

 <b>PETROBRAS</b>	<b>TECHNICAL SPECIFICATION</b>		Nº: <b>I-ET-0000.00-0000-24A-P9U-002</b>				
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	JOB: -		-		-		
	AREA: GENERAL		-		-		
-	TITLE: <b>TIE-IN SPOOL MANUFACTURING</b>		-		EDD/EDR		
<b>INDEX OF REVISIONS</b>							
<b>REV.</b>	<b>DESCRIPTION AND/OR REVISED SHEETS</b>						
0	THIS DOCUMENT SUPERSEDES AND REPLACES DOCUMENT I-ET-0000.00-6500-24A-P9U-002, REV. A.						
A	REVISED ITEMS 2.3, 3.2, 4.6, 4.7, 4.9 AND INCLUDED APPENDIX A.						
B	ITEMS HIGHLIGHTED						
C	GENERAL REVISION						
	REV. 0	REV. A	REV. B	REV. C	REV. D	REV. E	
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## 1 INTRODUCTION

### 1.1 General

1.1.1 This Technical Specification has the objective to establish the scope of work, minimum requirements and deliverables for fabrication and pre-commissioning of tie-in spools, whether DL or DA.

1.1.2 The construction of the Tie-in Spool shall be performed in compliance with Ref [A21] (latest edition), or another edition established in the specific project documentation.

1.1.3 Tie in spool structural design shall be in compliance with Ref. [C1].

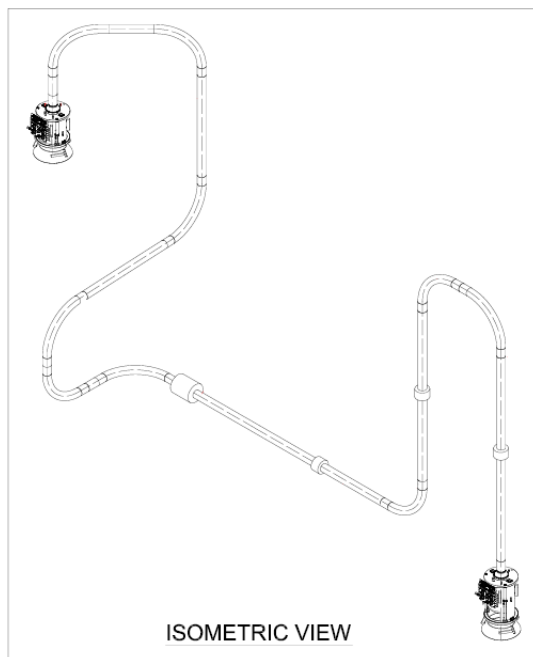


Figure 1: Typical 3-D Diverless (DL) Rigid Spool

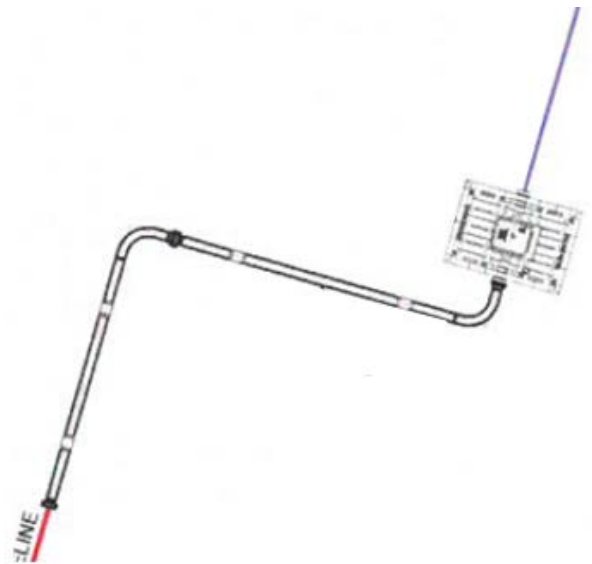



Figure 2: Typical 2-D Diver Assisted (DA) Rigid Spool

## 2 REFERENCES


### 2.1 International Codes

The codes included below shall be adopted in its latest edition, where applicable:

[A1]	AISC 89	MANUAL OF STEEL CONSTRUCTION (ASD)
[A2]	ANSI B31.8	GAS TRANSMISSION AND DISTRIBUTION PIPING SYSTEM
[A3]	API 5LW	RECOMMENDED PRACTICE FOR TRANSPORTATION OF LINEPIPE ON BARGES AND MARINE VESSEL
[A4]	<b>API SPEC 5L</b>	<b>LINE PIPE</b>
[A5]	API SPEC 17D	SPECIFICATION FOR SUBSEA WELLHEAD AND CHRISTMAS TREE EQUIPMENT

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[A6]	API SPEC 6A	SPECIFICATION FOR WELLHEAD AND CHRISTMAS TREE EQUIPMENT
[A7]	ASME B16.5	PIPE FLANGES AND FLANGED FITTINGS
[A8]	ASME B36.10M	WELDED AND SEAMLESS WROUGHT STEEL PIPE
[A9]	ASME IX	BOILER PRESSURE VESSEL CODE, WELDING QUALIFICATION
[A10]	ASME V	BOILER AND PRESSURE VESSEL CODE, NON-DESTRUCTIVE EXAMINATION
[A11]	ASME VIII	BOILER AND PRESSURE VESSEL CODE, RULES FOR CONSTRUCTION OF PRESSURE VESSELS – DIVISION 2 – ALTERNATIVE RULES
[A12]	AWS A 2.4	SYMBOLS FOR WELDING AND NDT
[A13]	AISC 89	MANUAL OF STEEL CONSTRUCTION (ASD)
[A14]	AWS D1.1	STRUCTURAL WELDING CODE-STEEL
[A15]	BS 7910	GUIDE ON METHODS FOR ASSESSING THE ACCEPTABILITY OF FLAWS IN METALLIC STRUCTURES
[A16]	<b>BS EN ISO 15589-2</b>	<b>PETROLEUM, PETROCHEMICAL AND NATURAL GAS INDUSTRIES — CATHODIC PROTECTION OF PIPELINE TRANSPORTATION SYSTEMS - PART 2: OFFSHORE PIPELINES</b>
[A17]	<b>DNV-RP-B204</b>	<b>WELDING OF SUBSEA PRODUCTION SYSTEM EQUIPMENT</b>
[A18]	DNV-RP-C203	FATIGUE DESIGN OF OFFSHORE STEEL STRUCTURES
[A19]	<b>DNV-SE-0474</b>	<b>RISK BASED VERIFICATION</b>
[A20]	DNV-SE-0475	VERIFICATION AND CERTIFICATION OF SUBMARINE PIPELINES
[A21]	<b>DNV-ST-F101</b>	<b>SUBMARINE PIPELINE SYSTEMS</b>
[A22]	<b>DNV-ST-N001</b>	<b>MARINE OPERATIONS AND MARINE WARRANTY</b>
[A23]	GL NOBLE DENTON 0030/ND	GUIDELINES FOR MARINE TRANSPORTATIONS – NDI 0030
[A24]	<b>ISO 3183</b>	<b>PETROLEUM AND NATURAL GAS INDUSTRIES — STEEL PIPE FOR PIPELINE TRANSPORTATION SYSTEMS</b>

