INDEX OF REVISIONS

REV.	DESCRIPTION AND/OR REVISED SHEETS
0	ORIGINAL
A	Changed product identification requirements in Section 1 Removed shipping addresses for project communications in Section 1.3 Changed riser configuration requirements in Section 2 Added requirement to present design data of the accessories/ancillaries to Section 4 Added requirement to define number and dimension of packages in Section 4 Added requirement to present datasheet in the design premise in Section 5 Added requirement to present maximum retrieval rate in Section 9 Added requirement to include ancillary assembly instructions in Section 10 Added requirement for instructions to avoid torsion in Section 10 Changed service life requirement and added installation analysis requirement to Section 11 Removed scope of qualification and added possibility to reject products in Section 11
B	New Annex VI with requirements for Bend Stiffener design data New requirements for temporary conditions in Annex V Permeation Data Adjustments to 10 Handling and Installation Manual Adjustments to 11 Design Basis

	REV. 0	REV. A	REV. B	REV. C	REV. D	REV. E	REV. F	REV. G
DATE	18/12/2019	01/11/2021	31/07/2023					
PROJECT	SUB/ES/DCT	SUB/ES/DCT	SUB/ES/DCT					
EXECUTION	Walter (UQ9R)	Walter (UQ9R)	Walter (UQ9R)					
CHECK	Eder (CSN8)	Eder (CSN8) Gasparetto (BEJH)	Eder (CSN8) Gasparetto (BEJH)					
APPROVAL	Lancelotti (CXAX)	Lancelotti (CXAX)	Lancelotti (CXAX)					

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This Technical Specification is part of I-ET-3000.00-1519-291-PAZ-001 – Flexible Pipe Technical Specification. Please refer to the Flexible Pipe Technical Specification for instructions, definitions and abbreviations.

1. General

The documents listed herein shall be supplied to Petrobras.

Ancillary documentation shall be presented according to the requirements of API 17 L1.

The design documentation shall be self-sufficient. The design documentation shall contain all items required herein for each document. Documents containing or based on references to design documentation of other projects will not be accepted.

In addition to the documents listed in API 17J, the manufacturer shall present a Design Basis document, described in item 11 below.

The Independent Review Certificate shall be submitted to Petrobras prior to the delivery of the flexible pipes.

1.1. Product Identification

Flexible pipe data sheets shall be identified by an exclusive numerical code composed of seven or eight digits, as per manufacturer practice. This code shall be unique for each specific product. The code shall have the value of flexible pipe internal diameter (in millimeters) placed in the first three digits. The following four of five digits shall represent an identification number by the manufacturer. The identification code shall be changed if there are any changes in the product.

For ancillary components and accessories, design documents shall allow quick identification of which pipe structure they apply to.

1.2. System of Units

The International System of Units (SI) as set out in ISO 31 shall be used for the technical documents to be submitted to Petrobras. However, for *flexible pipe* internal diameters and maximum design pressure values, the International System of Units shall be complemented with the corresponding values in inches and psi, respectively, between brackets.

1.3. Document Control

The manufacturer shall keep track of all the documentation exchanged through a master document register. The master document register shall be issued monthly and contain, for each document, at least the following data:

a) document title,

b) document identification,

c) document last revisions,

d) Petrobras comment or approval date,

e) the manufacturer comment date,

f) IVA comment or approval date, and

g) conclusion date

The documentation shall be sent to the Subsea Engineering Department to an e-mail address to be defined within each specific contract.

2. Design Premise

The following additional requirements apply:

Table 2.19: Additional requirements for the Design Premise.

Parameter	Comments
Design load case combination	All potential load cases for the flexible pipe system during manufacturing, storage, transport, testing, installation, operation, and retrieval shall be addressed. A matrix showing the load cases to be checked for each component of the flexible pipe system shall be established and shall conform with the design requirements.
Design criteria	Required safety margins and definition of structural capacities shall be specified for each layer of the pipe and components and shall conform with the requirements given in the design requirements. The manufacturer shall submit all safety margins which are not specified by the purchaser, including margins for fatigue prevention of ancillary components and accessories.

The Design Premise shall include a detailed list of all products, with their unique identification code.

The Design Premise shall also include the calculation of the pipe bore and annulus conditions according to Annex V.

The manufacturer shall present the preliminary riser configurations in the Design Premise. Any configuration other than the ones required in the project-specific data shall be duly justified.

If an inspection or monitoring system is being supplied, the system specification and information on its premise of operation shall be included in the Design Premise. Further operation requirements shall be presented in the Operating Manual.

The Design Premise shall be formatted according to template required in the project specific documentation.

3. Design Load Report

The Design Load Report shall clearly indicate the following information:

a) global analysis results, including installation, abandonment, operation, on-bottom stability, and interference;

b) loads acting at the riser interface with the platform including maximum bending moment, shear force and axial force;

c) local analysis results of metallic layers (i.e. pressure armor and tensile armor) and non-metallic extruded layers (i.e. internal pressure sheath, outer sheath and external protective layer), considering the worst positions for each specified riser function for installation (including Early and Offshore Leak Tests), abandonment and operation,

d) results of design analysis demonstrating the Minimum Allowable Radius at Design Water Depth (and at the project-specific water depth) due to flexible pipe bending collapse and tensile armor buckling, considering installation/retrieval, abandonment and operational conditions.

e) fatigue and service life analysis for the structure, end fittings, ancillary components, and accessories, considering the dry, wet and flooded pipe annulus;

f) adjustments and alternative solutions, whenever necessary, in order to assure that the riser interface with flowline is not subjected to dynamic loads.

g) dimensions of each proposed riser configuration, and the drawings and specification of the buoyancy modules and other necessary components;

h) Interference analysis results.

