PETROBRAS	**TECHNICAL SPECIFICATION**	Nº: I-ET-3D10.12-1350-274-PX9-001	
	CLIENT: AGUP		SHEET: 1 de 41
	PROGRAM: BÚZIOS 12		
	AREA: UN-BS		
SUB/ES	TITLE: **RISER SYSTEM REQUIREMENTS**		PUBLIC
			SUB/ES/EDA/EAI

INDEX OF REVISIONS

REV.	DESCRIPTION AND / OR AFFECTED SHEETS
0	ORIGINAL
A	REVISED PART MARKED WITH GREY BACKGROUND (ITEMS 6.4.1/6.5/ 6.5.6/ 7.2/ 7.6/ 9)
B	REVISED PART MARKED WITH GREY BACKGROUND, GAS TRANSFER PRECOMISSIONING ACTIVITIES (ITEM 7.3/7.4) AND TABLE A.1.

	REV. 0	REV. A	REV. B	REV. C	REV. D	REV. E	REV. F	REV. G
DATE	10/01/2025	31/07/2025	30/09/2025					
DESIGN	SUB/ES/EDA/EAI	SUB/ES/EDA/EAI	SUB/ES/EDA/EAI					
EXECUTION	E061	E061	E061					
VERIFICATION	CJLZ	CJLZ	CJLZ					
APPROVAL	NTHF	NTHF	NTHF					

INDEX

1. INTRODUCTION

1.1. SCOPE

This document establishes the minimum mandatory technical requirements to be complied with for the FPSO riser system for Búzios 12 projects.

In case of conflict between this document, the GTD, CS or other third-part requirements, PETROBRAS must be formally consulted for clarification.

1.2. APPLICABLE STANDARDS

[1] API 17D: Design and Operation of Subsea Production Systems

[2] API 6A: Specification for Wellhead and Christmas Tree Equipment

[3] DNV 2.22 (2013): Lifting Appliances

1.3. ACRONYMS AND DEFINITIONS

BOT	Build-operate-transfer
BSDL-SI	Diverless Bellmouth - standard interface (Portuguese acronym)
CONTRACTOR	Refers to the company responsible for the design, construction (or conversion), assembly, transport, installation and operation of the FPSO
CS	Classification Society
FAT	Factory Acceptance Test
FPSO	Floating Production Storage and Offloading Unit (also Unit)
GTD	General Technical Description
HOA	Hang Off Adaptor
KoM	Kick-off Meeting
LOI	Letter Of Intent
LRB	Lower Riser Balcony
MBL	Minimum Break Load
METOCEAN	Meteorological and Oceanographic Data
MPM	Most Probable Maximum
NPD	Norwegian Petroleum Directorate
PLET	Pipeline End Termination
PLR	Pig Launcher / Receiver
PWAG	Production/ Water Alternating Gas
QTF	Quadratic Transfer Function
RAO	Response Amplitude Operator
ROV	Remotely Operated Vehicle
SELLER	Refers to the company responsible for the BOT process
SF	Safety Factor
SLWR	Steel Lazy Wave Riser
SWL	Safe Work Load

TBC	To Be Confirmed
TiPT	Titanium Pull-In Tube
TSA	Thermal Spray Aluminum
TSJ	Tapered (Titanium) Stress Joint
TSUDL	Unified Diverless Support Tube (Portuguese acronym)
URB	Upper Risser Balcony
WAG	Water Alternating Gas
WCT	Wet Christmas Tree
WD	Water Depth

2. DESIGN DATA

2.1. GENERAL REQUIREMENTS

All Brazilian Administration, Flag Administration and CS requirements for the FPSO are to be fulfilled considering that the Unit cannot be dry-docked during the FPSO design life.

Analytical techniques and model test data are required to establish a sufficient database for the complete design of the system and its associated structural components (e.g., RAOs, QTFs, wind and current drag coefficients, roll damping coefficients, numerical models calibration, etc.).
Please refer to project GTD's for the required design life.

2.2. ACCEPTABLE SYSTEM

The riser system shall be installed along a balcony located on the portside of the Unit.

2.3. LOCATION

The FPSOs will be installed offshore, in Búzios 12 project. The Units heading is 180 deg relative to true North and WD at location is circa 1950 m. This information will be confirmed in the SUBSEA LAYOUT to be provided during the execution phase.

2.4. METOCEAN DATA

The riser system shall be designed in accordance with the data contained in the "METOCEAN DATA FOR DESIGN OF OFFSHORE SYSTEMS" specification (refer to GTD) and the applicable CS requirements.