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[A25]	ISO 15590 1,2 AND 3	INDUCTION BENDS, FITTINGS AND FLANGES FOR PIPELINES TRANSPORT SYSTEMS
[A26]	ISO 8501 – PART 1	STANDARD PREPARATION OF STEEL SUBSTRATES BEFORE APPLICATION OF PAINTS AND RELATED PRODUCTS - VISUAL ASSESSMENT OF SURFACE CLEANLINESS - PART 1: RUST GRADES AND PREPARATION GRADES OF UNCOATED STEEL SUBSTRATES AFTER OVERALL REMOVAL OF PREVIOUS COATINGS
[A27]	ISO 8502-3	PREPARATION DE STEEL SUBSTRATES BEFORE APPLICATION DE PAINT AND RELATED PRODUCTS - TESTS FOR THE ASSESSMENT DE SURFACE CLEANLINESS
[A28]	ISO 8503-2	STANDARD PREPARATION OF STEEL SUBSTRATES BEFORE APPLICATION
[A29]	ISO 9712	NON-DESTRUCTIVE TESTING – QUALIFICATION AND CERTIFICATION OF PERSONNEL
[A30]	NACE TM 0177	LABORATORY TESTING OF METALS FOR RESISTANCE TO SULFIDE STRESS CRACKING AND STRESS CORROSION CRACKING IN H2S ENVIRONMENTS
[A31]	NACE MR0175/ ISO 15156	SULPHIDE STRESS CRACKING RESISTANT METALLIC MATERIALS FOR OILFIELD EQUIPMENT
[A32]	NACE TM 0284	EVALUATION OF PIPELINE AND PRESSURE VESSEL STEELS FOR RESISTANCE TO HYDROGEN-INDUCED CRACKING
[A33]	NORSOK	STANDARD M-501 - COATING SYSTEM 7B - 450MM TWO-COMPONENT EPOXY COATING SYSTEM.

## 2.2 PETROBRAS and National Standards


[B1]	ABNT NBR 5425	GUIA PARA INSPEÇÃO POR AMOSTRAGEM NO CONTROLE E CERTIFICAÇÃO DE QUALIDADE
[B2]	ABNT NBR 5426	PLANOS DE AMOSTRAGEM E PROCEDIMENTOS NA INSPEÇÃO POR ATRIBUTOS
[B3]	ABNT NBR 5427	GUIA PARA UTILIZAÇÃO DA NORMA ABNT NBR 5426 - PLANOS DE AMOSTRAGEM E PROCEDIMENTOS NA INSPEÇÃO POR ATRIBUTOS
[B4]	NBR NM ISO 9712	ENSAIOS NÃO DESTRUTIVOS — QUALIFICAÇÃO E CERTIFICAÇÃO DE PESSOAL EM END
[B5]	ABNT NBR 10387	ANODOS DE LIGA DE ALUMÍNIO PARA PROTEÇÃO CATÓDICA

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[B6]	<b>ABNT NBR 14725-1</b>	<b>PRODUTOS QUÍMICOS - INFORMAÇÕES SOBRE SEGURANÇA, SAÚDE E MEIO AMBIENTE PARTE 1: TERMINOLOGIA</b>
[B7]	ABNT NBR 15158	LIMPEZA DE SUPERFÍCIE DE AÇO POR COMPOSTOS QUÍMICOS
[B8]	ABNT NBR 15185	INSPEÇÃO VISUAL PARA SERVIÇOS DE PINTURA INDUSTRIAL
[B9]	ABNT NBR 15239	TRATAMENTO DE SUPERFÍCIE DE AÇO COM FERRAMENTAS MANUAIS E MECÂNICAS
[B10]	ABNT NBR 16212	TUBOS - ESTOCAGEM EM ÁREA DESCOBERTA
[B11]	<b>ABNT NBR 16265</b>	<b>INSPEÇÃO DE ANODOS PARA PROTEÇÃO CATÓDICA</b>
[B12]	N-133	SOLDAGEM
[B13]	N-381	EXECUÇÃO DE DESENHO E OUTROS DOCUMENTOS TÉCNICOS EM GERAL
[B14]	<b>N-1591</b>	<b>LIGAS METÁLICAS E METAIS - IDENTIFICAÇÃO ATRAVÉS DE TESTES PELO IMÃ E POR PONTOS</b>
[B15]	N-1597	ENSAIOS NÃO-DESTRUTIVOS - VISUAL
[B16]	N-1710	CODIFICAÇÃO DE DOCUMENTOS TÉCNICOS DE ENGENHARIA
[B17]	N-2344	SEGURANÇA EM TRABALHO DE RADIOGRAFIA INDUSTRIAL

### 2.3 Technical Specifications

[C1]	I-ET-0000.00-0000-24A-P9U-001	RIGID SPOOL STRUCTURAL DESIGN
[C2]	<b>I-ET-0000.00-0000-210-P9U-004</b>	<b>WELDING AND NDT OF SUBMARINE RIGID PIPELINE, RISERS AND PIPELINE COMPONENTS</b>
[C3]	<b>I-ET-0000.00-0000-200-PEK-001</b>	<b>WELDING AND NDT REQUIREMENTS FOR SUBSEA EQUIPMENT PRESSURE-CONTAINING PARTS</b>
[C4]	I-ET-0000.00-0000-970-PSQ-001	PROCEDURE AND PERSONAL QUALIFICATION AND CERTIFICATION
[C5]	I-ET-0000.00-0000-219-P9U-003	CLAD BENDS MANUFACTURING REQUIREMENTS
[C6]	I-ET-0000.00-0000-278-P9U-001	TECHNICAL SPECIFICATION FOR VORTEX SUPPRESSORS - "STRAKES"
[C7]	ET-3000.00-1500-251-PEK-001	FIXADORES EM AÇO BAIXA LIGA DE ALTA RESISTÊNCIA PARA APLICAÇÃO SUBMARINA
[C8]	ET-3000.00-1500-251-PEK-002	RASTREABILIDADE DE FIXADORES DE ALTA RESISTÊNCIA PARA UTILIZAÇÃO SUBMARINA
[C9]	<b>I-ET-0000.00-0000-974-P9U-001</b>	<b>HYDROSTATIC TEST OF SUBSEA PIPELINES AND RISERS</b>

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### 3 DEFINITIONS AND ABBREVIATIONS