The manufacturer shall also supply, together with the Design Load Report, the global analysis models in digital format.

4. Design Report

The Design Report shall clearly state the following additional information:

a) Pipe Datasheet (see 5);

b) permissible crushing loads in the form of crushing curves for each laying vessel and each structure;

c) range of water depth for each structure regarding the buckling and collapse failure modes and the effects of bending;

d) Maximum Design Pressure (absolute) for the Maximum Water Depth, Operational Water Depth and at sea level;

e) calculation of permeated annulus gases as per 0;

f) calculation of the stresses and strains imposed by manufacturing in the tensile and pressure armors and the final residual stresses and strains profiles in the unloaded pipe body, after FAT and OLT.

g) description of each pipe component, including the end fittings, accessories and ancillary equipment. The documentation shall include at least the drawings with dimensions,

weight, material specifications, design safety factors, safe working loads, and type of coating or anti-corrosive protection. The end fitting documentation shall include the detailed drawings and description of components of the gas-venting system and the applied materials;

h) Bend Stiffener Design Data as per Annex VI – Bend Stiffener Data

i) drawing showing the total height of hang off, connector and pull in head assembly on production unit interface;

j) Spyhole end fitting design;

k) justification of any differences between the connectors or interfaces specified by the purchaser.

l) versions of the design tools used for that given project.

The Design Report shall be comprised of a single document. The Design Load Report may be submitted as a separate document.

The Design Report shall contain the results of the analyses of the flexible pipe life cycle, including all proposed accessories and ancillary equipment. These analyses shall demonstrate that the flexible pipe and its accessories and ancillary equipment are adequate to sustain the loads and conditions imposed throughout the whole life cycle. The flexible pipe life cycle analysis shall include but not be limited by:

a) final results of structural, on-bottom stability, interference, TDP Displacement, fatigue, FEA, and service life analyses;

b) results of calculations of the cathodic protection to be designed by the manufacturer;

c) compatibility with storage bases, laying vessels and floating unit interface shall be demonstrated in this analysis;

d) structural calculation report of the accessories and ancillary equipment provided by sub-suppliers, including bend stiffener, bend restrictors and buoyancy modules and associated clamps.

If different, more restrictive, safety or utilization factors are adopted by the manufacturer they shall be clearly stated in the Design Report.

The Design Report shall also include Composition Drawings where each flexible pipe shall be represented by drawings with the following minimum content:

a) Sketch showing the flexible pipe with all ancillary components and accessories (one line diagram);

b) Complete material list for flexible pipe, ancillary components, and accessories, with all part numbers;

c) Identification of flexible pipe function (production, gas lift, export line, etc.);

d) Drawings with all dimensions, for each accessory and ancillary component;

e) Length and location for installation of anti-abrasive protection, as applicable;

f) Detailed list of materials packaging, with dimensions of the boxes, and manual for stock material preservation.

If any new test info changes the results or conclusions in the Design Report, the Design Report shall be revised and resubmitted accordingly.

5. Pipe Datasheet

The Pipe Datasheet shall be presented with the minimum content defined in Annex I.

The Pipe Datasheet shall be included in the Design Premise and in the Design Report.

The Pipe Datasheet shall also be supplied as an editable digital spreadsheet to be inserted into the database.

6. Manufacturing Quality Plan

7. Fabrication Specification

The following shall be available during manufacturing for examination by the third party inspector pointed out:

a) quality certificates of materials;

b) heat treatment records;

c) NDE procedures and records;

d) NDE operator qualification records;

e) welding procedures and qualification records;

f) qualification records of coating and painting procedures;

g) welder qualification records;

h) repair procedures;

i) inspection/test records;

j) procedures for preservation and packing of materials;

k) flexible pipes and accessories;

l) records on training carried out for end fitting mounters.

8. As-Built Documentation

As-Built Documentation shall be acquired and reported by the manufacturer or sub-suppliers or sub-vendors during the manufacturing and assembling activities. The As-built Documentation shall include the dates and periods during which the manufacturing activities were performed.

As-Built Data of individual products may be presented in tables such as the one exemplified for pipe body in Annex II. These tables should be presented for each fabrication run and for each accessory or ancillary equipment. Other items, like fasteners, vent valves, and sealing rings shall also have similar tables presented and shall be traceable by the lot number.

The As-Built Documentation shall also include the following:

a) main dimensions of the pipe body - on a layer-by-layer basis - controlled during manufacturing;

b) main dimensions of the end fitting, including data from the mounting procedure;

c) FAT records;

d) results of CIV tests on samples of extruded internal pressure sheath made of polyamides and tests on XLPE samples in order to confirm the material properties;

e) results of production tests;

f) calculated stress and strain profiles in the pressure and tensile armors.

For each of the pipe layers, the manufacturer shall include records of the dimensions measured along the manufacturing process, providing data on maximum, minimum and average measured data.

As for the process of each end fitting assembly, the following records shall be properly submitted to the pointed out inspector and annexed to the As-Built Documentation:

a) demonstrative records the execution of the assembly, step-by-step, and of the verifications of the hold points, according to the Manufacturing Quality Plan;

b) records that document the identification of the assemblers, inspectors, dates and place of the activities;

c) pictures of the main phases of the procedure. The characteristics of the photographic registrations (e.g. point of interest, resolution, scope, amplitude) will depend on the particularity of each procedure of assembly (e.g. for rough and smooth bore pipes).