The environmental conditions shall be considered in the several directions informed in the METOCEAN in order to cover all possible critical situations that the riser system may have to withstand during operational life.

The analyses shall be performed combining surface current and wind / waves according to a collinear approach, with current and wind / waves coming from the same direction, and a noncollinear approach, with current and wind / waves up to 45 deg apart. Wind and waves shall always be colinear.

NPD wind spectra shall be used if no other data is available. JONSWAP wave spectra shall be used according to the formulation presented in the METOCEAN. Only unimodal extreme sea-

states shall be considered. For fatigue analyses, the conditions presented in the "DURATION OF EXTREME CURRENT PROFILES AND CLUSTERS OF SIMULTANEOUS METOCEAN CONDITIONS" report (refer to GTD) shall be evaluated. If necessary, current profiles shall be truncated to the project WD.

3. FPSO INTERFACE

3.1. STRUCTURAL DESIGN

All structures shall be designed in accordance with the GTD and CS requirements.

All structures shall be designed as non-inspectable for the FPSO design life.

The calculation reports of the riser system structural components shall be submitted for PETROBRAS evaluation.

3.2. PAINTING AND CATHODIC PROTECTION

Structural elements shall be painted in accordance with the GTD.

The inner surface of I-tubes shall be protected with an anti-fouling painting scheme to avoid marine growth.

CONTRACTOR/SELLER shall not paint the bellmouths (BSDLs) and TSUDLs after their factory acceptance tests.

CONTRACTOR/SELLER shall provide adequate cathodic protection for the spread mooring and risers system structural elements, preferably via galvanic anodes.

4. CONTROL AND MONITORING

The control systems of the risers pull-in systems shall be provided with dedicated PLCs. Refer to the GTD for additional provisions.

All machinery monitoring sensors (pressure, temperature, flow, malfunctions, etc.) shall be interconnected to the local control panels at the operator's cabins. Malfunction and shutdown signals shall be linked to the Unit Control Safety System and visible in the Central Control Room.

The local control panels shall provide the required functions, indications and alarms to ensure easy and safe operation. Where several winches are used, the control panel may be a common centralized console to operate all equipment from the same stand.

The local control panels shall be installed in enclosed, weather-proof cabins located in protected areas to safeguard the operators against potential line breaks but also as close as safely possible to the winches, so that the operator may visually monitor operations.

The control panels shall be rated IP66 and compatible with the area classification (hazardous / non-hazardous) and a marine / salty / aggressive environment with water splashes.

All indicators and controls shall be clearly labeled. The readout from indicators shall be easily readable in bright sunshine. All information displayed on the control panel shall be in the English language, unless otherwise stated in the technical documentation.

As a minimum, the control panels shall include the following controls and alarms:

- Proportional speed control for paying-out or paying-in (joystick) with an automatic return to the neutral position (brakes on after coming to a stop) and a dead band around the 'zero speed' position to avoid unintended movements;

- A switch to toggle between 'tension release' and manual / speed modes (if applicable);
- Stall load limiter to enable safe operations at lower loads. CONTRACTOR/SELLER shall inform the lowest stall load settings possible and associated accuracy;
- HPU start and stop;
- HPU hydraulic pressure display;
- Load indication via calibrated load cells fitted to each winch frame. A 'hydraulic pressure vs. load' chart shall also be provided by CONTRACTOR/SELLER;
- Length totalizer and pay-in / pay-out speed;
- Event logs;
- Emergency stop push button;
- Alarm lights due to low oil level in the HPU reservoir, high oil temperature, power pack general alarm;
- Shutdown lights due to low-low oil level in the HPU reservoir, high-high oil temperature, power pack malfunction, automatic pay-out stop (due to achieving the minimum required length of chain / rope in storage);
- Automatic pay-out stop bypass (enclosed button) to be used in chain disposal or rope change-out operations.

5. HYDRAULIC POWER UNITS

Hydraulic Power Units (HPUs) shall be supplied and installed in suitable locations near the mooring hook-up systems.

The HPUs shall be dimensioned to supply enough power to simultaneously operate all the equipment necessary as defined in the operational procedures. A minimum of 2 x 100% or 3 x 50% hydraulic pumps shall be provided for redundancy.

The HPUs shall be self-contained skid units with adequate access and sufficient ventilation for maintenance purposes. The units shall incorporate easy access for removal of replaceable equipment and for routine maintenance activities.