#### 3.1 Abbreviations


1	DA	Diver Assisted
2	DL	Diverless
3	<b>FMJ</b>	<b>Fabrication and Measurement Jig</b>
4	FEA	Finite element analysis.
5	FEM	Finite element method.
6	MDP	Maximum Design Pressure
7	<b>MEG</b>	<b>Monoethylene Glycol</b>
8	MPQT	Manufacturing Procedure Qualification Tests
9	SCF	Stress concentration factor.
10	VES	“Válvula Esfera Submarina” (Subsea Isolation Ball Valve).
11	WPQT	Welding Procedure Qualification Tests

#### 3.2 Definitions

The following definitions are used for the purpose of this Technical Specification:

1	CONTRACTOR	The company responsible for procurement of necessary material, fabrication and load out of the Tie-in Spool.  NOTE: When the term “CONTRACTOR” is referred in this technical specification, it refers to the CONTRACTOR responsible for the scope fulfillment
2	<b>Fatigue-sensitive</b>	<b>Minimum total fatigue life (factored by design fatigue factors - DFFs) to be achieved by non fatigue sensitive spool sections shall be greater than 40 times the Design Life, for the operational phase. Fatigue sensitive sections are the sections not classified as non fatigue sensitive.</b>
3	Installation Support Vessel	Support Vessel <u>in charge</u> of the installation of the Tie-in Spool. The Tie-in Spool Installation Support Vessel is also denominated ‘Support Vessel’ throughout this specification.
4	Jig	Dummy structures designed and fabricated to mimic the PLET and BAP hubs.
5	May	A course of action permissible within the limits of this.
6	Must not	Prohibited requirement.
7	Out of roundness	The deviation of the linepipe perimeter from a circle. This can be stated as ovalization (%), or as local out of roundness, e.g. Flattening, (mm).
8	Ovalization	The deviation of the perimeter from a circle. This has the form of an elliptic cross section.
9	Rigid Pipeline	A continuous line of steel linepipes, of any length without frequent branches used for transport fluids.



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10	Shall	Mandatory requirement.
11	Should	Preferred requirement.
12	Spoolpiece	Piping accurately fabricated with sections of rigid linepipes (straight sections and / or bends). The spoolpiece is also denominated 'spool' throughout this specification.
13	<b>THIRD PARTY</b>	<b>Independent company responsible for verification that an activity, a product or a service is in accordance with the specified requirements.</b>
14	<b>Verification</b>	<b>Definition in accordance with [A19].</b>

## 4 SCOPE OF WORK

### 4.1 Inspection

4.1.1 CONTRACTOR shall be responsible for inspecting all material delivered for the project, ensuring that they are free from defects and they are also in compliance with applicable Technical Specifications and Materials Requisitions. CONTRACTOR shall, at its own expenses and responsibility, carry out all necessary inspection and tests and perform what is required to ensure that the material or the equipment is in good conditions and fully capable to be used and applied to the expected function.

4.1.2 CONTRACTOR shall issue a reception inspection report in conformity to Annex A, applicable to all components, equipment and consumables.

### 4.2 Fabrication

4.2.1 The fabrication activity under CONTRACTOR's scope shall comprise, at least, the execution of particular specifications:

4.2.1.1 Specification for spool welding and NDT;

4.2.1.2 Specification for qualification and application of coatings;

4.2.1.3 Specification for MPQT and Manufacturing of bends;

4.2.1.4 Specification for spool general fabrication, including fabrication drawings and procedures;

4.2.1.5 Specification for pre-commissioning;

4.2.1.6 Specification for vortex suppressors.

4.2.2 PETROBRAS reserves the right to witness at any time the manufacturing of any equipment or material required for spool construction as well as the construction of spool itself. CONTRACTOR shall provide full access to PETROBRAS authorized representatives to the manufacturing/fabrication site when required by PETROBRAS.

### 4.3 Verification

#### 4.3.1 General

4.3.1.1 CONTRACTOR shall provide verification for the fabrication and construction activities

and any other activity included in its scope of work. The verification activity shall guarantee the minimum quality specified and expected for the final product.

4.3.1.2 **The THIRD PARTY** shall be selected according to each project specific contractual documents.

4.3.1.3 The definition of **THIRD PARTY** selected shall be declared by CONTRACTOR after contract signature.

**4.3.2 VERIFICATION OF CRITICAL COMPONENTS MANUFACTURING, FABRICATION AND QUALIFICATION**

4.3.2.1 The verification level shall be according to each specific project Master Specification, in accordance with Ref. [A20] (latest revision).

4.3.2.2 The critical components shall be defined by **THIRD PARTY** in accordance with an appropriate risk analysis. However, at least, the following critical components shall be considered for verification purpose, including qualification tests:

- a) Mother pipes for induction bends;
- b) Induction bends;
- c) Non-destructive tests for all girth welds and repairs;
- d) Girth welds and repair welding;
- e) Parent coating, field joint coating and repairs;
- f) Anodes and electrical connection to pipes;
- g) Flanges, studs, bolts and nuts.

Obs: Linepipes, girth welds and forgings shall be considered as “pressure containing components” as defined in **Ref. [A21]**.

4.3.2.2.1 **The THIRD PARTY** shall witness all qualification tests of critical components as well as the samples collection for tests execution. A statement presenting inspector signature shall be released communicating the witness of all tests and their results, fulfilling the acceptance criteria established.


4.3.2.2.2 For the specific cases below, the **THIRD PARTY** shall execute an in-place inspection during all production activities (i.e. in fabrication yard). In these cases, the **THIRD PARTY** shall supervise all production and witness all production tests. The inspectors shall be available during all production period:

- a) Non-destructive tests for all Girth Welds;
- b) Girth welds;
- c) Field joint coatings and repairs qualification and application;
- d) Pre-commissioning activities;
- e) Anode installation;
- f) Jig tests, if any.
- g) Flanges, studs, bolts and nuts fabrication.

In these specific cases, the **THIRD PARTY** inspectors shall be resident in fabrication yard or mill available during these activities. The **THIRD PARTY** inspectors shall witness all of them.

4.3.2.2.3 Based on these requirements, at least, the **THIRD PARTY** shall provide trained, experienced and qualified people for the following inspection activities:

- One representative for welding of Spool Girth Welds;

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- One representative for NDT verification for Girth Welds (in case of AUT checking the validation of the results interpretation made by CONTRACTOR);
- One representative for field joint coating qualification and application;
- One representative for the pre-commissioning activities.

Considering welding and NDT inspection for the activities declared in the bullets above, the **THIRD PARTY** employees shall fulfill at least the requirements presented in Ref. [C4], related to personnel qualification.

NOTE: The presence of **THIRD PARTY** representative does not implicate in the absence of PETROBRAS representative.

4.3.2.2.4 At the end of verification activities, the **THIRD PARTY** shall release a Statement of Compliance, Design Verification Report or similar documentation. The statement or report signed by **THIRD PARTY** shall affirm that the defined product or equipment met the requirements stated by PETROBRAS and applicable standards.

