PETROBRAS	TECHNICAL SPECIFICATION	Nº: I-ET-0000.00-0000-250-P9U-001	
	CLIENT:		SHEET: 1 de 21
	JOB:		
	AREA: GENERAL		
	TITLE: SLEEPER FOR LATERAL BUCKLING INITIATION		EDD/EDR -

INDEX OF REVISIONS

REV.	DESCRIPTION AND/OR REVISED SHEETS
0	THIS TECHNICAL SPEC. REPLACES DOCUMENT I-ET-0000.00-6500-250-P9U-001 REV. A.
A	REVISION OF ITEMS 2.2, 2.3, 2.4, 3.1, 3.2, 3.3, 3.6, 4.2 E 5.4
B	REVISION OF ITEMS 1.1, 1.2, 2.2, 2.4, 3.1, 3.2, 3.3.1, 3.3.2, 3.3.3, 3.3.4, 3.6, 4.2, 5.3, 5.4 AND 5.5

	REV. 0	REV. A	REV. B	REV. C	REV. D	REV. E
DATE	04/12/2017	17/03/2020	15/08/2022			
EXECUTION	ER48	ER48	ER48			
CHECK	UP65	U4TX	U4TX			
APPROVAL	CLZ2	CLZ2	CLZ2			

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1 INTRODUCTION

1.1 General

This Technical Specification establishes the scope of work and minimum requirements for the Engineering and Construction of sleepers used for lateral buckling initiation and its related ancillaries.

Therefore, this specification is applied to the pipelines that shall experience lateral buckling due to high operation temperatures and pressures. In some cases, the proposed method to ensure a safe buckle at selected locations is to install single and/or dual sleepers (to provide a vertical upset at these locations) in order to reduce the critical initiation buckling load and have a more controlled buckle during operation.

This specification defines the minimum technical requirements for the supply of single and/or dual sleepers in order to assure their structural integrity for the design life.

The minimum scope of work for the engineering design activity includes:

- Sleeper design;
- Definition of sleeper locations;
- VIV fatigue analysis of spans in the pipeline crossing over sleeper;
- Detailed drawing of sleeper painting & marking;
- Sleeper structural detail drawing.

1.2 Abbreviation

The following abbreviations are applied in this document:

API	American Petroleum Institute
AWS	American Welding Society
DNV	Det Norske Veritas
FAT	Factory Acceptance Testing
FEA	Finite Element Analysis
FEM	Finite Element Model
ITP	Inspection Test Plan
KP	Kilometer Post
MPI	Magnetic Particles Inspection
NDT	Non-Destructive Testing
OD	Outside Diameter
RT	X-Ray Testing
UT	Ultrasonic Testing
VIV	Vortex Induced Vibration
WD	Water Depth

1.3 Definitions

CONTRACTOR	Company responsible for the design, manufacture, testing and delivery of the specified sleeper and supply of services to perform the duties specified within the scope of this specification. This is used interchangeably with “Supplier” or “Manufacturer” or “Vendor”.
SHALL	Indicates a mandatory requirement for CONTRACTOR.
SHOULD	Indicates a preferred course of action for CONTRACTOR.

MAY	Indicates an optional course of action for CONTRACTOR.
WORK	The entire project requirements as stated in the scope description.

1.4 Deviations

All deviations to this Specification, and other referenced specifications or attachments listed in the contract, shall require written approval by PETROBRAS prior to execution of the work.

2 REFERENCES

2.1 General

CONTRACTOR shall maintain compliance with existing codes, standards, specifications, Guidelines and/or Directives and regulatory requirements recognized within the industry including but not limited to such documents as listed and/or contained.

The standards listed below apply to this specification. In case of disparity between the requirements of such standards and those established in this document, the specifications of this document shall prevail.

The latest revision of the following Codes, Standards and Specifications shall be used unless indicated by PETROBRAS.