6. RISERS SYSTEM

6.1. GENERAL

The riser system will be a coupled system, slots that will connect flexible risers and umbilicals shall be equipped with BSDL-SI (Diverless Bellmouth- Standard Interface) and slots that will connect rigid risers or flexible risers as alternative, shall be equipped with TSUDL (Unified Diverless Support Tube). See sections 6.4.4 and 6.4.5.

Note: the TSUDL can support both rigid risers and flexible risers.

CONTRACTOR/SELLER shall design, fabricate and install the riser balcony structures and facilities, including bellmouths (BSDL-SI), TSUDLs, I-tubes, hang-offs, hardpiping and the pull-in system.

All relevant information regarding the riser configurations is available in Appendix A – riser configuration data.

Refer to GTD for the riser slot quantity and details. The FPSO shall be prepared for all alternatives and diameters there informed. Refer to the “RISER SUPPORTS ARRANGEMENT” drawing (refer to GTD) for wells identification, functions, diameters, positions, bundles composition, etc.

6.2. RISER BALCONY AND PULL-IN STRUCTURE

CONTRACTOR/SELLER shall design, fabricate and install a balcony of sufficient size to accommodate the number of I-tubes for flexible risers and TSUDLs for rigid risers defined in the “RISER SUPPORTS ARRANGEMENT”.

The riser balcony shall be composed of two parts: a Lower Riser Balcony (LRB), where bellmouths, TSUDLs will be located, and an Upper Riser Balcony (URB), vertically above the LRB, for the flexible risers hang-off or rigid riser hang-off (TipT case). See Figure 1 and Figure 2.

CONTRACTOR/SELLER shall also design, fabricate and install a platform over the URB to support the riser pull-in system. The vertical clearance between the bottom of the last sheave at the main pull-in wire rope path — in the flexible direct pull-in configuration — and the top flange of the upper I-tubes at URB level shall be at least 8 m. Refer to item 6.5.

The bellmouths sustain the bend-stiffeners of flexible risers at the LRB and the I-tubes guide the risers for connection with the FPSO piping at the URB. The flexible risers shall be arranged in one layer, parallel to the FPSO side. See Figure 1.

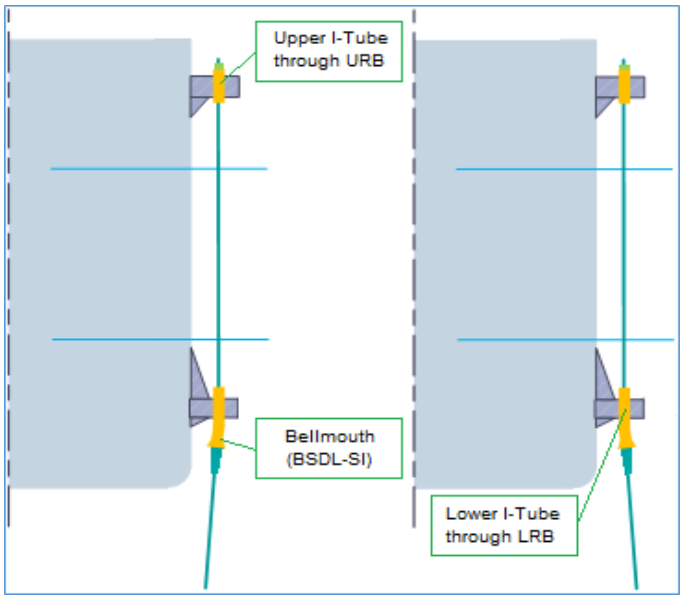


Figure 1 – I-Tube Assembly with two I-Tube Sections. (Illustrative).

Rigid risers can be supported in two different ways, depending on the type of riser interface used (TiPT or HOA). They can be directly connected to the Lower Balcony section (LRB) using Support Tubes (TSUDL) as hang-off system (HOA case) or can be fitted to the hull through the LRB and the URB (TiPT case), see figure 2.

Another feature of the Riser Balcony is that support positions expected for Rigid Risers shall also consider the possibility of connecting Flexible Risers in place of them.