#### 4.3.3 VERIFICATION OF NON-CRITICAL COMPONENTS MANUFACTURING, FABRICATION AND QUALIFICATION

4.3.3.1 For components not defined as “critical” by PETROBRAS or **THIRD PARTY**, CONTRACTOR shall submit for PETROBRAS approval the inspection strategy in order to guarantee the final product will achieve the minimum adequate quality. For non-critical component, the inspection may be executed by a SUBCONTRACTOR other than **THIRD PARTY**.

#### 4.3.4 PRE-COMMISSIONING STATEMENT (“ATESTADO DE PRÉ-COMISSIONAMENTO”)

4.3.4.1 CONTRACTOR shall be responsible for contracting a **THIRD PARTY** in order to release the “Atestado de pré-comissionamento”.

4.3.4.2 **The THIRD PARTY** shall be selected according to each project specific contractual documents.


4.3.4.3 The **THIRD PARTY** shall accomplish all requirements stated in **Art. 18º III from Resolução ANP Nº 52, 2015** and shall issue an “Atestado de Comissionamento” for all sections of the spool, considering the requirements for Pre-Commissioning included in this Technical Specification.

4.3.4.4 CONTRACTOR shall execute any other activity required by **THIRD PARTY** in order to fulfill the requirements of **Art. 18º III from Resolução ANP Nº 52, 2015**, if necessary.

## 5 TECHNICAL REQUIREMENTS FOR FABRICATION OF TIE-IN SPOOL AND MANUFACTURING OF COMPONENTS

### 5.1 General

5.1.1 CONTRACTOR shall consider the technical specifications herein for the provision of material and components under its scope. CONTRACTOR shall be responsible for adopting more conservative criteria or select other materials if the minimum technical specification is considered not adequate for the specific project. In this case, CONTRACTOR shall submit for PETROBRAS approval another material, manufacturing process or test methods for tie-in spool parts.

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5.1.2 CONTRACTOR shall adopt the linepipe steel according to the specific project requirements, considering the transported fluid composition and corrosion allowance thickness.

**5.2 SPECIFICATION FOR TIE-IN SPOOL WELDING AND NDT**

5.2.1 CONTRACTOR shall specify the linepipe girth welding and non-destructive testing (NDT) according to all the requirements of the References [C2] and [C4].

5.2.2 In case of connectors from different suppliers, the WPS qualification for the welding between the pup piece and the connector may be performed in accordance with Ref. [A17]. The additional requirements from ref. [C3] shall also be considered. A qualification plan shall also be presented in the execution phase.

5.2.3 CONTRACTOR shall establish a numbering system in order to keep a traceability of each weld joint. This tracking numbering system shall be adopted in inspection reports and weld maps, making capable to localize each weld in each spool and to keep a complete traceability of production.

5.2.4 GIRTH WELDS ACCEPTANCE CRITERIA

5.2.4.1 ECA-based acceptance criteria is not required. The welds shall be inspected by AUT, the acceptance criteria shall be in compliance with Table E-2 of Ref. [A21]. Alternatively, it is acceptable to replace the AUT with radiography and manual ultrasound as per items D.2.2 and D.2.4 from the APPENDIX D of Ref. [A21], respectively, if it is demonstrated that the welds are not fatigue sensitive (see definitions on section 3.2).

5.2.5 PRODUCTION TESTS

5.2.5.1 Production tests do not need to be executed for tie-in spool.

5.2.6 CORROSION TESTS


5.2.6.1 Whenever corrosion tests are required, according to specific project requirements, resistance to Sulphide Stress Cracking (SSC) and the requirements for resistance to corrosion caused by H<sub>2</sub>S for all pressurized girth welds shall be according to Ref. [C2]. If all the requirements of item 4.2.2 of Ref. [C2] are fulfilled the tie in spool girth welds may be exempted of the performance of the SSC tests. In case Contractor prefer to carry out SSC tests, instead of complying with hardness and other requirements of item 4.2.2 of Ref. [C2], such tests shall be according to table 3 of Ref. [C2] except that SSC specimen dimensions shall be 115 x 15 x 7.5 mm (respectively length x width x depth), The weld excess penetration ("root intact") shall be added to the depth dimension.

5.2.7 OTHER WELDMENTS

5.2.7.1 Attachment welds for anode pads shall comply with Refs. [A14], [B12] and [C4] including procedures and personnel qualifications.

**5.3 SPECIFICATION FOR INDUCTION BENDS - MATERIALS & PROCESSING**

5.3.1 Only seamless pipes will be accepted as mother pipes for bends manufacturing.

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### 5.3.2 MANUFACTURING REQUIREMENTS

- 5.3.2.1 For C-Mn bends, CONTRACTOR shall fulfill the requirements stated in Ref. [A25] with modified and additional requirements stated by Chapter 8 of the Ref. [A21].
- 5.3.2.2 For clad bends, CONTRACTOR shall fulfill the requirements stated in Ref. [C5] with modified and additional requirements stated by Chapter 8 of the Ref. [A21].

### 5.4 SPECIFICATION FOR VORTEX SUPPRESSOR (if applicable)

- 5.4.1 CONTRACTOR shall elaborate a strake vortex suppressor Technical Specification for PETROBRAS approval. The referred specification shall consider, at least, the requirements provided in the Ref. [C6].
- 5.4.2 CONTRACTOR may propose fairings vortex suppressor instead of strake. In this case, the request shall be submitted to PETROBRAS for approval. In this case CONTRACTOR shall elaborate a specific Technical Specification for fairings, informing the minimum requirements desired for each project. This Technical Specification shall be submitted to PETROBRAS approval.

### 5.5 SPECIFICATION FOR PARENT COATING, INDUCTION BEND COATING, FIELD JOINT COATING AND REPAIR IN FJC AND PARENT COATING

- 5.5.1 CONTRACTOR shall execute anticorrosion or insulation coating on pipes, induction bends and on field joints according to specific project coating requirements.
- 5.5.2 Coating repairs (if any) shall be executed according to specific project coating requirements.

### 5.6 SPECIFICATION FOR STUDS, BOLTS AND NUTS

- 5.6.1 The stud bolts and nuts shall be in compliance with Refs. [C7] and [C8].


### 5.7 SPECIFICATION FOR FLANGES

- 5.7.1 Flanged connections shall be designed in accordance with [A5] and [A6].
- 5.7.2 BX rings made by Alloy 625 (UNS N06625) shall be adopted, and shall present maximum hardness of 190 HB.
- 5.7.3 Flange face and groove shall be overlaid with a minimum thickness of 3 mm of Alloy 625 (UNS N06625), shall present minimum hardness of 220 HB, and iron content less than 5% at 0,5 mm from groove / face surface.

