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	CLIENT: <b>PETROBRAS</b>				SHEET: <b>1 of 15</b>		
	JOB: <b>GENERAL</b>				CC:		
	AREA: <b>RIGID SUBMARINE PIPELINES</b>				PROJECT:		
DDP		TITLE: <b>CARBON STEEL BENDS MANUFACTURING REQUIREMENTS</b>				 <b>EDR</b>	



**INDEX OF REVISIONS**

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0	ORIGINAL EMISSION
A	<b>REVISION OF ITEMS 1.1, 3.1, 3.2, 3.4, 5.1.2, 5.1.15, TABLE 5-1, 6.2, 6.4, 8.3, 8.4, 8.5, 8.6</b>

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THIS FORM IS PART OF PETROBRAS' N-381 REV. M.

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## 1. INTRODUCTION

### 1.1. BEND MANUFACTURING SCOPE

This Technical Specification sets forth the technical requirements for fabricating, inspecting, testing, finishing, marking and shipment of special long radius Carbon steel bends **made from SMLS mother pipes.**

Bends fabricated according to this Technical Specification shall be in compliance with DNVGL-ST-F101 – October 2017. This document shall be read in conjunction with section 8 of DNVGL-ST-F101 and **ISO 15590-1:2018**. All additional and modified requirements to DNVGL-ST-F101 are mentioned in this technical specification. DNVGL-ST-F101 clause numbers are given in “[square brackets]” and ISO 15590-1 clause numbers are given in “/traces/”.

The scope of supply includes the provision of all materials, services and activities necessary for manufacturing, storage and delivery of Carbon steel induction bends.

### 1.2 - VERBAL FORMS, TERMS AND ABBREVIATIONS

**[1.8.1 Table 1-7 Section 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.



**[1.8.2 Table 1-8 Section 1] Addition** - The following terms are applied in this document:

**CONTRACTOR** – A party contractually appointed by PETROBRAS to fulfil all, or any of, the activities associated with Bend manufacturing

**PETROBRAS** - Including its employees, inspectors, and other representatives.

**[1.8.3 Table 1-9 Section 1] Addition** - The following abbreviations are also applied:

ABNT	<i>Associação Brasileira de Normas Técnicas</i>
CLR	<i>Crack Length Ratio</i>
CMTR	<b><i>Certificated Material Test Report</i></b>
CSR	<i>CSR Crack Sensitivity Ratio</i>
CTR	<i>CTR Crack Thickness Ratio</i>
DPT	<i>Dye Penetrant Test</i>
MDB	<i>Material Data Book</i>
OD	<i>Outside Diameter</i>
PCM	<i>Critical Metal Parameter</i>
QMS	<i>Quality Management System</i>
WT	<i>Wall Thickness</i>

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## 2. REFERENCES

### 2.1 GENERAL

The governing design code for this specification shall be DNVGL-ST-F101 with additional and modified requirements to ISO 15590-1. The requirements of this reference shall apply unless otherwise stated in this specification.

The relevant codes, standards and specifications are listed in section 2.1.1. shall be taken to mean the latest edition including addenda, supplements, or revisions applicable at the date of contract.

2.1.1. **[1.7 Section 1] Addition** - The following references shall also be considered:

[1] ISO 13628-15	Petroleum and natural gas industries — design and operation of subsea production systems — part 15: Subsea Structures and Manifolds
[2] ABNT NBR 15273	Petroleum and natural gas industries – induction bends for pipeline transportation systems
[3] I-ET-0000.00-0000-211-P9U-003	Seamless Mother Pipes Requirements
[4] BS EN ISO/IEC 17024 (July 2012)	Conformity assessment – general requirements for bodies operating certification of persons
[5] ASTM E92-17	Standard Test Methods for Vickers Hardness and Knoop Hardness of Metallic Materials
[6] ASTM G-39	Standard practice for preparation and use of bend beam stress corrosion test specimens

## 3. GENERAL REQUIREMENTS



### 3.1. PURPOSE AND COVERAGE

3.1.1. **/1/ Modification** - The purpose of this specification is to provide supplementary requirements for supply **IB 450-PSL2 induction bends. Minimum bend radius will be defined in the Material Requirements document, issued for each specific project.**

3.2. **[1.7.1 Section 1] Modification** - Where there is a conflict between the requirements of this specification, the Pipeline Project Design Basis and the referenced DNVGL, the order of precedence of the documents shall be:

- 1st – **Material Requirements (specific for each pipeline project);**
- 2nd – This Technical Specification;
- 3rd – DNVGL-ST-F101;
- 4th – ISO 15590-1 and ISO 13628-15 [1].

