1.1 of ASTM G1 [7]. Subsequent rinsing shall be performed using water with low chloride content.

6.2.9 **[7.4.4.1 and C.8.1.7] Modification** - Provided that Carbon Steel tools shall not be used for CRA parts, Purchaser shall propose material in order to do not contaminate the CRA layer. The following additional requirements shall be applied to CRA sections, in order to avoid contamination of CRA layer:
(a) Fabrication of clad overlay pipes shall be performed in a workshop, or part thereof, which is reserved exclusively for this type of material. During all stages of manufacturing, contamination of CRA layer with carbon steel and zinc shall not be permitted. Direct contact of the CRA layer with carbon steel or galvanized handling equipment (e.g. hooks, belts, rolls, etc.) shall not be permitted. Tools such as earthing clamps, brushes etc., shall be stainless steel suitable for working on type of material in question and not previously used for carbon steel. Contamination of weld bevels and surrounding areas with iron and low melting point metals such as copper, zinc, etc. is not acceptable. The grinding wheels shall not have previously been used for carbon steel. Parts of internal line-up clamps that are in contact with the CRA layer shall be non-metallic or of a similar alloy as the internal pipe surface.
(b) In the occasion of clad overlay pipes fabrication, PETROBRAS will send a team of authorized employees to Supplier fabrication facilities before the start of activities in order to evaluate the conditions provided, in order to avoid contamination of CRA section with Carbon Steel. Purchaser shall, at its own costs, execute any modification required by Petrobras for CRA riser fabrication.
(c) Supplier shall have in its facilities pickling equipment in case of accidental contamination of internal CRA layer, or a suitable equipment to suitably remove the contamination by a procedure previously validated by PETROBRAS. Care shall be taken to avoid C-Mn exposition to pickling, especially the contact zone between CRA and C-Mn layer.
(d) Pipe ends shall be protected by end cap until the beveling moment for girth weld execution.

6.3 CORROSION RESISTANCE REQUIREMENTS

6.3.1 **[7.4.7.8 and C.6.4.7] Addition** - The minimum and maximum PRE values shall conform to UNS N06625. Figure 1 presents the PRE values for UNS06625.

$$\begin{aligned} &\text{N06625} \\ &\%\ \text{Cr} = 20.0 - 23.0 \\ &\%\ \text{Mo} = 8.0 - 10.0 \\ &\%\ \text{N}_2 = 0.0 \end{aligned}$$

$$\begin{aligned} \text{PREmin} &= 20.0 + (3.3 \times 8.0) + (16.0 \times 0.0) = \mathbf{46.4} \\ \text{PREmax} &= 23.0 + (3.3 \times 10.0) + (16.0 \times 0.0) = \mathbf{56.0} \end{aligned}$$

Figure 1 - PRE values for UNS06625.

6.3.2 **[C.6.4.8 and C.8.1] Modification** – Iron (Fe) dilution shall be measured using semi quantitative EDX technique. After final machining, the iron content at inner surface shall not exceed 10% (Fe%$\leq$ 10).

6.3.3 **[7.4.8.9 and C.6.4] Addition –** Pitting corrosion resistance of weld overlay shall be validated by testing during MPQT in accordance with ASTM G48 Method A. The maximum weight loss shall not exceed 4.0 g/m2 when tested at 50°C for 24 hours. After testing, visible pits shall not be found at 20x magnification.

6.3.4 **[C.6.4.17] Modification** - Corrosion testing and microstructure examination of UNS06625 weld overlay shall be performed during MPQT. During production microstructure examination of weld overlay and backing steel interface shall be performed at least once per production shift.

6.4 **SMALL SCALE SUPPLEMENTARY TESTING REQUIREMENTS**

6.4.1 **[7.1.8.6] Addition** – **Weldability tests** shall be executed unless SUPPLIER presents a track record supplying successfully DNV 450 WO UNS N06625. If the testing is deemed necessary, a testing matrix shall be proposed by SUPPLIER for PETROBRAS validation. The testing matrix shall prove that full weld overlay clad pipes may be welded without any special resources or welding methods. Pipes shall be able to be welded using at least GTAW and GMAW methods.