2.2 Design Reference Documents

[1]	DESIGN DOCUMENTATION	*PIPELINE DATASHEET*
		PIPELINE DESIGN BASIS
		PIPELINE DESIGN ROUTE
		PIPELINE ALIGNMENT SHEET
		PIPELINE FREE-SPAN ANALYSIS
		PIPELINE ON BOTTOM ROUGHNESS ANALYSIS
		PIPELINE CROSSING DESIGN
		PIPELINE GLOBAL BUCKLING DESIGN
[2]	ENVIRONMENTAL DATA	*METOCEAN DATA*

		PIPELINE GEOPHYSICAL DATA
		PIPELINE GEOTECNICAL DATA
[3]	SLEEPER DOCUMENTATION	*SLEEPER DESIGN REPORT*
		VIV FATIGUE AT SLEEPER CROSSING REPORT
		SLEEPER CROSSING LOCATION DRAWING
		SLEEPER PAINTING & MARKING DETAIL DRAWING
		SLEEPER STRUCTURAL DETAIL DRAWING

2.3 Industry Standards

[4]	DNV-ST-F101	*SUBMARINE PIPELINE SYSTEMS*
[5]	DNV-RP-C212	*OFFSHORE SOIL MECHANICS AND GEOTECHNICAL ENGINEERING*
[6]	API-RP-2GEO	*GEOTECHNICAL AND FOUNDATION DESIGN CONSIDERATIONS*
[7]	ISO-19901-4	*PETROLEUM AND NATURAL GAS INDUSTRIES — SPECIFIC REQUIREMENTS FOR OFFSHORE STRUCTURES — PART 4: GEOTECHNICAL AND FOUNDATION DESIGN CONSIDERATIONS*
[8]	API RP 2A LRFD	*CONSTRUCTING FIXED OFFSHORE PLATFORMS - LOAD AND RESISTANCE FACTOR DESIGN*

[9] API RP 2A WSD — *RECOMMENDED PRACTICE FOR PLANNING, DESIGNING AND CONSTRUCTING FIXED OFFSHORE PLATFORMS - WORKING STRESS DESIGN*

[10] AWS D1.1 — *STRUCTURAL STEEL WELDING CODE*

[11] ABNT NBR 10387 — *ANODO DE LIGA DE ALUMÍNIO PARA PROTEÇÃO CATÓDICA*

[12] N-381 — *EXECUÇÃO DE DESENHO E OUTROS DOCUMENTOS TÉCNICOS EM GERAL*

[13] N-1710 — *CODIFICAÇÃO DE DOCUMENTOS TÉCNICOS DE ENGENHARIA*

[14] N-2064 — *EMISSÃO E REVISÃO DE DOCUMENTOS DE PROJETO*

2.4 Other Specifications

[15] ET-3000.00-1500-940-PEK-001 — *PROJETO DE PROTEÇÃO CATÓDICA PARA EQUIPAMENTOS SUBMARINOS*

[16] I-ET-0000.00-0000-940-P9U-003 — *GLOBAL BUCKLING DESIGN OF SUBSEA PIPELINE*

[17] I-ET-0000.00-0000-275-P9U-001 — *PIPELINE AND CABLE CROSSINGS*

[18] I-ET-0000.00-0000-940-P9U-002 — *RIGID PIPELINE ON-BOTTOM ROUGHNESS AND FREE SPAN DESIGN*

The last edition of these specifications shall be used for designing, fabricating and testing the sleepers that make up the scope of supply of this technical specification.

3 TECHNICAL REQUIREMENTS

3.1 General Requirements

Sleepers are used for controlling lateral buckling behavior and are secondary structures to be installed on the seabed purely for the purpose of supporting the pipeline. However, their structural integrity, as well as the pipeline, must to be assured for the entire design life.

The sleeper shall be designed as per the following minimum requirements:

1. In cases of single sleeper, each sleeper shall be composed of one structure in order to achieve the nominal vertical out-of-straightness, defined in pipeline global buckling design [16], to reduce the critical buckling load and to avoid vortex induced vibration (VIV) on the spans.

2. In cases of dual sleeper, two single sleepers shall be positioned to achieve the nominal vertical out-of-straightness, defined in pipeline global buckling design, to reduce the critical initiation buckling load and to avoid vortex induced vibration (VIV) on the spans.