3.2.1. **/9.2/ Addition** - CONTRACTOR shall, at his expense, perform all tests mentioned in this technical specification. SUPPLIER shall consider that unless otherwise written agreed, PETROBRAS will not accept historical data in order to waive tests or acceptance criteria. PETROBRAS representatives shall witness all qualification testing activities carried out in SUPPLIERS laboratories and yard.



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### 3.3. MOTHER PIPE REQUIREMENTS

- 3.3.1. **[8.2.3.2 Section 8] Addition** – SUPPLIER shall perform metallurgical design of mother pipe in order to comply with final bends required mechanical properties.
- 3.3.2. **[8.2.3.2 Section 8] Modification** – Mother pipes shall withstand requirements as per the following PETROBRAS specification - Seamless (SMLS) Pipes Requirements [3].
- 3.3.3. **[8.2.3.2 and table 8-2 Section 8] Modification** - The chemical composition of C-Mn mother pipe, shall be in agreement with the following maximum values (in weight %): C - 0.16 %, Mn - 1.65%, S - 0.002%, P – 0.015%, Mo - 0.35%, Al - 0.06 %, N – 0.008%, Ti - 0.05%, Nb - 0.05% and V - 0.08%. The maximum carbon equivalent (CE) of quenched and tempered or normalized C-Mn steel mother pipe (delivery condition N or Q, respectively) shall be 0.43 for DNV 450 SMLS and 0.44 for DNV 485 SMLS.
- 3.3.4. **[8.2.3.2 Section 8] Addition** - All heats for the mother pipes backing steel shall meet the following requirements when compared with ones supplied for MPQT: the C content shall not be increased by more than 0.02% and the CE values shall not be increased by more than 0.02 or the Pcm values shall not be increased by more than 0.02.
- 3.3.5. **[8.2.3.2 Section 8] Addition** – SUPPLIER shall select mother pipe carbon steel WT in order to respect minimum WT on each point of the bend.
- 3.3.6. **[8.2.3.2 Section 8] Addition** – Mother pipe shall be supplied as bare condition.
- 3.3.7. **[8.2.3.2 Section 8] Addition** – All mother pipes for the same OD bend group shall be manufactured from the same SUPPLIER. Multi-sourcing of backing steel is not recommended since this is considered an essential variable. Mother pipes for WPQT rings shall be heat treated in the same heat treatment batch of production bends.

### 3.4. INDUCTION BENDING PROCESS

- 3.4.1. **[8.2.3 Section 8] Addition** – The forming (bending) temperature shall be continuously monitored and recorded with, at least, 2 (two) pyrometers located at extrados and intrados to ensure that the temperature difference between readings is not higher than 50°C in the hot bent area. An additional manual pyrometer may also be used to measure the temperature at the neutral line on each 5° during forming.
- 3.4.2. **[8.2.3.7 Section 8] Addition** – The following items shall be considered as additional essential variables to the ones given in /table 1/:
- ✓ Any change in mother pipe supplier and in the heat treatment conditions on mother pipe before induction bending;
  - ✓ Any change in bend radius.

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3.4.3. **/9.3/ Addition** - Pipe bending shall be carried out by induction bending process. The following additional requirements shall apply:

- ✓ Mother pipe shall be circumferentially heated at the point of bending in a continuous heating cycle without stops and starts.
- ✓ Attachment of braces or other restraints utilized to prevent warping of bends shall not be welded to the body of the bend.
- ✓ Mother pipe shall not come into contact with non-ferrous metals while hot.
- ✓ Prior to bending, mother pipes shall be visually inspected in order to be free of scale, dirt and other foreign materials, if necessary they may be externally blast cleaned in accordance with ISO 8501-1 (Sa 2 1/2). The cleaned pipe surfaces shall be protected from moisture, oil and rust.