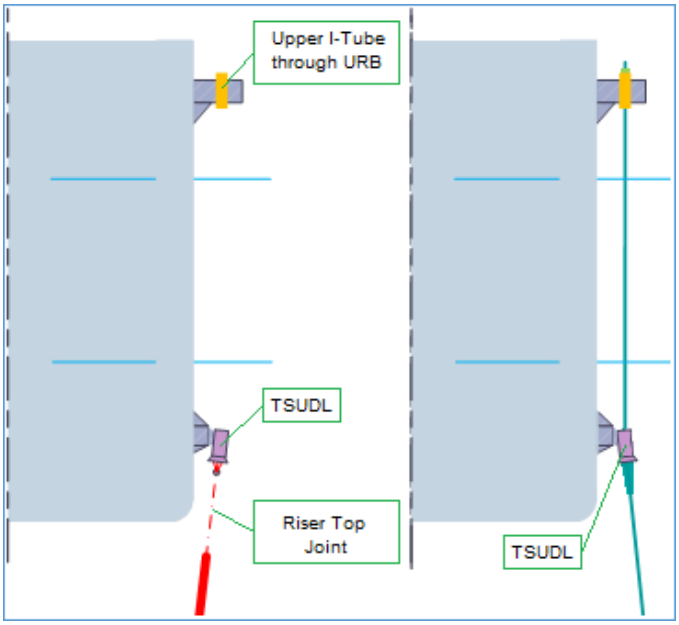


Figure 2 – Riser Support Tube Assembly (TSUDL & Upper I-Tube) (Illustrative).

NOTE: Figure 2 illustrates one TSUDL configuration for both Rigid (HOA case) (Starboard approach) and Flexible or Rigid (TiPT case) (direct approach). Nevertheless, TSUDL can be used for direct and starboard approach of any type of riser (rigid or flexible).

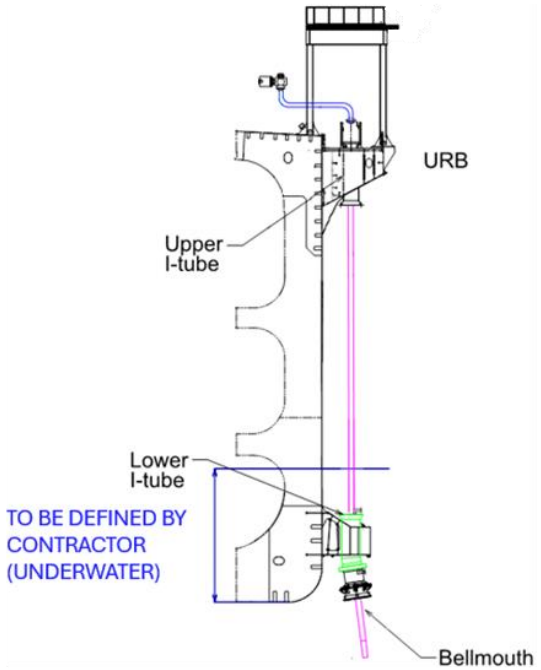
The Unit side-shell shall be provided with hardpiping near the rigid riser positions for underwater connection after the pull-in and pre-commissioning of the risers (see item 6.4.6 for further hardpiping requirements) and hullside umbilicals for lower balcony monitoring and control (see item 6.4.7 for further hullside umbilical requirements).

The LRB position shall guarantee that no clashing between risers and the FPSO structures will occur considering extreme (100-yr offsets and motions) and accidental cases (1-yr offsets and motions coupled with accidental heeling of the FPSO).

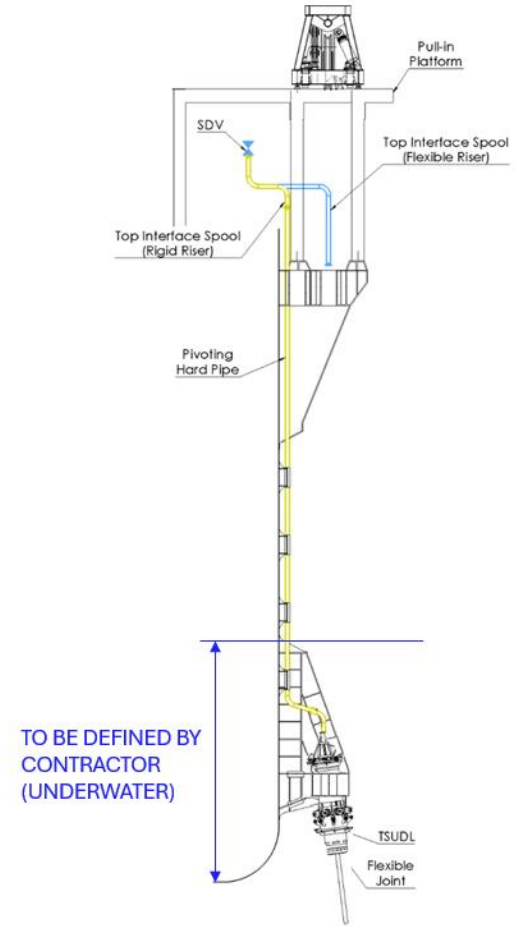
The vertical position of TSUDLs, BSDLs shall be such as to guarantee full immersion of stress / flexible joints (including flanges and connecting studs) at any operational draft.