3. Each sleeper shall be composed of a steel tubular structural member with the following minimum requirements: maximum OD, minimum WT, minimum length and material yield strength.

4. Each sleeper shall be painted in accordance with the project's specific coating document. To complement corrosion protection a cathodic protection system shall be designed in accordance with reference [15]. Steel sleeper should be fitted with independent cathodic protection [16].

The minimum requirements concerning wall thickness and outside diameter shall be based on the results from the structural analysis presented on sleeper design report which shall include the design loads considered and potential sleeper embedment on

sandy and/or clayed soils, and potential embedment of the structures during design life.

Materials proposed for tubular steel to comply with requirements shall include structural steel, like DNV pipe material [4]. For example, reused pipe (but certified) can be considered in the proposal.

Sleeper length shall be based on the results from pipeline global buckling design (Detailed FEA), considering the maximum lateral buckle amplitude achieved on the sleepers. A sleeper (longitudinal and transversal) installation tolerance of +/- 5 meters shall be considered and an angular installation tolerance related to seabed plan of +/- 5 degree shall be adopted. If the sleeper has stopping device at the ends, in order to avoid any possibility of the pipeline falling off the support along design life, an angular installation tolerance related to seabed plan of +/- 10 degree shall be adopted.

The pipeline crossing over sleepers shall be compliance with all requirements applicable to steel supports stablished in Technical Specification of Pipeline and Cable Crossings [17].

3.2 Sleeper Location

The total number and position of single and/or dual sleepers along the route shall be confirmed with the latest results from detailed FEA on pipeline global buckling design, including end expansion, route curve pullout, global buckling, buckle interaction and walking behaviors.

Spacing between dual sleepers shall be based on results of VIV fatigue analysis at sleeper locations.

3.3 Sleeper Design

3.3.1 Embedment Calculation

The maximum acceptable sleeper embedment has to be such that the net vertical upset at the sleeper shall be in compliance with the value considered in pipeline global buckling analyses. This statement is important mainly for the sections on soft clayed soils, where higher initial embedment is likely to occur.

The sleeper embedment calculation shall be performed in accordance with DNV-RP-C212 [5], API-RP-2GEO [6] or ISO-19901-4 [7].

The required net vertical upset shall be verified during installation, short-term and long-term operational conditions. Long-term settlement shall not be neglected due to its influence in pipeline lateral buckling during design life.

If required, CONTRACTOR shall design the installation of each of the sleepers over a foundation (e. g. concrete mattresses) in order to increase the bearing area and therefore, guaranty a net vertical upset. The sleeper foundation design shall be issued for PETROBRAS approval.

3.3.2 Cathodic Protection Requirements

The corrosion protection of the sleepers shall be provided by a combination of anti-corrosion coating and cathodic protection system using galvanic aluminum anodes in order to provide protection for the entire design life.

Cathodic protection shall be according to PETROBRAS technical specification ET-3000.00-1500-940-PEK-001 [15].

The cathodic protection design shall consider the internal area of tubular or beam elements in case, it is expected that, such surfaces get in contact with seawater.

Anodes dimensions and mass shall be in accordance with reference [11].

Anode shall be installed in the lower section of the sleeper whenever possible in order to keep the center of gravity as low as possible.

Complete cathodic protection analysis, developed on Mathcad spreadsheet, along with the anode distribution drawing shall be presented for PETROBRAS approval.

3.3.3 Structural Sleeper Design (FEA)

Finite element analysis (FEA) shall be performed using ABAQUS or ANSYS software, including contact surface analysis between pipes (sleeper & pipeline). The predicted friction factor between the pipeline and sleeper shall be considered in the FEM.

The stress and strain results shall be analyzed, and the wall thickness and the material of the sleeper steel pipe shall be specified in accordance with these results. In addition, stresses on pipeline due to contact with the sleeper shall be verified through the local analysis.

3.3.4 Sleeper Installation Aids

Sleepers shall be installed by lifting using adequate rigging (slings, shackles, etc.).