### 3.5. POST BENDING HEAT TREATMENT



3.5.1. **/9.4/ Modification** – All bends shall be subjected to a quenching plus tempering post bending heat treatment after completion of the bending process in order to achieve the required mechanical and corrosion properties.

3.5.2. **/9.4/ Addition and [8.4.5 Section 8] Modification** – All heat treatment facilities shall be equipped so that the temperatures of at least three locations can be read and continuously recorded. Thermocouples shall also be attached to intrados and transition zone extrados. All these selected locations shall be clearly defined in the MPS in order to check the hottest and coldest parts of the furnace, as indicated by a current furnace survey. The accuracy of the temperature measurement shall be demonstrated during MPQT.

3.5.3. **[8.2.3.8 Section 8] Addition** – Heat treatment shall be fully traceable.

3.5.4. **[8.4.5 Section 8] Addition** – The following requirements shall apply for post bending heat treatment:

- ✓ For tempering operation, minimum allowable temperature shall be 540°C;
- ✓ For each heat-treatment batch, a sketch indicating piece numbers and their relative position inside the furnace shall be issued. This document shall be part of the final manufacturing data book;
- ✓ Stacking of pieces is not permitted. A minimum distance of 50mm between each piece shall be ensured;
- ✓ Temperature to be controlled at  $\pm 10^{\circ}\text{C}$ ;
- ✓ Time required for moving the component from the furnace to the quench tank shall not be higher than 60s.

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### 3.6. INFORMATION TO BE SUPPLIED BY PETROBRAS

3.6.1. In order to comply with ISO 15590-1 requirements, PETROBRAS shall provide the following information at the specific project documentation.

- ✓ Minimum and maximum design temperatures;
- ✓ Minimum wall thickness after bending;
- ✓ Charpy impact temperature;
- ✓ Hold points for witness and for PETROBRAS approval will be available in PETROBRAS comments on SUPPLIERS ITP.

## 4. MANUFACTURING PROCEDURES AND QUALIFICATION

### 4.1. GENERAL REQUIREMENTS

4.1.1. **/9.2 and 10.1/ Modification** – MPS shall be provided and qualified by contractor, and approved by PETROBRAS prior to commencement of production bending. The following requirements shall apply:

- ✓ Contractor shall submit a specific MPS and ITP according to item 8.2.3 of DNVGL-ST-F101 and annex A of ISO 15590-1 for PETROBRAS validation;
- ✓ SUPPLIER's proposed bend fabrication procedure shall include all operations, in the correct sequence, together with the operating parameters for each pipe bend group.

4.1.2. **[8.2.3.7 Section 8] Addition** – A change in any of the variables of contractor's bend fabrication procedure shall require a full re-qualification of the procedure.

### 4.2. MANUFACTURING PROCEDURE QUALIFICATION TESTING

**/9.2/ Addition** – One MPQT bend shall be selected from the pipe bend group(s) for test bending. MPQT shall be made on finished test bend of a 90° bend angle. The completed test bends shall meet the mechanical properties and dimensional tolerances specified herein. Once the bend fabrication procedure has been qualified and accepted by Petrobras, it shall be adhered to in all respects in the fabrication of all production bends.

### 4.3. RETESTING

4.3.1. If a test sample of either mechanical or corrosion test fails to meet the specified requirements, two further samples shall be extracted, prepared and tested. All samples shall meet the specified requirements.

4.3.2. In case of failure of any retest, the causes shall be investigated and analyzed; corrective actions shall be proposed to PETROBRAS representative. After approval of corrective actions, a new qualification test bend shall be executed.