Whenever a manufacturing activity is performed by a third party, the flexible manufacturer shall include, as a minimum, the following information in the As-Built Documentation:

a) Sub-supplier or Sub-vendor identification;

b) Type of activity carried out or type of product supplied;

c) Specification of product or activity;

d) Reference date of activity or supply.

The manufacturer shall have a specific document attached to the As-Built Documentation listing the nonconformities identified during manufacture, including the information required in item (h) of API 17J.

The manufacturer shall organize as-built and non-conformity data, in such a way that process and product traceability is guaranteed and that manufacturers, sub-suppliers, and vendors are easily identified by the final client.

9. Operation Manual

The Operation Manual shall be prepared for the flexible pipe system and shall address all flexible pipe life cycle phases.

The Operation Manual shall also clearly state the following:

a) maximum differential and absolute pressures for in-situ testing or testing onshore or in the laying vessel considering the FAT, OLT and SIT pressures listed in API 17J;

b) estimated service life considering the most severe combination of operating temperature and pressure as per project specific data;

c) detailed in service inspection, monitoring, and maintenance/replacement plan;

d) description of devices designed for checking flange-to-flange pipe connections against leakage before laying of line (N_2 Seal Test);

e) flexible pipe commissioning procedure;

f) the limit values and any specific equipment required to tighten and loosen fasteners used in any connectors, accessories and ancillary equipment being supplied;

g) maximum pressurization and depressurization rates;

h) maximum pipe retrieval rate and any recommendations in order to mitigate the risk of burst of the external sheath during recovery operations;

i) any limitations in use, such as MBR for installation or operation, maximum pressure for offshore leak test, special procedures for reeling or handling, etc.;

j) procedure for hibernation of any section of flexible pipe for temporary abandonment on sea bottom, considering all components and accessories installed and the pipe with open or closed ends, with seawater, tap water and inhibited water;

The manufacturer shall supply procedures for repair of damages that the flexible pipe, end fittings, accessories and ancillary equipment may suffer during its life cycle. These procedures shall account for the activities to take place in the laying vessel or in an unprotected area onshore. The procedures shall contain the list of required equipment, materials, qualified personnel, logistic and facilities as well as the estimated duration.

The repair procedure for the Outer Sheath shall be detailed in an operational level, allowing the outer sheath repair to be performed by the laying vessel crew. Therefore, the repair procedure shall contain all the necessary parameters to ensure the compliance with the design criteria (e.g. temperature set points, gas mixture and required applied tension).

The manufacturer shall also provide the records of Vacuum Test carried out in each flexible pipe section prior to delivery, including the measured annulus volume either in the Operating Manual or As-built Data.

The manufacturer shall include, in the Operation Manual, a procedure for the annulus integrity test to be carried out after pipe installation and during operation. This procedure shall include the acceptance criteria and be adequate for use on board of the installation vessel and during operation. The procedure shall account for any necessary correction of the measurements due to the effects of operational parameters. The test procedure and equipment shall comply with the safety requirements of the maritime unit.

10. Handling and Installation Manual

The manufacturer shall also present a Handling and Installation Manual, to be delivered with the Design Report.

The Installation Manual shall provide the procedure for each pipe with the description of every steps including the assembly and disassembly of the bend restrictors and buoyancy modules and their clamps.

The Installation Manual shall also include:

a) restrictions for pipe installation, retrieval and abandonment such as restrictions in the bending radius, laying restrictions for flooded bore conditions or mandatory installation sequence;

b) design, main dimensions and quantity of required buoyancy modules/floaters necessary for the installation, retrieval and operation of the structures, as well as their positioning along the pipe;

c) detailed design of the bend stiffeners required for installation-aid in riser intermediate connections, if applicable;

d) handling recommendations to avoid torsion build-up in the flexible pipe sections indicating torsion limits and how to assess them;

e) requirements to be considered during API flanges connections, including:

   i. Recommended bolt torque for each type of lubricant;

   ii. Corresponding friction coefficient and bolt preload tension;

   iii. Reference standard;

f) composition drawings with the final as-built lengths of each flexible pipe section.

g) packaging list containing the description of the components, quantity, dimensions, and weights of each crate.

11. Design Basis

The Design Basis shall include the following information:

a) The Design Premise (as per item 2);

b) Commercial Data Sheets, including, as a minimum, the contents of tables 1, 2 and 3A of Annex I;

c) Handling, installation and retrieval feasibility study considering the General Functional Requirements, Design Requirements and project specific data regarding compatibility with onshore bases, laying vessels, production unit and subsea equipment as specified in project-specific data;

d) Demonstration that the proposed products are within the range of validated design methodologies, materials range of use and manufacturing processes;

e) Demonstration that the proposed materials are qualified for the intended use;

f) Installation analysis demonstrating that the proposed products are adequate according to the contract requirements and standardized envelopes of use;

g) Demonstration of the service life compliance for risers and flowlines, considering all the applicable failure mechanisms and the suitability of the proposed products for use according to the contract requirements (reference design requirements);Internal pressure sheath analysis results, considering the effects of long-term exposure to internal pressure and temperature, creep, swelling, ageing, temperature/pressure cycles and fatigue;

h) For smooth bore flexible pipe, results of:

   i. Internal pressure sheath creep analysis, considering the effects of internal pressure and temperature;

   ii. Internal pressure sheath collapse analysis, considering the effects of pressure resulted from permeated water column in the most internal annulus;

   iii. Leak proof intermediate sheath (i.e. anticollapse sheath) creep analysis, considering the effect of external pressure and temperature.

i) The maximum allowable pressurization and depressurization rates for each proposed flexible pipe structure;

j) Information on any exception or deviation from the applicable technical documents, including technical specifications and standards, that was accepted during contract negotiations.