### 5.8 SPECIFICATION FOR TIE-IN SPOOL GENERAL FABRICATION

#### 5.8.1 DIMENSIONAL CONTROL

- 5.8.1.1 Dimensional surveys shall be performed on the individual components, fabricated assemblies and the finished assembly.
- 5.8.1.2 The inspection report shall record an as-built dimension against each specified dimension on design detailed drawings.
- 5.8.1.3 Tolerances, errors and accuracies shall be included in the reported dimensions. **The**

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combined fabrication and field metrology errors shall be in compliance with Ref. [C1].

5.8.1.4 The subsea metrology system to be used shall be in accordance with the design requirements.

## 5.8.2 FIT-UP TEST

5.8.2.1 After assembly, the Tie-in Spool shall be fit-up tested according to the results of subsea metrology. Fit-up tests shall be performed with the following objectives:

- a) Simulate subsea measurements and installation activities;
- b) Simulate misalignment of mating hubs to obtain practical limits of misalignment;
- c) Simulate the connection of the Tie-in Spool, by actuating the hydraulic connectors;
- d) Familiarize installation personnel with subsea installation procedures. Under PETROBRAS' discretion, specialized installation personnel shall have free access to fabrication yard in order to witness the fit-up tests.

5.8.2.2 The first fit-up test shall be performed with the JIGs positioned in accordance with the results of the subsea metrology.

5.8.2.3 The second fit-up test shall be performed with the JIGs positioned in accordance with the results of the subsea metrology and considering the accuracy of the metrology system, taking into account the most severe design case from the load case matrix analysis (at least, the most severe metrology accuracies combination design case). The Tie-in Spool shall be hydrotested after connection and external sealing test.

NOTE: The JIGs position on the fit-up tests described shall also take into account the dimensional variation of the Tie-in Spool due to the differential temperature between the yard (fabrication phase) and subsea bottom (installation phase).

5.8.2.4 CONTRACTOR shall demonstrate the soil suitability / soil stiffness during fit-up test and pre-commissioning activities.

5.8.2.5 CONTRACTOR shall submit a detailed fit-up test procedure for PETROBRAS approval.

5.8.2.6 For DL Tie-in Spools, each fit-up test shall comprise spool coupling, connectors locking, proper operation of all hydraulic and mechanical functions. After each connector locking, shall be performed a seal test.


5.8.2.7 For DL Tie-in Spools, photographic records of the softlanding indicator in extended and retracted conditions (before and after retraction) shall be included in the reports.

5.8.2.8 For DL Tie-in Spools, photographic records of connector fingers locking indicator (before and after locking) shall be included in the reports.

## 5.8.3 MARKING

5.8.3.1 The tie-in spool sections shall be permanently marked by an agreed method. The marking shall as a minimum comprise of the following:

- (a) Description (Project and Application);
- (b) Identification Number (i.e. PETROBRAS Purchase Order (PO) number);

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- (c) Material grade;
- (d) Lift Weight;
- (e) Part Number;
- (f) Serial Number.


#### 5.8.4 HANDLING, PACKING AND STORAGE

- 5.8.4.1 The tie-in spool sections shall be handled by nylon ropes, slings or by hand. Hooks and wire ropes shall not be used, apart from at specific pad-eyes provided for this purpose. Lifting or moving operations shall not cause permanent plastic deformation or excessive stress on the assembly. All completed assemblies shall be stored off the ground in a clean dry environment. CONTRACTOR shall provide all the fittings necessary for this task.
- 5.8.4.2 All packaging shall be designed to accommodate safe road, sea freight and offshore transportation, handling and lifting. During transportation, handling, loading and storage, the tie-in spool sections shall be fully protected from damage. In order to prevent the ingress of debris and other forms of contamination, and to provide protection, each section end shall be fitted with a protective cover.
- 5.8.4.3 All bare steel surfaces shall be coated with a corrosion protection coating that can be removed by solvent cleaning prior to final corrosion coating or service. CONTRACTOR shall propose a suitable system for PETROBRAS approval. All coated pipes and parts shall be stored protected against sun light exposition.

#### 5.9 PRE-COMMISSIONING PROCEDURE

##### 5.9.1 GENERAL

- 5.9.1.1 Pre-commissioning activities can be performed on each individual flanged section of tie-in spool (including hydrostatic test).
- 5.9.1.2 The pre-commissioning activities of tie-in spool comprise cleaning and caliper inspection, treated water filling, pressure test, dewatering and MEG and MEG gel filling (MEG / MEG gel filling if requested in the specific project contractual documents).
- 5.9.1.3 CONTRACTOR shall issue a procedure for pre-commissioning of tie-in spool. The procedure for pre-commissioning shall include the description of the methodology to be used to perform the caliper inspection, treated water filling, pressure test, dewatering and MEG gel filling (MEG filling if requested in the specific project contractual documents).
- 5.9.1.4 The pressure test of the spools shall be performed in the fabrication yard, prior to shipping.
- 5.9.1.5 CONTRACTOR shall provide all material required for the pre-commissioning activities.
- 5.9.1.6 Pre-commissioning activities shall be included in the "Commissioning Statement", item 4.3.4.

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## 5.9.2 CLEANING AND CALIPER INSPECTION

5.9.2.1 CONTRACTOR shall perform the cleaning and caliper inspection of tie-in spool, consisting of running a train composed, at least, of 1 (one) brush pig and 1 (one) gauge pig, before the pre-commissioning procedure. The cleaning and caliper inspection shall be in compliance with the requirements of Ref. [A21], latest edition (or another edition established in the specific project documentation).

NOTE: for spools with **internal coating or CRA layer**, brush pigs shall be made of nylon or any other material that do not damage the **coating or the CRA layer**. Material shall be submitted by CONTRACTOR to PETROBRAS.

5.9.2.2 The cleaning and caliper inspection shall be performed before the pressure tests specified in the Section **5.9.3**.

5.9.2.3 Pig velocity shall be controlled between minimum 0,1 m/s and 0,5 m/s throughout the entire duration of the pigging run.

5.9.2.4 During the pumping operations, should any abnormal pressures be encountered, then the time, pressure seen and approximate pig position shall be logged.

5.9.2.5 During the pumping operations the following parameters will be recorded at 1 minute-interval:

- Instantaneous and cumulative volumes of water pumped;
- Length of assembly filled;
- Pumping pressure;
- Ambient temperature and water temperature.


5.9.2.6 Gauge plate diameter shall be according to Ref. [A21]. CONTRACTOR shall calculate the gauge plate diameter and provide to PETROBRAS for approval. CONTRACTOR shall take into account the pipeline tolerances and the internal diameters of induction bends and spools accessories if any.