Lifting analysis shall be performed using slings and all support structures added to the sleeper. Lifting analysis shall consider the sleeper installation for the worst case, scenario of recovering the sleeper in air full of water. This analysis shall include gravity loads and reaction loads on cables, and shall be performed using FEM, according to the API-RP-2A criteria [8] and [9].

Complete padeye details regarding the structural and location design can be used, in this case they shall be presented on sleeper structural detail drawing.

All installation aids are included in CONTRACTOR's scope and shall be defined in sleeper structural detail drawing.

3.4 VIV Fatigue at Sleeper

The VIV fatigue analyses in the pipeline crossing over sleepers shall be performed in accordance with Petrobras Technical Specification of On-Bottom Roughness and Free Span Assessment [18].

3.5 Welding & NDT Requirements

Structural fabrication, and all materials used, shall be in accordance with applicable specifications, codes and standards indicated in Section 2.3.

CONTRACTOR shall assemble and fabricate any structural components in CONTRACTOR's shop or yard, whenever possible. Work shall not be performed when weather conditions prevent satisfactory workmanship or prevent adequate inspection.

Welding and weld inspection shall meet the requirements of AWS D1.1 [10], "Structural Steel Welding Code ". Specific fabrications and welding requirements as follow:

1. CONTRACTOR shall furnish shop drawings to PETROBRAS, for information, prior to fabrication.

2. CONTRACTOR shall obtain written PETROBRAS approval, for any deviation from this specification, before starting fabrication.

3. CONTRACTOR shall maintain copies of procedures in each fabrication area and provide supervision to ensure adherence to procedures.

4. Welded connections shall be full penetration continuous seal welds, to protect members against corrosion, unless otherwise specified on CONTRACTOR's shop drawings.

5. Welding shall not be performed when prevailing weather conditions, including airborne moisture, blowing sand, or high wind, would impair weld quality. Windshields shall be used when practical.

Extend of non-destructive testing (NDT) required is as follows:

6. 100% visual inspection for all welds (critical and non-critical).

7. 100% ultrasonic testing (UT) and magnetic particles inspection (MPI) for all critical full penetration welds.

8. 20% ultrasonic testing (UT) and magnetic particles inspection (MPI) for all full penetration non-critical welds.

On full penetration welds with thickness less than 6 mm, x-ray testing (RT) can be used instead of ultrasonic testing (UT).

The top 25% of the circumferential weld will be considered critical (where the design load is applied) and 100% ultrasonic inspection will apply. The rest of the welds will be considered non-critical including welding of lifting attachments, padeyes, etc., as well as the longitudinal weld which will be positioned at 3 and 9 o'clock far from top of structure.

CONTRACTOR shall be responsible for transportation of all components to yard.

CONTRACTOR shall evaluate the possibility of doing the final assembly (one final weld) at dock site in order to reduce the length of the steel tubular member to be road transported.

3.6 Painting & Marking Requirements

Sleepers shall be coated externally with epoxy base paint according to project's specific coating document.

Sleeper marking is required in order to assure the pipeline will be laid on the center of the sleeper as per installation corridor tolerance, and dual marking shall be required as defined in sleeper painting & marking detail drawing.

4 FACTORY ACCEPTANCE TESTING (FAT)

4.1 Load Test

A static load test shall be performed in order to assure no pipe dents are expected.

The static load for this test shall consider the maximum loadings from all pipeline design phases (installation, operational, etc.). In addition, an adequate safety factor shall be considered and references shall be properly cited.

CONTRACTOR shall provide a test procedure for PETROBRAS approval.

4.2 Friction Test

A friction test shall be carried out by CONTRACTOR to determine friction factor between sleeper coating and pipeline external coating.

Tests shall determine the friction factor in the predicted project conditions, such as temperature, contact pressures, etc. for the different project pipelines, if they have different characteristics, such as weight, external coating, etc. Moreover, sleeper-pipeline friction tests shall be performed in a submerged way.

The friction test velocity shall be previously defined and shall be monitored and recorded during the tests.