In the Design Basis, the manufacturer shall demonstrate that the products, components and materials being proposed are qualified for use according to API, IVA and Petrobras requirements. The products and requirements shall be shown to be within the validated ranges of the Design Methodology. Material compatibility with internal fluids and injected chemicals as specified in the internal fluid data documentation shall be demonstrated in the Design Basis.

Design Basis will only be accepted with the associated IVA Design Basis Review indicating that the products are adequate to the functional and design requirements and in line with validated or acceptable design methodologies. The Design Methodology Verification Report shall be available to be checked with the Design Basis Review.

Remarks, limitations and pending tests indicated in the Design Basis or in the Design Basis Review shall be subjected to Petrobras evaluation and may result in product rejection. If a product is rejected, the manufacturer shall propose and supply a product, without remarks, limitations or pending tests without any additional cost or delays in the delivery.

If a monitoring or inspection system is being proposed, the Design Basis shall provide all information on the devices and components, including description and drawings that details eventual changes in the pipe body cross section and end fittings.

12. Responsibility Term

The manufacturer shall submit a Responsibility Term, signed, along with the proposal. The model of the Responsibility Term is presented in Annex III.

13. IVA Documentation

IVA scope of work and required documentation are presented in document I-ET-3000.00-1519-291-PAZ-003 – Flexible Pipe Certification Requirements.

The Design Basis Review shall be presented with the Design Basis.

The Independent Review Certificate shall be presented before delivery of the products.

The Design Methodology Verification Report certificate shall be presented with the Design Basis to demonstrate that the supplier is able to manufacture the products. The associated reports, including those related to the Failure Mode Analysis, Design Methodology Review, Manufacturing Process Review and Material Review shall be available for Petrobras review by Petrobras representatives in the local offices of the manufacturer (in Brazil).

Annex I Minimum Data Sheet Content

I.1 Flexible pipe structure

The following tables indicate the minimum information that shall be included in *flexible pipe* structure data sheets (and in the attached documentation) concerning to each structure proposed by the manufacturers.

Unless otherwise specified, the data highlighted marked with asterisk (*) can be provided in the *Design Report*, if not available in the *Design Premise*.

1- GENERAL DATA	
Manufacturer Identification	
Pipe Family as per Table 1 of API RP 17B 3rd Edition	
Flexible Pipe Structure Identification Code	
Application	Note 1
Internal Diameter (inches)	
Internal Fluid Description	Note 2
Maximum Differential Design Pressure (MPa)	
Maximum Design Pressure (MPa) @ Maximum Water Depth	
Maximum Design Pressure (MPa) @ Operational Water Depth	
Maximum Design Pressure (MPa) @ Sea level	
Minimum Design Pressure (MPa)	
Incidental Pressure (MPa)	
Design Maximum Temperature (°C)	
Design Minimum Temperature (°C)	
Maximum Pressure Differential (MPa)	
Maximum Specified Water Depth (m)	
Hydrostatic Pressure Test - Factory Acceptance Test (MPa)	
Accidental Overpressure	

Note 1: Static or dynamic *jumper*, *flowline* and *riser*.
Note 2: Crude oil, Produced/Injected water, Natural gas, Oil.

2- STRUCTURE COMPOSITION DATA	
Flexible Pipe Structure Identification Code:	
MATERIAL	LAYER

Number of the Layer/ Layer Description	Generic Specification Code/ Type	Material Commercial Name	UTS (MPa)/ Hardness (Vickers)	Structural Capacity (MPa) / Modulus of elasticity (MPa)	Wire Width X Thickness (mm/mm)	Lay Angle (Deg)	Layer Commercial Name	Mass (kg/m)	ID (mm)	Thickness (mm)
(Note 1)	(Note 2) / (Note 3)	(Note 4)	(Note 5)	(Note 6)			(Note 7)			

Note 1: Number of the layer is the given sequence numbering of a layer, from the inside to the outside of the pipe. Layer description shall be filled-in the Table according to the layer description in the table below. Layer description may be repeated within a certain pipe structure, depending on the specified application.

Layer Description
Carcass
Internal pressure sheath
Back-up (or anti-creep) internal pressure sheath
Anti-wear
Pressure armour
Back-up pressure armour
Internal tensile armour (Inner Pair)
External tensile armour (Inner Pair)
Internal tensile armour (Outer Pair)
External tensile armour (Outer Pair)
Holding bandage
Low strength tape
Leakproof intermediate sheath
Non-leakproof intermediate sheath
Insulation
Outer sheath
Mechanical Protective Layer
External Protective Sheath

Note 2: Material Specification Code is to be filled-in by the manufacturer as per Table of codes below:

Code	Generic Material Specification
AISI 304	American Iron & Steel Institute - Stainless Steel 304
AISI 304L	American Iron & Steel Institute - Stainless Steel 304 Low carbon
AISI 304Hard	American Iron & Steel Institute - Stainless Steel 304 Hard
AISI 316	American Iron & Steel Institute - Stainless Steel 316
AISI 316L	American Iron & Steel Institute - Stainless Steel 316 Low Carbon
Duplex AISI 2205	UNS S31803 - Duplex 2205
Duplex AISI 2304	UNS S32304 - Duplex 2304
PA-11	Polyamide-11
PA-12	Polyamide-12
PVDF	Polyvinylidene Fluoride
MDPE	Medium Density Polyethylene

HDPE	High Density Polyethylene
X-LPE	Cross-linked Polyethylene
Carbon Steel	Carbon steel
PU	Polyurethane
Polyaramid	Aramid fiber tape
Fiber glass composite	Fiber Glass and polymeric composite tape

Note 3: Material "type" - for a non-metallic layer – shall identify if it is an EXTRUDED layer or a TAPE. In case of a TAPE, the manufacturer shall inform the total number of tapes applied in order to achieve the layer thickness.