## 5. MECHANICAL PROPERTIES AND ASSOCIATED TEST REQUIREMENTS

### 5.1. QUALIFICATION TESTING

- 5.1.1. **/10.2.1/ Modification** – One MPQT bend shall be selected from the pipe bend group(s) for test bending.
- 5.1.2. **/10.2.1/ Addition** – At least one finished test bend per bending manufacturing procedure shall be tested for qualification. Table 5-1 defines which tests are applicable for MPQT and production. **During production, a validation of the requirements shall be performed by testing the prolongation test pieces obtained from each test unit, defined by each heat treatment batch.**
- 5.1.3. **/Table 2/ Modification** – Acceptance criteria for chemical composition, tensile and impact test shall be according to requirements defined in item 5.1 of this technical specification.
- 5.1.4. **/Table 2/ Addition** – HIC tests and SSC tests shall be carried out on Qualification Test Bend, as per requirements of ISO 15590-1 annex B. HIC/SSC tests can be carried out in alternative solution. These requirements are summarized in table 5-3.
- 5.1.5. **/Table 3/ Modification** - The number, type and location of tests shall comply with ISO 15590-1, table 2 and figure 1. Additional requirements defined in table 5-2 of this specification shall also be a herein.

**Table 5-1 – MPQT and production testing of bends**

Test		MPQT	Production
Chemical Analysis	Chemical Composition	X	X
Physical Tests	Tensile	X	X
	Impact	X	X
	Through-thickness hardness	X	X
	Surface Hardness	X	X
	Metallographic examination	X	X
	HIC and SSC	X	N.A.
	CTOD	N.A.	N.A.
NDT	Visual Inspection	X	X
	Bend Ends (UT and MT)	X	X
	Bend Body (UT, MT and/or PT)	X	X
	Thickness verification	X	X
	Residual magnetism	X	X

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- 5.1.6. **/10.4.2.2/ Modification** - Tensile testing at ambient temperature shall be carried out in accordance with ASTM A370-17a. Tensile properties shall be in accordance with table H.2 Annex H ISO 3183.
- 5.1.7. **/10.4.3.1/ Modification** - Charpy V-notch test pieces shall be prepared and tested in accordance with ASTM A370-17a. Testing of Charpy V-notch impact properties shall be performed on transverse test specimens 10 x 10mm. Sub-size samples may be allowed after PETROBRAS written approval.
- 5.1.8. **/10.4.3.3/ and [8.2.3.10 Section 8] Modification** - Test absorbed energy levels shall be minimum 73J for average value for 3 specimens and 55J for a single value, based on full size specimens. The CVN test temperature shall be informed in the Design Basis.
- 5.1.9. **/10.4.4.1/ Modification** - Through-thickness hardness testing shall be performed with the Vickers method in accordance with ASTM E92-17 [5].
- 5.1.10. **/10.4.4.2 and B.4.5.2/ Modification** - The hardness levels shall not be greater than 250 HV10.
- 5.1.11. **/10.4.5.1/ Modification** – Three surface hardness readings using portable equipment shall be performed in each quadrant for each position stated in table 5-2.
- 5.1.12. **/10.4.5.2 and B.4.5.2/ Modification** – Surface hardness may also be reported as HRC, respecting the limit of 22 HRC.
- 5.1.13. **/10.4.6.1/ Addition** – The micrographic examination shall be made at a distance of 2,0 mm from the external and internal surfaces and at a mid-wall position.





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**Table 5-2 – Location of test pieces and type of test for destructive testing of bends**

Location	Test
Tangent side A	Tensile CVN Impact Through-thickness hardness Metallographic examination
Transition zone side A	Tensile CVN Impact Through-thickness hardness Surface hardness Metallographic examination
Bend extrados	Tensile CVN Impact CVN Impact at mid thickness Through-thickness hardness Surface hardness HIC and SSC
Bend intrados	Tensile CVN Impact CVN Impact at mid thickness Through-thickness hardness Surface hardness Metallographic examination
Transition zone side B	Tensile CVN Impact Through-thickness hardness Surface hardness Metallographic examination
Tangent side B	Tensile CVN Impact Through-thickness hardness Metallographic examination