5.9.2.7 Design to be provided by CONTRACTOR for PETROBRAS review. Minimum requirements to be followed:

- a) the gauging plate shall be assembled on a bidirectional disk pig;
- b) the gauging plate shall be made of aluminum, with at least eight radial cuts and the minimum thickness below:
  - 1/8" for pipes with diameter < 6";
  - 1/4" for pipes with diameter > 6";
- c) gauge plate is acceptable if no deflection of the plate is observed;

5.9.2.8 On completion of the pigging-operation, the pig(s) shall be removed for inspection and pictures taken from the gauge-plate. There shall be a minimum of 1 (one) run for the pig-train for each jumper.



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### 5.9.3 PRESSURE TEST

- 5.9.3.1 The tie-in spool shall be pressure tested (hydrotested) in compliance with Ref. [A21], latest edition (or another edition established in the specific project documentation).
- 5.9.3.2 Test pressure shall be calculated according to specific project design pressure for the system.
- 5.9.3.3 The pressure test shall comprise the following stages: pressurization, stabilization, hold **period** and depressurization. The hold period shall be of at least **8** hours. The pressure test shall be chart and digital recorded and shall clearly show all stages of the cycle.
- 5.9.3.4 CONTRACTOR shall provide all necessary temporary fixings and equipment as required to complete the work, including the equipment to seal the connectors at the JIGs. In addition, CONTRACTOR shall provide the equipment and structures required for safe and reliable displacement testing.
- 5.9.3.5 The test is acceptable if the system is free from leaks and **if the pressure profile over the test hold period shows a clear convergence to a fixed value above 99% of the specified test pressure. This may required an extension of the holding time.**
- 5.9.3.6 Temperature monitoring **of the water used in the hydrotest** shall be performed continuously with the use of thermocouple **which shall be** connected to a data acquisition system. Pressure shall be monitored continuously by pressure transducers connected to data acquisition system.
- 5.9.3.7 **The instrumentation requirements shall be in compliance with section 8.7.2 of Ref. [A21].**
- 5.9.3.8 CONTRACTOR shall submit a detailed hydrotest procedure to be approved by PETROBRAS before pressure test start.

### 5.9.4 LEAK TEST

- 5.9.4.1 For flanged connections to be assembled after hydrotest, a leak test with N<sub>2</sub> shall be performed by means of a test port connected to the groove of the flange (refer to figure 3 below for a tipycal test port).

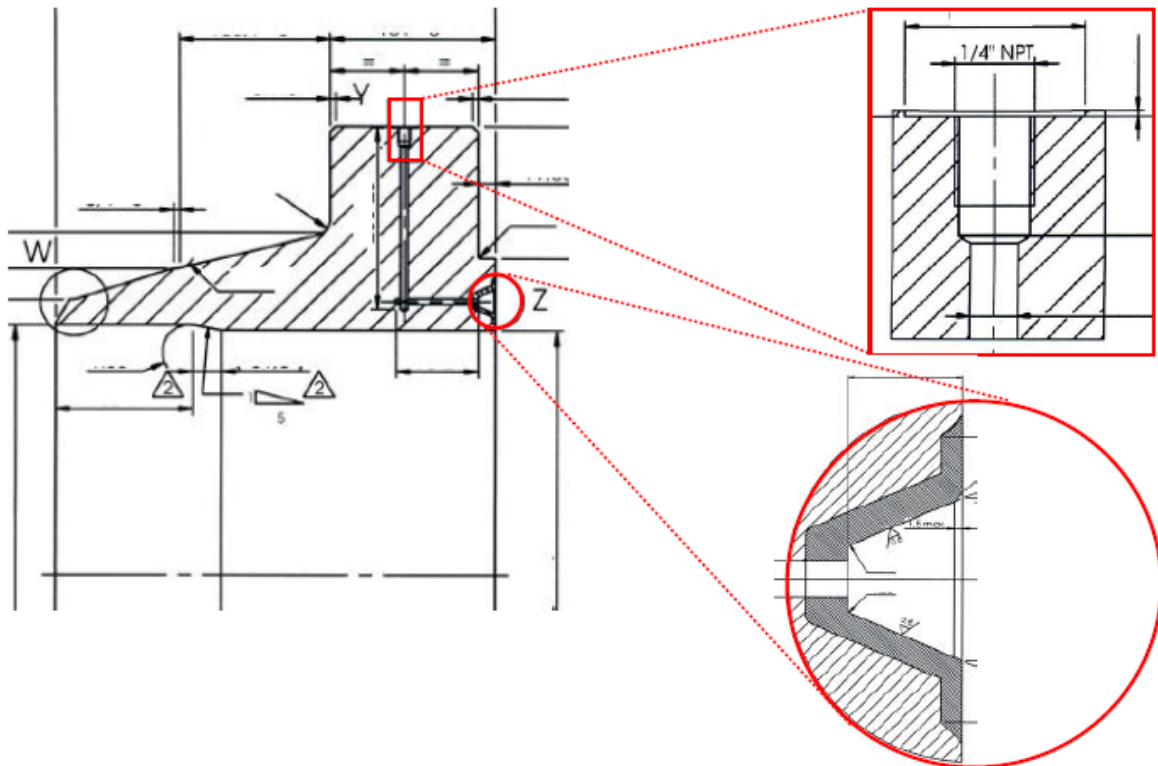


Figure 3: Typical N<sub>2</sub> test port on flanged connection

5.9.4.2 Pressure test shall be done with N<sub>2</sub> at the same pressure defined for the project hydrotest. Test to be executed during 15 minutes and acceptance criteria is a negative pressure variation of 0.5%.

### 5.9.5 DEWATERING

5.9.5.1 The dewatering operation consists of, at least, the complete removal of water within the spool by pigging to permit a safe MEG gel filling operation (MEG / MEG gel filling if requested in the specific project contractual documents).

### 5.9.6 MEG GEL FILLING

5.9.6.1 The spool sections shall be entirely filled with MEG to suppress the potential for hydrate formation after the dewatering operation, if requested in the specific project contractual documents. However, for gas export pipelines the MEG gel filling is mandatory.

5.9.6.2 If requested in the specific project contractual documents, spools to be installed in vertical position shall be filled with a batch of liquid MEG packed by MEG gel at the ends or at the vertical legs of spool, in case of diverless jumpers to maintain the tie-in spool entirely filled throughout the installation phase. Refer to Figure 4.