Note 4: "Material Commercial Name" is to be filled-in by the manufacturer, based on its own codification method, but shall give an indication of the raw-material micro-structural characterization (e.g. for carbon steel the "commercial name" shall represent an unique steel with a proper chemical composition, mechanical properties, and metallurgical micro-structure. For polymers, the "commercial name" shall represent a unique polymer with a proper chemical formulation). If possible, the "commercial name" shall also give an indication of the raw material manufacturer or sub-vendor.

Note 5: "UTS" stands for "Ultimate Tensile Strength" (MPa).

"Hardness" stands for the maximum hardness (Vickers scale) for the steel at the formed condition, for the wire cross section (applicable to metallic materials).

Note 6: "Structural Capacity" (MPa), applicable to metallic materials.

"Modulus of elasticity" (MPa). Additionally, Stress/Strain curves* of the polymers used in the flexible pipe construction, for the temperature range from the design minimum temperature to the design maximum temperature shall be presented.

Note 7: "Layer Commercial Name" is to be filled-in by the manufacturer, based on its own codification method.

3A- TECHNICAL DATA	
Internal Diameter (inch)	
Outside Diameter (mm)	
External Volume per unitary length ($dm^3.m^{-1}$)	
Internal Volume per unitary length ($dm^3.m^{-1}$)	
Free volume in annular in the Annulus ($dm^3.m^{-1}$)	
Total steel surface in in the Annulus ($m^2.m^{-1}$)	
Linear mass desnsity, line empty ($kg.m^{-1}$)	
Linear mass density, line full of sea water ($kg.m^{-1}$)	
Apparent linear weight density in sea water empty, considering dry annuli ($N.m^{-1}$)/($kgf.m^{-1}$)	
Apparent linear weight density in sea water full of sea water, considering dry annuli ($N.m^{-1}$)/($kgf.m^{-1}$)	
Specific gravity in sea water empty	
Calculated burst pressure (MPa)	

Calculated Hydrostatic Collapse Resistance (MPa)	
Calculated Hydrostatic Collapse Resistance considering the effects of crushing loads (MPa)	
Damaging pull in straight line (kN)	
Maximum working tension, considering normal recurrent operation (kN)	
Minimum bending radius for storage (m)	
Minimum bending radius for laying at 20°C, considering line in hydrostatic equilibrium (m)	
Minimum bending radius for normal recurrent operation at 20°C (m)	
Natural bending radius at the temperature of the Maximum Specified Water Depth and atmospheric pressure (inside and outside) (m)	
Natural bending radius at operating maximum temperature inside, the temperature of the Maximum Specified Water Depth outside, maximum operating pressure inside, and the pressure equivalent to the Maximum Specified Water Depth outside (m)	
Axial stiffness (EA) at 20°C and atmospheric pressure (inside and outside) (kN)	
Axial stiffness to compression at 20°C and atmospheric pressure (inside and outside) (kN)	
Bending stiffness (EI) [see Note 8] at 20°C and atmospheric pressure (inside and outside) (kN.m²)	
Bending stiffness (EI) [see Note 8] at the temperature of the Maximum Specified Water Depth and atmospheric pressure (inside and outside) (kN.m²)	
Bending stiffness (EI) [see Note 8] at the temperature of the Maximum Specified Water Depth (inside and outside), atmospheric pressure inside and pressure equivalent of the Maximum Specified Water Depth outside (kN.m²)	
Bending stiffness (EI) [see Note 8] at the temperature of the Maximum Specified Water Depth (inside and outside) and pressure equivalent of the Maximum Specified Water Depth outside and inside (kN.m²)	
Bending stiffness (EI) [see Note 8] at the temperature of the Maximum Specified Water Depth (inside and outside), maximum operating pressure inside and pressure equivalent of the Maximum Specified Water Depth outside (kN.m²)	
Bending stiffness (EI) at the temperature of the Maximum Specified Water Depth (inside and outside), 110% of maximum design pressure inside (top side) and pressure equivalent of the maximum specified water depth outside (kN.m²)	
Bending stiffness (EI) [see Note 8] at operating maximum temperature inside, 20°C outside, maximum operating pressure inside, and atmospheric pressure outside (kN.m²)	
Bending stiffness (EI) [see Note 8] at operating maximum temperature inside, the temperature of the Maximum Specified Water Depth outside, maximum operating pressure inside, and the pressure equivalent to the Maximum Specified Water Depth outside (kN.m²)	
Limp torsional stiffness (GJ) at 20°C and at the atmospheric pressure inside and outside ($N.m^2.rad^{-1}$)	
Limp torsional stiffness (GJ) at the temperature of the Maximum Specified Water Depth and at the atmospheric pressure inside and outside ($N.m^2.rad^{-1}$)	
Stiff torsional stiffness (GJ) at 20°C and at the atmospheric pressure inside and outside ($N.m^2.rad^{-1}$)	
Stiff torsional stiffness (GJ) at the temperature of the Maximum Specified Water Depth and at the atmospheric pressure inside and outside ($N.m^2.rad^{-1}$)	
Thermal Exchange Coefficient at the design maximum temperature inside, at the temperature of the Maximum Specified Water Depth outside, and with dry armour annulus, short term ($W.m^{-1}.K^{-1}$)	
Thermal Exchange Coefficient at the design maximum temperature inside, at the temperature of the Maximum Specified Water Depth outside, and with dry armour annulus, long term ($W.m^{-1}.K^{-1}$)	