**Table 5-3 – Requirements for HIC and SSC testing of bends**

Corrosion Test	Methodology	Solution	Acceptance criteria
HIC	NACE TM 0284	B of NACE TM 0177	CLR<15% CTR<5% CSR<2%
SSC	Four point bend test ISO 7539-2 or ASTM G-39 [6]	B of NACE TM 0284	No cracks (10x magnification)

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## 5.2 PRODUCTION TESTING

- 5.1.14. **/9.3 / Modification** - Induction bending shall be carried out in accordance with qualified MPS and ITP.
- 5.1.15. **/10.2.2/ Modification** - The extent of testing and inspection that shall be performed during production is specified in Table 5-1 of this specification, including the prolongation test pieces obtained from each test unit.
- 5.1.16. **/10.2.2/ Addition** - MDB shall be submitted to PETROBRAS approval including all reports and documents stated in clause 14 of this specification.

## 6. DIMENSIONAL REQUIREMENTS

### 6.1. INTERNAL DIAMETER



- 6.1.1. **/10.6/ and [8.2.3.14 Section 8] Addition** - The diameter at both extremities may be verified by caliper rule.
- 6.1.2. **/10.7/ and [8.2.3.15 Section 8] Modification** - Conformity to specified minimum internal diameter shall be shown by passing of gauge consisting of two gauge plates with a diameter of 95% of the largest nominal inner diameter, or 97% of the minimum inner diameter of the largest nominal inner diameter. The gauge plates shall be rigidly fixed at a distance of 1.5 x ID. Each production bend shall be submitted to a drift test using a pig equipped with the two gauge plates described above.

### 6.2. WALL THICKNESS

- 6.2.1. /10.6/ Modification** - Wall thickness measurements shall be made by ultrasonic methods, in accordance with ASTM E797-15, in at least 3 readings per quadrant for each location stated in table 5-2. The minimum wall thickness after bending shall be as per Material Requirements for each specific project.

### 6.3. OUT-OF-ROUNDNESS

- 6.3.1. **/10.6/ and [8.2.3.14 Section 8] Modification** - Out-of-roundness in bend body measured at intervals of one pipe outside diameter along the bend length shall be within  $\pm 2,5 \%$  of the nominal outside diameter. Inside diameter Out-of-roundness over a length of 100mm (4") from each end, measured internally shall not exceed  $\pm 1,5 \%$  of the nominal internal diameter.

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#### 6.4. BEND **OUT OF PLANE**

6.4.1. **/10.6/ and /Table 4/ Addition** - The bend out of plane tolerance shall be 10 mm maximum for 90 degrees and 5 mm maximum for bends less than 90 degrees.

#### 6.5. TANGENT LENGTH

6.5.1. **/10.6/ Addition** - The minimum tangent length on both ends shall be a minimum of 300 mm, for the bends with angles larger than 20 degrees.

#### 6.6. BEND LENGTH

6.6.1. **/10.6/ Addition** - The overall bend length including tangents shall be  $\pm 50$  mm of the intended length.

### 7. HYDROSTATIC TESTING

7.1.1. **/10.8/ and [8.7 Section 8] Addition** - Hydrostatic testing shall be carried out prior to final inspection on each production bend. If 100% of mother pipes have been hydrostatically tested at the pipe mill, Hydrostatic testing may be performed on one bend of each group of production bends.

7.1.2. **/10.8/ and [8.7 Section 8] Addition** - Induction bends that fail hydrostatic testing shall be rejected and the rest of the bends in that group shall be hydrotested. A full investigation shall be undertaken to determine the failure mechanism. CONTRACTOR shall propose a new bending procedure for PETROBRAS approval, if required.

### 8. NON-DESTRUCTIVE TESTING



#### 8.1. GENERAL

8.1.1. **/10.5/ Modification** - After final heat treatment and prior to visual or other non-destructive inspection, the entire outside surface of all bends shall be cleaned to a cleanliness grade of ISO 8501-1 (Sa 2 ½).