The URB shall be designed with walkways around the upper I-tubes to assist hang-off installation operations, pipe spool and umbilical connections, etc. The design shall minimize assembly / disassembly of riser SDVs (shutdown valves) during pull-in / pull-out operations. Ideally, the standing piping leading to ESDV should enable performing each kind of riser connection (for rigid or flexible riser) by assembling just one spool and, as far as possible, side shell hardpiping should comprise an upper section centered with its lower section, passing through the URB by a proper opening, as shown in Figure 3, in order to avoid obstructions of upper I-Tubes. In any case, handling facilities shall be provided to enable easy and safe operations.

Figure 3 shows the riser balcony arrangement considering each type of riser support for the project, BSDL and TSUDL.



a) BSDL Arrangement - Flexible/ Umbilical Riser



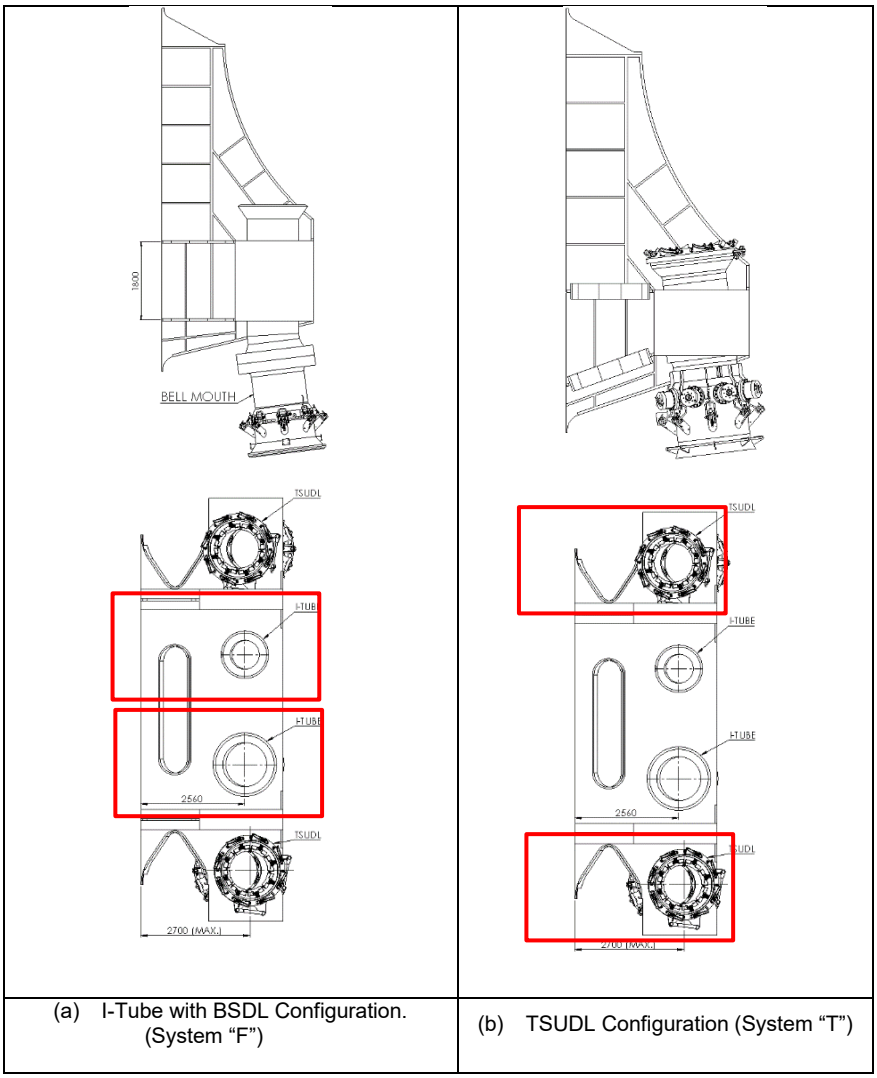
b) TSUDL Arrangement - Rigid Riser

Figure 3 - Riser Balcony Arrangement.

6.2.1. SUPPORT SYSTEMS (DEFINITIONS)

As described above, three kinds of riser support systems are required: System "F" is for connection of Flexible and Umbilical Risers and System "T" is for Rigid Riser or alternative Flexible Riser.