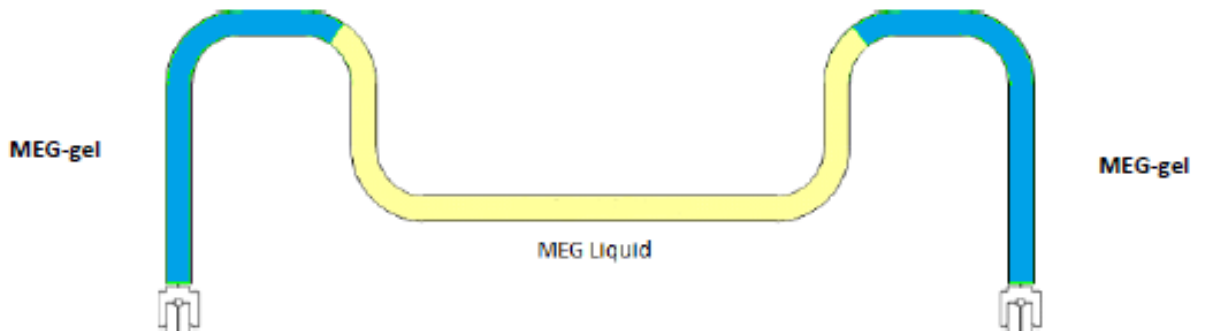



Figure 4: Schematic for tie-in spool MEG / MEG gel filling

- 5.9.6.3 Spools to be installed in the horizontal position shall be completely filled with MEG Gel (if requested in the specific project contractual documents) and plugged with foam pigs at both ends.
- 5.9.6.4 The gel to be used shall not react with ethanol. CONTRACTOR shall perform tests in order to guarantee that the MEG gel mixture will be chemically compatible with ethanol. The results of these tests shall be presented in a report with pictures and methodology.
- 5.9.6.5 Both ends of each spool section shall be closed with low pressure caps or blind flanges.
- 5.9.6.6 Low pressure cap shall fit in the connectors properly and it shall be designed to seal the MEG gel plug preventing leakage during installation of the spool.
- 5.9.6.7 Low pressure cap shall be designed to withstand the weight of the MEG gel plug inside the spool during installation.
- 5.9.6.8 Low pressure cap design shall guarantee no hydraulic and/or mechanical lock during removal of the cap for spool installation.
- 5.9.6.9 In case of piggable pipeline, the use of pig at the end of the spool in conjunction with the low pressure cap for preventing MEG gel leakage is acceptable but in any case PETROBRAS shall authorize by writing this use.
- 5.9.6.10 In this case, the pig shall be designed to withstand the weight of the MEG gel plug and to avoid the water ingress inside the spool. Beyond that, the pig shall be compatible with the pipeline piggability characteristics.

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## 6 DOCUMENTATION

### 6.1 General

6.1.1 CONTRACTOR shall release a data book at the conclusion of scope of work. The minimum content of data book shall be as presented in the following items.

### 6.2 CONSTRUCTION, FABRICATION AND MANUFACTURING REPORT

6.2.1 For each material, equipment and procedure, CONTRACTOR shall present all technical documents issued, including but not limited to:

- a) Inspection and test plans;
- b) Qualification test reports;
- c) Factory Acceptance Tests Reports (as applicable);
- d) Site Integration Tests Reports (as applicable);
- e) Production Test Reports;
- f) As-built drawings of spools.

6.2.1.1 Where applicable in accordance with the requirements in this technical specification, the reports shall be properly signed by PETROBRAS and/or **THIRD PARTY** representative.

6.2.1.2 Additionally, CONTRACTOR shall present the register of all girth welds executed in project. The register shall present the maximum length and height detected in each girth weld executed for the project, for welding subjected to AUT. The register shall be included in Welding Book.

6.2.1.3 **The as-built drawings shall make reference to metrology and fabrication drawings as well as the respective procedures. The dimensional errors shall be clearly presented.**

6.2.1.4 "Relatórios Diários de Ocorrência", Non-Conformance Reports and Meeting Notes released during project shall be included in this section. The reports and meeting notes shall be organized in accordance with subject, data, etc.


### 6.3 PRE-COMMISSIONING REPORT

6.3.1 The pre-commissioning shall include a pigging report, that shall include at least the following information:

- 6.3.1.1 Pig and Brush Pig notorious occurrence during pigging operation;
- 6.3.1.2 Caliper pig photographic register and damages detected (if any);

6.3.2 The pre-commissioning report shall include a hydrostatic test report, that shall include at least the following information:

- 6.3.2.1 Summary of the work performed;

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6.3.2.2 Hydrostatic test charts;

6.3.2.3 The hydrostatic test charts shall be remarked;

6.3.2.4 The signed THIRD PARTY hydrotest certification.

6.3.3 The pre-commissioning report shall include **the dewatering** and **MEG** gel application report, explaining the necessary steps for MEG gel filling.

#### **6.4 THIRD PARTY REPORT**

6.4.1 All **THIRD PARTY** reports shall be included in Data Book section. The reports shall be organized in accordance with subject, data, etc.

6.4.2 The “Atestado de Comissionamento” shall also be included in this Data Book section.

#### **6.5 PETROBRAS TECHNICAL SPECIFICATIONS**


6.5.1 All project technical specifications released by PETROBRAS shall be included in this section;

#### **6.6 DATA BOOK DELIVERY CONDITION**

6.6.1 The Data Book content declared in section **6.1** shall be compiled into a set of **external Hard Disks with USB connection** with a html navigator and delivered to PETROBRAS. Link to every single report shall be included in the electronic menu. The structure defined in section **6.1** shall be respected.

6.6.2 All documents shall be delivered in pdf format and, whenever required by PETROBRAS, also in native format. Videos shall be delivered in MPEG and drawings in **dwg** format.

6.6.3 CONTRACTOR shall provide two (2) copies of the Data Book to PETROBRAS in digital format.

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## Annex A - Material Reception Inspection Requirements

### A1. GENERAL

Materials shall be inspected by a qualified inspector just after they are received and before they are applied in the fabrication, and they shall comply with the purchase documents and design specifications.

Materials and components shall be identified and have certificates of quality and/or Data Book. The identification shall allow the traceability up to the certificate of material quality and/or Data Book.

All metallic materials, when not identified or certified, shall not be received. When the materials do not present certificates, or when there are doubts about them, such materials shall undergo the metal and alloy identification tests, according to Ref. [B14], comparing their results with their identification.

### A2. PIPES

A2.1. All pipes shall be checked for identification in their ends, with painting, according to criteria of [A4] or [A21], when applicable.


A2.2. The following characteristics of pipes shall be checked for compliance with specifications indicated in design or referred standards:

- a) thickness, out-of-roundness and diameter;
- b) bevel and orthogonality;
- c) weld reinforcement;
- d) state of internal and external surfaces;
- e) out-of-straightness;
- f) coating specification and condition;
- g) residual magnetism;
- h) concrete and coating cutback;
- i) relative position of anode when mounted in pipeline;
- j) concrete coating specification and condition.

A2.3. It shall be checked if the pipe data book has the following minimum content:

A2.3.1. Seamless pipes:

- a) chemical composition of batches, with their respective numbers;
- b) mechanical tests (tension, hardness, impact, and others specified in the design);
- c) nondestructive testing;

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- d) certificates of quality;
- e) material requisition and technical specification of the pipe.