6.4.2 **[7.4.7.3 and C.6.4.6] Addition –** Hardness - The maximum hardness of the CRA layer shall be limited to 345 HV10 for straight pipes and 325 HV for mother pipes.

6.4.3 **[C.6.4.5] Modification –** The macro sections shall be documented by photographs (magnification of at least 10X). The macro section shall show a sound weld merging smoothly into the base material and meeting Quality level B of ISO 5817.

6.5 **NDT REQUIREMENTS**:

6.5.1 **[Table 7-16] Modification** – For inspection of backing steel material, the acceptance level for laminar imperfection in ultrasonic testing shall be as per U1 in ISO 10893-8.

6.5.2 **[Table 7-16] Modification** – For surface testing of clad welds, liquid penetrant testing shall be performed according to D.3.3.2 of appendix D in [1] on 100% of inner surface of weld overlay. Acceptance criteria shall be as per item D.3.6.9.

6.5.3 **[Table 7-16] Modification** – For bonding imperfection in clad welds, ultrasonic testing shall be performed according to D.3.3.4 and reports in accordance with D.3.3.5 of appendix D in [1] on 100% of the interface between backing material and weld overlay. Acceptance criteria shall be as per item D.3.6.10.

6.6 DIMENSIONAL REQUIREMENTS:

6.6.1 **[Table 7-22] Addition** - The total deviation from a straight line, over the entire linepipe length, shall be $\leq$ 0.15% of the whole pipe length and any local deviation shall be <3mm within any 1m of pipe length. The end straightness shall be measured in, at least, two perpendicular planes. The method of determining straightness shall be subject to PETROBRAS approval and a minimum of three measurements per shift shall be recorded.

6.6.2 **[Table 7-20] 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.

6.6.3 **[7.7.2.1 and 7.7.2.2] Addition** – The following requirements shall apply:

Wall thickness (pipe ends and pipe body):

- ✓ The weld overlay clad pipes manufactured in accordance with this technical specification shall have a CRA over thickness to allow for a pipe end inside diameter machining, to achieve the required pipe end tolerances. The wall thickness of the weld overlay layer shall be -0/+2,0 mm.
- ✓ An ultrasonic wall thickness measurement shall be performed in approximately 1,0 m length for each pipe.
- ✓ Wall thickness measurement shall be carried out in 12 locations as follows (0°); 30°; 45°; 90°; 120°;135°; 180°; 225°; 240°; 270°, 315° and 345°.
- ✓ During MPQT weld overlay wall thickness measurements shall be performed in approximately 1,0 m length for one pipe. Recordings shall be carried out by macrographs.

Internal diameter, external diameter and hi-lo:

- ✓ All pipes shall be supplied with a pipe end actual inside diameter tolerance defined in the MPS. The demand of pipe sorting/pipe matching activities shall be evaluated.
- ✓ The inside diameter may be fixed by the pipe manufacturer after the completion of the first 25 pipes. The tolerance shall be based on the actual fixed inside diameter and shall apply over the length of the pipe end inside machining. However, once established the “actual inside diameter”, this actual diameter shall be applied for the whole production (all lots manufactured).

NOTE: If a long term agreement is signed related to a certain standardized pipe dimension (characterized for its diameter and thickness), the “actual diameter” shall be kept constant along all contract validity.

- ✓ The pipe end inside diameter measurement shall be performed by means of a laser dispositive.
- ✓ The inside diameter shall be calculated as an average out of the measured ID values and the OoR shall be calculated under consideration of the minimum and maximum measured value.
- ✓ The pipe inside diameter measurement shall be performed in 100% of pipe ends, at a distance of 20 mm from the pipe end and at a distance as specified in the purchase order, i.e. the specified length of the inside machining.
- ✓ The pipe end OD tolerance shall be based on an actual OD which shall be fixed after start of production as the ID is mandatory. OD tolerance: shall be defined in MPS.

Pipe end surface requirements:

- ✓ Visual inspection in 100% of pipe ends, in order to verify the existence of grooves, scars or any other stress concentrator. The buffing extension beyond the taper length shall be verified.
- ✓ The roughness in 100% of pipe ends shall be measured and compared to the acceptance criteria.

NOTE 1: All measurement devices shall be calibrated in a laboratory registered in Brazilian Calibration Network - 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.