CONTRACTOR shall provide a test procedure for PETROBRAS approval.

The certificates of test equipment calibration shall be previously furnished.

All friction tests shall be performed and recoded in the presence of interested parts to be defined in the Inspection Test Plan (ITP).

Results of this friction test shall be in accordance with the assumptions used for sleeper design and pipeline global buckling design.

5 REPORTING

All documents to be issued shall be in accordance with the last revision of Petrobras standards below:

- N-381 - Execução de Desenho e Outros Documentos Técnicos em Geral, Ref. [12];
- N-1710 - Codificação de Documentos Técnicos de Engenharia, Ref. [13];
- N-2064 – Emissão e Revisão de Documentos de Projeto, Ref. [14].

5.1 Sleeper Design Report

The sleeper design report to be issued shall include, but shall not be limited to the following initial items:

- Introduction including field description;
- Objective;
- Summary and conclusions;
- Design data

  The item design data shall include, but shall not be limited to the following sub-items: design life, pipeline data, sleeper pipe material data, geotechnical data, cathodic protection data and design loads;

- Design methodology

  The item design methodology shall include, but shall not be limited to the following sub-items: sleeper net vertical upset, sleeper embedment, pipeline embedment, embedment calculation, soil bearing capacity, cathodic

protection design, lifting analysis, sleeper structural finite element analysis and friction factor between sleeper & pipeline;

- Results;
- References.

5.2 VIV Fatigue at Sleeper Crossing Report

The VIV fatigue at sleeper crossing report to be issued shall include, but shall not be limited to the following initial items:

- Introduction including field description;
- Objective;
- Summary and conclusions;
- Design data

  The item design data shall include, but shall not be limited to the following sub-items: pipeline profiles at sleeper crossing, pipeline data, operational data, environmental data and soil data;

- Analysis methodology

  The item analysis methodology shall include, but shall not be limited to the following sub-items: finite element model (FEM), VIV stress analysis and fatigue damage;

- Analysis results;
- References.

5.3 Sleeper Crossing Location Drawing

The sleeper crossing location drawing to be issued shall include, but shall not be limited to the following initial items:

- Reference documents;
- General notes;
- Legend;
- Geodesy information: horizontal datum, spheroid, projection, central meridian, etc.;
- Pipeline route with bathymetry lines to each 5 m, indicating all sleeper crossing locations, i. e., sleeper number, KP, Easting (m) and Northing (m) along the pipeline route;
- Detail of single sleeper and/or dual sleeper in plan view, indicating sleeper length, lay corridor at sleepers crossing and distance between sleepers in case of dual sleeper;
- Detail of single sleeper and/or dual sleeper in profile view, indicating the nominal vertical out of straightness and the span lengths achieved;
- Table including sleeper number, KP, Easting (m), Northing (m), WD (m), distance from previous sleeper (m), soil type, axial inclination and lateral inclination.

5.4 Sleeper Painting & Marking Detail Drawing

The sleeper painting & marking detail drawing to be issued shall include, but shall not be limited to the following initial items:

- Reference documents;

- General notes including a specific note that painting shall be in accordance with project's specific coating document;
- General notes shall also include graduation lengths centered over the 12 o'clock position with contrasting colours;
- General notes shall also include graduation widths of 150 mm at the 10 m marker (pipeline crossing area). All others shall be 50 mm;
- Sleeper drawing in plan view, indicating sleeper length, pipeline crossing area and all marks along the sleeper at least to each 2.5 m;
- Sleeper drawing in elevation view, indicating sleeper length, pipeline crossing area and all marks along the sleeper at least to each 2.5 m;
- Isometric views.

5.5 Sleeper Structural Detail Drawing

The sleeper structural detail drawing to be issued shall include, but shall not be limited to the following initial items:

- Material list;
- Reference documents;
- General notes
- Sleeper drawing in plan view, including all relevant structural details;
- Sleeper drawing in elevation view, including all relevant structural details;
- Sleeper cross section, including all relevant structural details;
- Isometric views, including all relevant structural details.