System "F" Starboard/Portside	I-Tube Assembly for Flexible/ Umbilical Riser/ Rigid (TiPT case).	Figure 4a
System "T" Starboard/Portside	(i) TSUDL (1st layer) for Rigid Riser (HOA case) as a Hang-off system; for Rigid Riser (TiPT case) or Flexible Riser as a bellmouth. (ii) Upper I-Tube for both Rigid (TiPT case) and Flexible riser, as a Hang-off.	Figure 4b



(a) I-Tube with BSDL Configuration. (System "F")

(b) TSUDL Configuration (System "T")

Figure 4 – LRB Arrangement for Porch Modules with BSDL(s) and TSUDL(s) (illustrative).

Note: Figure 3 and 5 shows the configuration examples for direct approach risers, but similar configuration is also used for keel hauling risers.

The position and clearances between riser slots shall be defined by the CONTRACTOR/SELLER based on interference studies during pull-in / pull-out operations and considering the FPSO heel,

trim and dynamic motions (roll and pitch). No interference between pull-in cables, sheaves, installed risers or any side-shell structure shall occur.

In order to enable proper riser connection / disconnection, PETROBRAS recommends a minimum clearance of 100 mm, between outer edges (of locking mechanisms) of adjacent BSDLs (for engaging / disengaging handles). Consequently, the resulting minimum separation distance between adjacent BSDLs, axis-to-axis, considering hydraulic actuator assembly for locking mechanisms, should be in accordance with Figure 5 and Table 1.

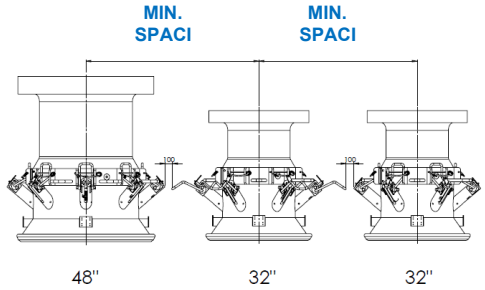


Figure 5 - Support Minimum Spacing.

Table 1 – Minimum(1) Separation Distance between BSDLs

I-Tube sizes [inch]		Axis-to-Axis Spacing [mm]
48	48	2700
48	32	2500 (2)
32	32	2300

(1) Values at the safe side. Contractor/seller may propose optimization through 3D modeling of BSDL assembly on LRB structures.
(2) For different sizes, reduction of separation distance may be achieved also by staggering vertical position BSDLs.

The distance between adjacent supports (I-tubes) shall provide a minimum spacing of 1600 mm face-to-face of the risers in order to allow for inspections by ROVs.

The distance between adjacent TSUDLs shall be assessed to avoid interferences, mainly for the hydraulic modules of the latch bars and MTLs. A sufficient space for TSUDL mechanisms operation and maintenance shall be provided.

CONTRACTOR/SELLER shall inform the as-built coordinates, top angle and azimuth angle for all riser supports at URB level (hang-off) and LRB level (bellmouths). The maximum construction tolerances shall be ± 0.5 deg for the top angles and azimuths.

6.3. RISER LOADS

CONTRACTOR/SELLER shall supply the supported interface loads for the risers vendors within 9 months after the project KoM.

CONTRACTOR/SELLER shall evaluate the riser configurations informed preliminarily in Appendix A – riser configuration data, in order to ensure proper dimensioning of the riser balcony and pull-in system structure. Final riser configuration for balcony dimensioning will be confirmed at KoM.

The acceptable methodology is described in “RISER TOP INTERFACE LOADS ANALYSIS” specification (refer to GTD). CONTRACTOR/SELLER shall consider that:

- For flexible risers in both systems “F” and “T” bending moments, shear forces and 10% of tension are applied on the LRB (due to friction) while 100% of tension is applied on the URB.
- For rigid risers in system “T”, bending moments, shear forces and tension are applied on the LRB. In addition, CONTRACTOR/SELLER shall consider 10% of bending moments, 10% of shear forces and 100% tension also in URB (due to TiPT case).
- Markup factors for the estimated riser loads are defined on this specification, except for the bending moments of umbilicals, for which the markup factor of 1.8 shall be applied.
- For assessment of fatigue top loads, CONTRACTOR/SELLER should employ closed form solutions with an assumption of a Weibull long term stress range distribution where a shape parameter to the safe side shall be used.

6.4. RISER INTERFACES

6.4.1. TOP FLANGES

CONTRACTOR/SELLER shall provide the flanges with ring gaskets, stud bolts and nuts for the risers interfaces according to API 6A and API 17D. The datasheets, including dimensional drawings, shall be submitted to PETROBRAS.