Thermal Exchange Coefficient at the design maximum temperature inside, at the temperature of the Maximum Specified Water Depth outside, and with flooded armour annulus, short term ($W.m^{-1}.K^{-1}$)	
Thermal Exchange Coefficient at the design maximum temperature inside, at the temperature of the Maximum Specified Water Depth outside, and with flooded armour annulus, long term ($W.m^{-1}.K^{-1}$)	
Equivalent thermal conductivity of flexible pipe layers ($W.m^{-1}.K^{-1}$) [see Note 9],	
Equivalent heat capacity of flexible pipe layers ($J.kg^{-1}.K^{-1}$) [see Note 9],	
Equivalent volumetric mass of flexible pipe layers ($kg.m^{-3}$) [see Note 9],	
Spooling tension (kN)	
Erosional Velocity ($m.s^{-1}$)	
Dimensions (width/thickness) of pressure armor wire (mm)	
Dimensions (width/thickness) of tensile armor wire (mm)	
Dimensions (width /thickness) of carcass wire (mm)	
Friction coefficient for tensile armor wire fatigue stress calculation (steel/steel)	
Friction coefficient for tensile armor wire fatigue stress calculation (steel/polymer)	
Permissible Tension in straight line without internal pressure, considering normal recurrent operation (kN)	
Permissible Tension at the operating MBR without internal pressure, considering normal recurrent operation (kN)	
Permissible Axial Compression (kN) at 20°C inside, at the temperature of the Maximum Specified Water Depth outside, atmospheric pressure inside and the pressure equivalent to the Maximum Specified Water Depth outside	
Maximum fatigue accumulated damage*, for the tensile armours, for the specified service life (%)	
Maximum fatigue accumulated damage* for the pressure armours, for the specified service life (%)	
Maximum accumulated wearing* for the tensile armours, for the specified service life (% of nominal thickness)	
Maximum accumulated wearing* for the pressure armours, for the specified service life (% of nominal thickness)	
Maximum allowable temperature for the internal pressure sheath to continuously operate along the specified service life considering the maximum operating pressure and the specified internal fluid (°C)	
Maximum allowable time for the internal pressure sheath to continuously operate under the design maximum temperature, the maximum operating pressure and the specified internal fluid (h)	
Maximum allowable time* for the internal pressure sheath to continuously operate at the maximum operating pressure under 3 temperature steps of the specified internal fluid from the operating temperature to the design maximum temperature (h/h/h)	
Laying Tension, for the Maximum Specified Water Depth with the pipe full of water, for the specified installation vessel (kN) (vessel name)	
Design Tension* obtained from the Global Analysis for the Maximum Specified Water Depth (kN)	
Maximum and minimum riser top angle* in the bend stiffener region in relation to the neutral position of the catenary obtained from the Global Analysis for the Maximum Specified Water Depth (kN) and considering all the design load cases and combinations	

Minimum bending radius* obtained from the Global Analysis for the Maximum Specified Water Depth and considering all the design load cases and combinations (m)	
Minimum allowable bending radius for prevention buckling of tensile armour and hydrostatic collapse during installation of the pipe for the intact annulus and empty bore conditions in the Maximum Specified Water Depth (m)	
Minimum allowable bending radius for prevention buckling of tensile armor and hydrostatic collapse during installation of the pipe for the flooded annulus (annulus not intact) and empty bore conditions in the Maximum Specified Water Depth (m)	
Minimum allowable bending radius for prevention buckling of tensile armor during installation of the pipe for the intact annulus and flooded bore conditions in the Maximum Specified Water Depth (m)	
Minimum allowable bending radius for prevention buckling of tensile armor during installation of the pipe for the flooded annulus (annulus not intact) and flooded bore conditions in the Maximum Specified Water Depth (m)	
Minimum allowable bending radius for prevention buckling of tensile armor and hydrostatic collapse during operation of the pipe for the intact annulus and empty bore conditions in the Maximum Specified Water Depth (m)	
Minimum allowable bending radius for prevention buckling of tensile armor and hydrostatic collapse during operation of the pipe for the flooded annulus (annulus not intact) and empty bore conditions in the Maximum Specified Water Depth (m)	
Minimum allowable bending radius for prevention buckling of tensile armor during operation of the pipe for the intact annulus and flooded bore conditions in the Maximum Specified Water Depth (m)	
Minimum allowable bending radius for prevention buckling of tensile armor during operation of the pipe for the flooded annulus (annulus not intact) and flooded bore conditions in the Maximum Specified Water Depth (m)	

Note 8: Graphics showing pipe Bending Moment versus pipe Curvature, for the listed annulus, temperature and pressure conditions, high lightening the bending stiffness before and after the sliding of pipe layers and the critical curvature.

Note 9: Equivalent thermal properties at 20°C (Thermal conductivity, heat capacity and volumetric mass) of flexible pipe layers to be considered for transient thermal simulations. The equivalent properties have to be defined for equivalent cylindrical layer(s) with same ID and OD than flexible structure. The thermal properties shall be informed for the temperature of 20°C and insulation with maximum water absorption and creep, as applicable, at operating temperature and design water depth, which is considered conservative for transient thermal simulations.

4- SKETCH OF *FLEXIBLE PIPE* SHOWING ALL LAYERS - The manufacturer shall present a sketch of the flexible pipe body section showing and identifying all the layers.