#### A2.3.2. Welded pipes:

- a) chemical composition of plates, with their respective numbers;
- b) nondestructive testing of plates;
- c) welding procedure qualification;
- d) nondestructive testing of pipes;
- e) mechanical tests of plates, pipes and others specified in the design;
- f) hydrostatic test results;
- g) certificates of quality;
- h) material requisition and technical specification of the pipe.

### A3. ANODES

A3.1. Anodes shall comply with packaging, wrapping and identification requirements, as per Ref. [B5].

A3.2. Anodes shall have certificate of quality, as per Ref. [B5].

A3.3. The minimum requirements for receipt inspection of galvanic anodes to be used in submarine pipelines shall comply with Ref. [B11].

A3.4. Anodes dimensions, mass and other properties shall be within tolerances indicated in Ref. [A16].


### A4. FLANGES

A4.1. It shall be checked if all flanges have printed identification, meeting the respective fabrication standards, with the following information:

- a) type of flange;
- b) face type;
- c) fabrication standard;
- d) material specification and grade;
- e) number of batch;
- f) nominal diameter;
- g) pressure class;
- h) surface finishing of contact face;
- i) type of groove;
- j) lot or service order number;
- k) thickness of pipe to be welded;
- l) impact test temperature;

A4.2. Certificates of quality of material of all flanges shall be in accordance with the relevant specification.

A4.3. Certificates of quality of flanges shall have the report of groove measurement, to be performed using tridimensional machine.

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A4.4. It shall be checked if the following characteristics of all flanges comply with the specifications indicated in design or with specified supplying standards:

- a) inside diameter;
- b) bevel;
- c) height and outside diameter of raised face;
- d) finish of contact face;
- e) surface finish of groove;
- f) face dimensions for ring-type joint;
- g) groove depth, type and pitch;
- h) bevel or socket weld.

A4.5. It shall be checked if all flanges have cracks, bends, dents, burrs and corrosion, as well as the general condition of face and groove, with no presence of agents causing corrosion, according to criteria of specified standards.

A4.6. All flanges, before being packed or wrapped, shall have their machined surfaces protected with anti-oxidant grease, so as ensure their conservation, storage in covered area, for the minimum period of 2 years.

A4.7. It shall be checked if the flange data book has the following minimum content:

- a) certificate of material;
- b) non-destructive testing reports;
- c) testing report and certificates;
- d) calculation sheet, when applicable;
- e) dimensional reports.

## **A5. FITTINGS**

A5.1. It shall be checked if all fittings are identified with painting or stamping by the manufacturer, with the following data:


- a) complete material specification;
- b) diameter;
- c) pressure class and thickness;
- d) type and manufacturer's trademark.

A5.2. The certificates of quality of the material shall comply with the applicable standards.

A5.3. It shall be checked if the following characteristics of all fittings comply with the specifications indicated in design:

- a) end diameter;
- b) concentricity;
- c) center-face distance, when applicable;
- d) bevel, socket weld;
- e) thickness;



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- f) forged elbows angularity;
- g) state of the surface, regarding dents, corrosion, cracks, tack welds , and arc burn.

## **A6. GASKETS**

A6.1. All gaskets shall be inspected to ensure that they are identified, indicating the following characteristics:

- a) manufacturer's name;
- b) type and number;
- c) material;
- d) lot number;
- e) part number;
- f) pressure class;
- g) dimensional standard of fabrication.

A6.2. The following characteristics of all gaskets shall be checked for compliance with specifications indicated in design or referred standards:

- a) type and number (ring), according to standards specified in design;
- b) hardness (ring), according to standards specified in design;
- c) dimensions and surface finish.

## **A7. BOLTS, STUDS AND NUTS**

A7.1. It shall be checked if packages of bolts, studs and nuts are identified with the following characteristics:

- a) specification (fabrication standard);
- b) type of bolt, stud or nut;
- c) type of thread and threaded for full length;
- d) dimensions (diameter and length);
- e) manufacturer's lot number;


A7.2. It shall be checked if certificates of quality of material of all lots of bolts, studs and nuts comply with the standards specified in design.

A7.3. It shall be checked if all characteristics described in A7.2 comply with the specifications adopted by the design or referenced standards:

- a) bolt and/or stud length, bolt and/or stud and nut diameter, nut height and distance between faces and edges, and thread type and pitch, according to criteria of standards defined in design;
- b) bolts and/or studs duly protected, without dents, cracks and corrosion.

## **A8. SAMPLING OF PIPES, BOLTS AND/OR STUDS AND NUTS**

A8.1. The inspection plan shall follow at least the sampling inspection criteria, in accordance with standards [B1], [B2] and [B3], as follows:

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- a) pipes: general inspection level II, QL 15, simple sampling plan and consumer risk 5%;
- b) bolts and/or studs and nuts: general inspection level II, QL 10, simple sampling plan and consumer risk 5%;

### **A9. WELDING CONSUMABLES**

A9.1. The inspection of consumables upon receipt shall be done in accordance with the sampling plan of Annex A of Ref. [B12]. All requirements related to inspection upon receipt of 4.7 of Ref. [B12] shall be met.

A9.2. For situations of piping welding, except those in which 6.1 above allows the use of Ref. [A4] / [A24] as base code for pipe specification, the entire new batch of welding consumables not tested during the qualification of welding procedure shall undergo the batch testing mentioned in Appendix C-400 of Ref. [A21]. For other situations, the welding consumables shall be certified by the welding qualification and certification system of FBTS, according to 4.3.11 and 4.7.1 of Ref. [B12], not being required the batch testing.

A9.3. It shall be checked the presence of oxidation in bare electrode coils. If there is any, the consumable shall be separated.

A9.4. The welding consumable specific to a given welding process may not be used in another process, unless otherwise stated by the manufacturer.

### **A10. FIELD JOINT COATING MATERIALS**

A10.1. It shall be checked if all materials have printed identification, meeting the respective fabrication standards, with the following information:


- a) manufacturer's name;
- b) number of batch;
- c) lot number;
- d) material specification;
- e) package weight.

A10.2. The general condition of materials shall be checked for:

- a) preservation conditions and control/register of temperature for the FBE;
- b) dents, tears or other damage in the packages;
- c) general aspect of package regarding weather damage.

A10.3. A dimensional inspection shall be performed in the materials to compare with the tolerances defined in design and purchase documents, identifying:

- a) thickness, length and width, when applicable;
- b) volume, when applicable;
- c) weight.

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A10.4. The traceability of fabrication raw materials shall be checked in the respective certificates of quality, confirming number of batch, lot number, marking and material specification, comparing with data on package.

A10.5. Certificates of quality of material shall be in accordance with the respective material specification and have coverage of at least two years.

A10.6. In case of chemicals, it shall be checked the existence of the chemical safety information sheets (FISPQ), which shall follow the materials during transportation, handling, storage and waste disposal phases, according to Ref. [B6].