The interface flanges materials shall be defined in accordance with the GTD. The materials selection report shall be submitted for PETROBRAS.

All flanges shall be provided with 3 mm nickel alloy UNS6625 overlaid through the whole sealing area.

Ring-grooves shall have minimum hardness of 220 HB and iron content less than 5% at 0.5 mm from the overlay surface.

CONTRACTOR/SELLER shall provide ring gaskets, stud bolts and nuts for all the interface flanges with risers:

- Sets of ring gaskets, stud bolts and nuts to be supplied shall fully attend to the needs for both temporary (e.g., fit-up, testing, preservation) and offshore installation.
- Stud bolts and nuts of underwater flanges shall be made in ASTM A 320 L7 and shall comply with “High-Strength Low-Alloy Steel Fasteners for Subsea Applications”, refer to GTD.
- Stud bolts and nuts shall be suitable for hydraulic bolt tensioning.
- The ring gaskets shall be compatible with the flanges and with maximum hardness 190 HB. SBX gaskets are not acceptable.

NOTE: Surfaces where stud bolts and nuts are assembled shall not be coated to assure electrical contact between flanges and stud bolts.

CONTRACTOR/SELLER shall provide hardpiping / spool pieces, ending in swivel flanges with the specs given in the tables below to interconnect the riser end-flanges to the FPSO piping. All alternatives defined in GTD and “RISER SUPPORTS ARRANGEMENT” drawing shall be taken into account. (See note 1and note 2)

Note 1 - In the WAG positions, the closing spool shall have an interface for connection to a 4" flexible riser.

Note 2 - In the Gas Transfer positions, the closing spool shall have an interface for connection to a 6" flexible riser.

Table 2 – Flexible riser, umbilical and Rigid Riser (TipT case) interfaces

Riser Top Flange		FPSO Spool Flange		
ID [in]	**Spec**	**ID [mm]**	**Spec**	**Flange Height [mm]** (Figure 6)
4 or 6	7 1/16" API 6BX 10000 psi BX-156 with N2 test port (2)	152.40	7 1/16" API 17SV 10000 psi BX-156 (2)	810 ± 2.5(2)
6.5	7 1/16" API 6BX 10000 psi BX-156 with N2 test port (2)	165.10	7 1/16" API 17SV 10000 psi BX-156 (2)	810 ± 2.5(2)
8	9" API 6BX 10000 psi BX-157 with N2 test port (2)	203.20	9" API 17SV 10000 psi BX-157 (2)	960 ± 2.5(2)
UEH	9" API 6B 2000 psi flat face(2)	-	-	600 ± 2.5(2)
UEH Power Import	9" API 6B 2000 psi flat face (2)	-	-	see (1) and (2)

(1) For Power Import Umbilical space/distance requirements refer to GTD.
(2) To be confirmed.

Table 3 – Rigid riser interfaces

		Riser Top Flange (HOA) (1)	FPSO Spool Flange
ID [in]	**Nominal size (Inch)**	**Spec**	**Spec**
6 / 6.5	9(2)	API 15000 psi, 6BX -158 with N2 test port (2)	API 17SV 15000 psi, 6BX-157 (2)
8	9(2)	API 15000 psi, 6BX - 158 with N2 test port (2)	API 17SV 15000 psi, 6BX – 157 (2)
9	9(2)	API 15000 psi, 6BX - 158 with N2 test port (2)	API 17SV 15000 psi, 6BX – 157 (2)

(1) ID transition (see sec.6.4.1.2 in case of HP for related risers presents larger ID.
(2) To be confirmed.

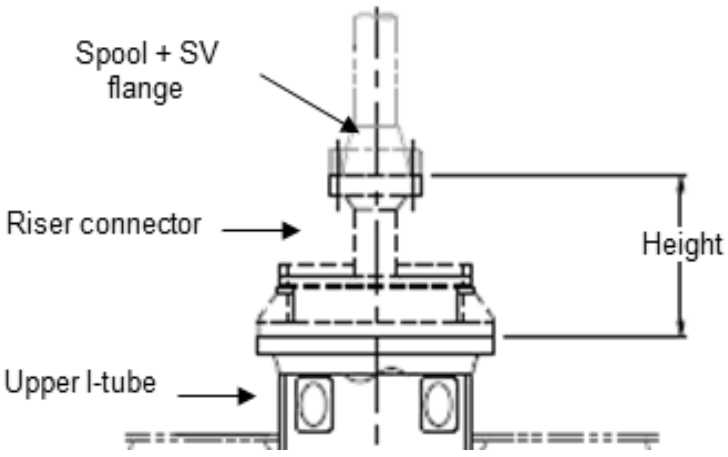


Figure 6 – Hang-off detail.