The technical data for installation shall be provided for all the vessels specified for installation, as applicable. In addition, the following curves shall be supplied:

— Graphics showing, for each specified installation vessel and tensioners, the following:

a) Permissible Crushing Load for each tensioner pad (tf/m) versus Laying Tension (tf) curve, and

b) Minimum Required Crushing Load for each tensioner pad (tf/m) versus Laying Tension (tf) curve.

— Graphics showing the Permissible Crushing Load (tf/m) for specified laying equipment (wheel, clamping devices) versus Laying Tension curve.
— Development of the crushing curves shall consider the laying vessels defined in the project specific documentation.

I.2 Bend Stiffener

The following tables indicate the minimum information that shall be included in the *bending stiffener* data sheets (and in the attached documentation) concerning to each *bend stiffener* design proposed by the manufacturer.

1- GENERAL DATA	
Bend Stiffener Identification Code	
Flexible pipe Structure Identification Code	
Material Specification Code for: (1) Body (2) Reinforced Structure, (3) Stud bolts & nuts, (4) Insert, (5) Liner	**Note 1**
Material Commercial Name for: (1) Body (2) Reinforced Structure, (3) Stud bolts & nuts, (4) Insert, (5) Liner	**Note 2**
Specification of metallic coating of carbon steel insert	**Note 3**
Internal Diameter (mm)	
Maximum Outside Diameter (m)	
Minimum Outside diameter (mm)	
Length (mm)	
Conic part length (mm)	
Design Temperature (°C)	

Note 1: Material Specification Code is to be filled-in by the manufacturer, based on previous information given by Petrobras, as per Table of codes below. The manufacturer shall clearly identifya new code, if necessary (in order to complement the existing data):

Code	Material Specification
Alloy 718	UNS N07718
Alloy 625	UNS N06625
Carbon Steel	Carbon steel
PU	Polyurethane

Note 2: “Material Commercial Name” is to be filled-in by the manufacturer, based on its own codification method, but shall give an indication of the raw-material micro-structural characterization (e.g. for carbon

steel the "commercial name" shall represent an unique steel with a proper chemical composition, mechanical properties, and metallurgical micro-structure. For polymers, the commercial name" shall represent a unique polymer with a proper chemical formulation). If possible, the "commercial name" shall also give an indication of the raw material the manufacturer or sub-vendor.

Note 3: "Specification of metallic coating of carbon steel insert" is to be filled-in by the manufacturer, with the indication of its code, which shall characterize a specific process.

2- TECHNICAL DATA	
Volume (m^3)	
Weight in air (kgf/m)	
Weight in sea water (kgf/m)	
Density (kgf/m^3)	
Minimum bending radius for storage (m)	
Minimum bending radius for laying (m)	
Maximum bending radius for operation (m)	
Maximum top angle for operation (degrees)	
Tensile Strength at 23 ^oC(MPa)	
Shore Hardness at 23 ^oC(^oA)	
Elongation at Break at 23 ^oC (%)	
Tension for maximum top angle for operation(kgf)	
Bending stiffness (EI) at 20 °C ($KN.m^2$)	

3- MODULE OF ELASTICITY(YOUNG'S MODULUS)/TEMPERATURE CURVE

1) The manufacturer shall present representative curve(s) for each of the proposed bending stiffener design.

Note: Curve at the strain range from 0 to 20% for the operating temperature considered in design (i.e. actual temperature at the polyurethane body).

2) The manufacturer shall inform the load rate to produce the curve mentioned. Petrobras recommends 200%/min load rate. Also, the manufacturer shall supply information if the module shown on the curve is the secant or tangent.

4- SKETCH OF BEND STIFFENER

The manufacturer shall present a sketch of each of the proposed bending stiffener design, showing the main dimensions and identifying all the parts.

I.3 Flexible pipe system

The following table indicates the minimum information that shall be included in flexible pipe system data sheet proposed by the manufacturer.

GENERAL FLEXIBLE PIPE SYSTEM DATA

Manufacturer Identification	
Pipe Family as per API RP 17B	
Flexible Top Riser Structure Identification Code)	
Flexible Intermediate Riser Structure 1	
Flexible Intermediate Riser Structure 2	
Flexible Intermediate Riser Structure N	
Flexible Bottom Riser Structure	
Flexible Flowline Structure 1	
Flexible Flowline Structure 2	
Flexible Flowline Structure N (at the subsea equipment interface	
(Offshore) Early Leak Test Pressure of the Flexible Flowline Structure N	Note 1
(Offshore) Leak Test Pressure at the Maritime Unit (Total System Installed)	Note 2

Note 1: Test pressure applied, at the installation vessel interface, after flowline connection in the subsea equipment (MPa)

Note 2: Test pressure applied, at the maritime unit interface (MPa)

Annex II As-Built Data

AS-BUILT DATA: PIPE BODY - EXAMPLE	
Identification Code	
Supplier Identification	
Manufacturer Identification	Note 1
Flexible Pipe Structure Identification Code	
Flexible Pipe Body Identification Code	Note 2
Actual *Flexible Pipe* Section Length (m)	Note 3
Mean Outside Diameter (mm)	Note 4
Carcass Outside Diameter (mm)	Note 5
Maximum *Carcass* Ovality (%)	Note 6
Internal Pressure Sheath Thickness	Note 7
Corrected inherent viscosity - CIV (dl/g)	Note 8
Pressure Armour Outside Diameter (mm)	Note 7
Pressure Armour Pitch (m)	Note 7
Pressure Armour Ovality (%)	Note 6
Tensile Armour Outside Diameter (mm)	Note 7
Tensile Armour Pitch (m)	Note 7
Outer Sheath Thickness	Note 7
External Protective Sheath Thickness	Note 7
Hydrotest Pressure	Note 9
Reference Date	Note 10
Non-conformities?	Yes or No (Manufacturer to give details, if Yes - Note 11)