8.1.2. **/10.5/ Addition** - Each production bend shall be inspected by non-destructive testing (NDT) in accordance with the NDT testing requirements and acceptance criteria contained in Appendix D of DNVGL-ST-F101. CONTRACTOR shall submit NDT procedures to PETROBRAS for approval.

#### 8.2. VISUAL INSPECTION

8.2.1. **/10.5.1/ Modification** - After the bends have been fabricated the entire length of each bend shall be 100% internally and externally visually inspected for surface defects in accordance with ISO 3183.

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### 8.3. INSPECTION OF BEND ENDS

- 8.3.1. **/10.5.4 and B.7.1 / Modification** - Ultrasonic inspection for laminar imperfections in accordance with ISO 10893-8 (automated/semi-automated system) shall be performed around the entire circumference of the bend ends over a minimum distance of 100 mm from the bend end.
- 8.3.2. **[8.2.3.13 Section 8] Addition** – Acceptance criteria of UT for laminar imperfections shall be as per table D-12 of DNVGL-ST-F101.
- 8.3.3. **/10.5.4/ Modification** - For all bends, the bend ends shall be inspected by MT in accordance with ISO 10893-5 or PT in accordance with ISO 10893-4. Acceptance criteria for laminar imperfections shall be as per item 7.2 of ISO 10893-5, i.e. not greater than 6mm in circumference.

### 8.4. INSPECTION OF BEND BODY



- 8.4.1. **/10.5.5/ Modification** - For all bends, the bend body shall be inspected over an arc of 180°, 90° each side of the extrados by MT in accordance with ISO 10893-5 or PT in accordance with ISO 10893-4. Acceptance level shall be M2 of table 2 of ISO 10893-5.
- 8.4.2. **[8.2.3.13 Section 8] Addition** – Acceptance criteria of UT for laminar imperfections on bend body shall be as per table D-12 of DNVGL-ST-F101.
- 8.4.3. **/10.5.6/ Modification** - For all bends, for longitudinal and transverse surface imperfections the bend body shall be inspected over an arc of 180°, 90° each side of the extrados by UT in accordance with ISO 10893-10 (automated/semi-automated system) or in accordance with annex B (manual methods). Acceptance level shall be U2/C.

### 8.5. RESIDUAL MAGNETISM

- 8.5.1. **/10.5.7/ Modification** - Bends with residual magnetism greater than 20 gauss shall be demagnetized. Residual magnetism shall be measured at each pipe bend end.

### 8.6. SURFACE DEFECTS

- 8.6.1. **/10.5.8/ Addition** - The entire external and internal surfaces of the bends shall be visually inspected. The surface shall be free from defects, which may be injurious for the intended services. Bends shall be free of corrugations and indentations on the tangents caused by grips of the bending machine. No repair by welding shall be permitted on any part of the bend. Local buckles (kinks) in the bend are not permitted.
- 8.6.2. **/10.5.8/ Addition** - Local deviations from the original contour of the pipe shall not exceed 5% of the specified nominal wall thickness, nor shall they extend in any direction greater than 25% of the pipe outside diameter. If item is not followed, pipe bend shall be rejected. Depth of defects less than 5% of the specified nominal wall thickness (minor defects) may

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be removed by grinding provided the remaining wall thickness is within the specified limits and there is a smooth transition between the ground area and original contour. All repair areas shall be submitted to MT.

## 9. INSPECTION ON SUPPLIER'S YARD

### 9.1. ACCESS

SUPPLIER shall provide PETROBRAS' and CONTRACTOR's representatives free access to all areas of SUPPLIER's works when work is being performed concerning this Specification.

CONTRACTOR shall notify PETROBRAS of time and location of qualification testing, bend fabrication, heat treatment, and final inspection at least 40 days before the event. All documentation related to MPQT shall be approved by PETROBRAS before starting activities.

### 9.2. INSPECTION DOCUMENTS

9.2.1. **/11/ Addition** - The following inspection documents, as applicable, shall be presented to PETROBRAS for review at the time of inspection:

- ✓ Bending procedure and temperature control methods;
- ✓ Heat treatment procedures, charts and certificates;
- ✓ Ultrasonic testing procedures for qualification and production;
- ✓ Dimensional check forms for qualification and production bends;
- ✓ Qualification test forms (Mechanical and corrosion);

### 9.3. INSPECTION LABEL

Inspection Label shall be put on each bend.