6.6.4 **[Table 7-23] Modification** - The pipe end wall thickness, inside diameter and out of roundness shall be measured and reported for each pipe end.

7 DELIVERY CONDITIONS

7.1.1 **[7.8.2] Addition** - Weld overlay Clad pipes shall be supplied with square cut – non beveled ends.

7.1.2 **[7.8.3] Addition** - All pipe ends shall be closed with non-hook able plastic end caps to avoid impacts able to damage pipe end and to avoid dust ingress into the weld overlay clad pipe. The plastic protections provided shall be able to be installed and re-installed manually in pipe end during coating application.

8 DOCUMENTATION AND RECORDS

8.1.1 **[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 all documents are approved by PETROBRAS and purchaser.

Note 3: Before production commences, SUPPLIER shall release the resting of the documents stated in item 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 is still applicable for production purposes.

Note 4: 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.

8.1.2 **[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.

8.1.3 **[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 type and in DVD 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.

APPENDIX A – ADDITIONAL REQUIREMENTS:

A.1 GENERAL

A.1.1 This appendix presents the additional requirements for manufacturing and testing of full weld overlay clad 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 SE: This additional requirement is applicable when designer intends to take into account the strengthening effects of CRA weld overlay layer on riser/ pipeline design;

A.2 - AR SE – ADDITIONAL REQUIREMENT FOR THE DOCUMENTATION OF THE STRENGHNENING EFFECTS OF FULL WELD OVERLAY PIPE.

A.2.1 The additional requirement AR SE allows the consideration of the structural contribution of the CRA layer of full weld overlay clad pipe or pipeline and riser design, considering the limitations and limit states stated in the DNVGL Report for JIP Lined and Clad Pipeline Materials, Phase 4 – Guideline for Design and Construction of Lined and Clad Pipelines [10].

A.2.2 **[C.6.4.12 and 6.4.14] Modification** - All-weld tensile testing and Charpy-V-notch testing shall be performed.

A.2.3 **[B.2.4.13 and C.6.4.15] Addition** - In order to obtain CVN specimens to test the weld overlay as per table C-5 of [1], the CVN notch position shall be parallel to the surface, in the areas described at note 4 of this table. Additional weld overlay deposition may be necessary in order to obtain the necessary specimen length (55 mm) and the notch at the right position.

A.2.4 **[C.6.4.15] Addition** - Testing temperature shall be in accordance with item 7.8.1, Table 5 of API STD 2RD [3].

A.2.5 **[C.6.4.16] Addition** - The average and single Charpy V-notch toughness at each position shall not be less than specified for the base material (90J as average value and 80J as minimum individual value). Charpy V-notch testing shall exhibit a minimum of 50 % shear fracture appearance at the specified temperature.

Besides the acceptance criteria stated herein regarding the minimum and average absorbed energy, the shear area of each specimen extracted from backing steel (FL+5mm) shall not be lower than 85%, at tests executed at the impact testing temperature, as per item 7.8.1, Table 5 of API STD 2RD [3].

NOTE: The additional criterion reflects the criticism related to the establishment of the energy as a sole acceptance criterion for Charpy V notch testing. In the recent years, new materials and refined manufacturing processes could manufacture steels with high impact energies on charpy V notch testing, even in temperatures near the lower shelf of the ductile - brittle transition curve. In other words, the line pipe material could present a brittle behavior even if the impact energy is high.

Besides, there are several questions about the validity of CVN in the necessity to guarantee the occurrence of ductile behavior in case of fracture. The establishment of a minimum shear area aims to take advantage of the knowledge developed during drop weight tear testing development. See the article of Coshaw et al Journal of Pipeline Engineering – June 2010 Vol9, no 2.

APPENDIX B – ADDITIONAL INFORMATION TO ALLOW FULL WELD OVERLAY CLAD PIPE SUPPLY:

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

Type and quantity data:

- Clad pipe diameter;
- Total nominal thickness;
- CRA nominal thickness;
- Backing steel nominal thickness;
- Specified Minimum Yield Strength of Backing steel and CRA layer;
- 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 SE;

Process:

- Minimum design temperature;

Commercial:

- Delivery point;

Third Party Inspection:

- Third party inspection coverage (if applicable);