Note 1: Company (or list of companies) which manufactured, assembled, or finished the individual *product* (or pipe section)
Note 2: Identification code of the individual *product* (or pipe section).
Note 3: Actual value, measured between *connectors*.
Note 4: Actual value, obtained as a statistical average along the pipe length from the manufacturing process. The manufacturer shall inform calculation method and adopted criteria.
Note 5: Actual value, obtained as a statistical average along the pipe length from the manufacturing process.
Note 6: Maximum actual value, measured between *connectors*.
Note 7: Maximum, minimum, and average cross-section values along the pipe length between *connectors*
Note 8: Maximum and minimum values measured between extrusion run (or between *connectors*), obtained from coupons of manufactured pieces.
Note 9: Graph of the measured test pressure for the pipe section.

Note 10: For example, the manufacturing conclusion dates.
Note 11: Complete characterization, description, type, location and description of the corrective actions (e.g. repair data).

Annex III Responsibility Term

The Responsibility Term shall certify that all *flexible pipes, ancillary components* and *accessories* proposed comply with all provisions defined by Petrobras in this I-RM and in the documents referred on it.

The template for the Responsibility Term can be found below:

Responsibility Term

(Template)

- Material Requisition: I-RM_____/Revision _

_____(city), _____(date)

_____ (Bidder) certify that all *flexible pipes*, *ancillary components* and *accessories* offered in our proposal _____(proposal identification) comply with all technical requirements stated on the Material Requisition I-RM-_____/Rev.: ____ (revision considered on the proposal) and all clarifications.

_____

(Bidder representative legally qualified).

Annex IV Query Form Template

Whenever a query form is necessary, the manufacturer shall adopt the one presented hereafter in this annex. In case the manufacturer wants to use another query form pattern, it shall be submitted to Petrobras for approval.

Area for Bidder/Supplier Logo			
TECHNICAL QUERY FORM - TQF			
Project:		**TQF No.:**	
From:		**Rev.**	
To:		**Page:**	**1 / 1**
Subject:			
Reference document:			
Questions:			
Issued by:		**Date:**	
Answer:			
Answered by:		**Date:**	

Annex V Permeation Data

The bore and annulus steady state conditions adopted in the product design shall be submitted as per Table V.1 below. For transient conditions, an additional table shall be submitted, if relevant for verification of any failure mechanisms of any selected material.

Table V.1 – Summary of assumed bore and annulus conditions

Permeation Analysis																																
				Bore Conditions (2)											Annulus Conditions (2)																	
				CH_4 (4)		CO_2 (4)		H_2S (4)		H_2O (4)				CH_4 (4)		CO_2 (4)			H_2S (4)			H_2O (4)									
Section (1)	Operational Pressure (MPa)	Temperature (ºC)	BSW (%)	P CH_4	Fug CH_4	P CO_2	Fug CO_2	P H_2S	Fug H_2S	P H_2O	Fug H_2O	pH (5)	Condition (3)	P CH_4	Fug CH_4	P CO_2	Fug CO_2	Flowrate	P H_2S	Fug H_2S	Flowrate	P H_2O	Fug H_2O	pH (5)	Total Flowrate	Total Pressure (bar)	Vent Pressure (bar)	Valve Opening (Yes or No)	Condensed Water(Yes/No, rate)			

Table Notes:

(1) The table shall include ate least the following sections: top end fitting, top/intermediate riser connection, intermediate/bottom riser connection, TDP, riser/flow connection and connection at the subsea equipment. For configurations other than the free hanging catenary, the table shall include sections subjected to high curvatures (e.g. sag and hog for a lazy-wave configuration). Any other points that may present a critical condition shall be included. If duly justified/demonstrated by the manufacturer permeation design methodology, results at TDP and SAG/HOG zones may be disregarded in case they are less severe than at the top and bottom of given pipe application

(2) The permeation data shall also be presented for temporary conditions as defined in the internal fluid parameters specification.

(3) Annulus and bore conditions adopted in the product design shall address the following:

i. the pipe section and the degradation mechanisms throughout the service life, for the failure mechanisms of each material;

ii. the specified internal fluid parameters such as operating pressure, temperature, BSW, pH of water phase, and fluid composition; and

iii. the external environment.

(4) The manufacturer shall inform the polymer condition for which the predicted annulus condition was calculated in the product design: plasticized, deplasticized, or unplasticized material. If only one condition is shown, the manufacturer shall justify the criteria used in the design, showing that a conservative approach was adopted.

(5) Both Fugacity and Partial Pressure predictions shall be informed in the table, irrespectively of which is used by the manufacturer's design methodology. When there is no gas phase in the bore, partial pressure does not need to be provided. The presented pH shall be the pH of the water phase calculated under pressure.

(6) "P" and "Fug" mean, respectively, Partial Pressure and Fugacity. The partial pressure and fugacity for CH_4 and CO_2 shall be expressed in bar, whereas the values for H_2S and H_2O shall be in mbar.

Annex VI Bend Stiffener Data

Bend Stiffener Data		
Attribute	Value	Unit
Drawing ID		-
Part ID		-
Manufacturer		-
Total Length		mm
Length of Bend Stiffener Adapter		mm
Maximum Diameter		mm
Internal Diameter		mm
Bending Moment		kN.m
Shear Force		kN
Elastic Modulus		MPa
Weight		kg
Weight in water		kg
Density		kg/m^3

Construction Details			
Section #	Initial External Diameter	End External Diameter	Length of Section
1			
2			
3			
4			
5			
...			
...			