After coating application traceability shall be kept.



## 10. FINISHING AND REPAIRS

### 10.1. COATING

Bends shall be externally coated according to requirements informed by PETROBRAS on the coating assessment issued for a specific project.

### 10.2. WELDING REPAIRS

Weld repairs to parent pipe metal are not permitted. Weld-on bending aids, but not limited to, braces, brackets and cleats shall not be permitted.

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### 10.3. REJECTED BENDS

Bends that have been rejected by CONTRACTOR or PETROBRAS shall be marked “REJECTED” with the defects noted, and shall be set aside for later disposal.

## 11. MARKING

### 11.1. GENERAL REQUIREMENTS

SUPPLIER shall maintain identification throughout the pipe bending process. If the pipe identification is removed during the heating and bending operations, SUPPLIER shall restore it.

### 11.2. MARKING OF BENDS

Marking of bends shall be performed using white paint stenciling on a clean surface free of loose mill scale, rust, oil, grease and dirt. The stenciled surface shall be spray covered with a clear durable lacquer. Only paint marking shall be done.

Each bend shall be clearly marked by paint stenciling with 20mm letters on the inside and outside surface of the bend at both ends. No steel stamping will be permitted. The paint color shall contrast with the finish bend surface.

The following information shall be applied in English language and metric system:

- ✓ PETROBRAS's Name;
- ✓ Purchase Order number and SUPPLIER's name;
- ✓ Outside diameter and minimum Wall thickness;
- ✓ Material grade and weight;
- ✓ Bend radius and bend angle;
- ✓ Unique sequence number,

Markings shall not overlap and shall start 75mm from the end of each bend.

## 12. HANDLING, PACKAGING AND STORAGE



The CONTRACTOR shall submit procedures for handling, stacking during storage and stacking and securing bends for shipment for approval by the PETROBRAS.

No welding of temporary attachments for handling, stocking, transporting or securing shall be permitted.

All handling, loading and unloading shall be done in such a manner as to minimize mechanical damage and corrosion. Adequate padding shall be provided when loading bends for transport.

Loading onto or into rail cars, lighters, ship or other transportation means shall be done in accordance with ISO 3183 recommendations.

No on-deck overseas shipment is allowed without prior written approval by PETROBRAS.

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### 13. QUALITY ASSURANCE / QUALITY CONTROL

CONTRACTOR's Quality Plan shall include QA, QC, testing and inspection systems necessary to ensure that all requirements of this Specification are satisfied. CONTRACTOR shall ensure that all sub-contractors maintain equivalent QA, QC and inspection systems. Such quality assurance and quality control programs shall follow the requirements of ISO 9001.

### 14. DOCUMENTATION

A CMTR for each lot of bend(s) shall be submitted to PETROBRAS within two weeks of shipment. The CMTR should be on SUPPLIER's letterhead and shall include the following:

1. PETROBRAS inspection release certificate;
2. Certified test certificates;
3. Mother pipe certificates, including:
  - ✓ MPS and ITP;
  - ✓ Mechanical properties and test reports (original pipe);
  - ✓ Dimensional checks and visual examination;
  - ✓ UT reports of pipe body and pipe ends;
4. Bend control sheets, containing the following information:
  - ✓ Purchase order number;
  - ✓ Mechanical properties and test reports (qualification bend tests);
  - ✓ Chemical analysis;
  - ✓ Hardness test reports and Heat treatment records;
  - ✓ Dimensional checks and visual examination;
  - ✓ UT, MP and DPT reports of bend body and pipe ends;
  - ✓ Gauge pig passage report.
5. Quality control sheets, containing the following information:
  - ✓ Technical Queries;
  - ✓ Non-conformance reports.

A complete MDB shall be submitted for PETROBRAS approval with all CMTR for all lots of bends supplied.