The flexible riser end-fittings and rigid riser terminated in TipT will be provided with N_2 test ports and a gas bleed-off connection for depressurization in case of gas leakages.

CONTRACTOR/SELLER shall design the venting system in accordance with "ANNULUS PRESSURE MONITORING AND RELIEF SYSTEM" section of GTD.

Underwater flanged connections shall also be provided with leak test ports and means to drain any trapped fluids (see API 17D for reference). For stress / flexible joints, their N_2 leak test port may be used to drain water from the ring grooves.

6.4.1.1 SUPPORT TUBES

CONTRACTOR/SELLER shall design and fabricate the HOA termination Mockups to enable proper fit-up test at shipyard, in order to guarantee the correct dimensioning of spool pieces connecting the FPSO piping and HOA top flanges.

Reference is made to "UNIFIED DIVERLESS SUPPORT TUBE (TSUDL) - GENERAL REQUIREMENTS" (refer to GTD).

The design solution shall enable the insertion and locking of the Mockup assembly from the top of the support tube, taking into account the ID restriction on the top cone due to the sacrificial protection abovementioned. Figure 7 brings an example for this kind of solution.

The mockups shall be fabricated including blind flanges at the top end with the same specification of the riser top flange in order to enable fit-up and N_2 leak tests of the FPSO piping. Such tests shall be performed at the shipyard before final sail-away.

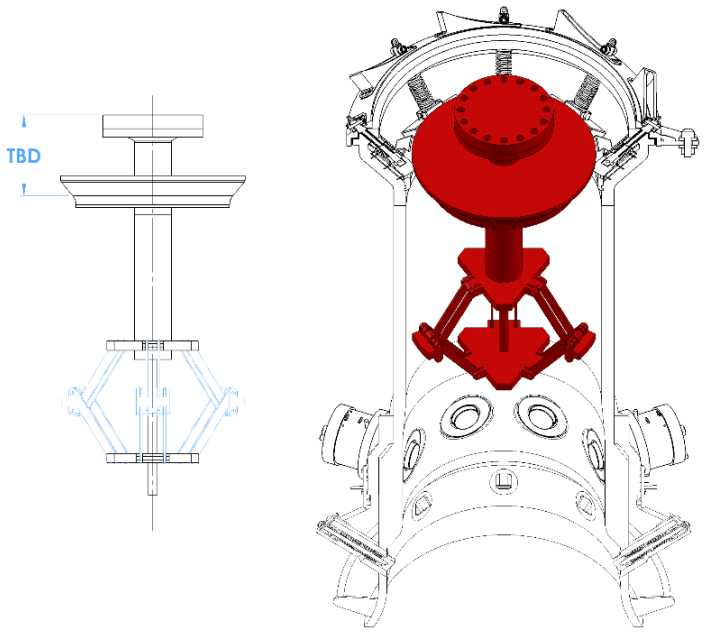


Figure 7 – Mockup of HOA Termination (Reference Only).

Target for the above dimension TBD (Figure 7) will be defined by PETROBRAS at the project kickoff meeting.

6.4.1.2 HOA TOP ASSEMBLY (ON SUPPORT TUBES)

For TSUDL Top assembly, ID Transitions between Risers and Hardpiping shall consider the following:

- Whenever hardpiping presents bore larger than the risers, the ID transition should be located on HOA Top flange (beneath its face).

- Whenever hardpiping presents bore smaller than the risers, the ID transition shall be performed inside the hardpiping or on its interface flange with riser.

6.4.2. HANG-OFFS

The hang-off systems (split-collar + pull-in head) for flexible risers and umbilicals will be supplied by PETROBRAS. Detailed schematic drawings of the flexible riser end-fittings and hang-off fittings (split-collars) will be provided during execution phase.

Proper means to move the riser hang-off systems to the connection deck and position them in place shall be provided.

6.4.3. I-TUBES

Flexible and Umbilical Risers will be connected to the hull through lower and upper I-Tubes attached to balcony sections, as shown in Figure 8. The upper I-Tube will anchor the riser axial loads on URB, and the lower I-Tube arrange will incorporate a diverless bellmouth (BSDL-SI) to support the riser bend stiffener.

Continuous guide tubes are not acceptable. The guide tubes shall be split into upper and lower parts in order to allow risers inspection.

CONTRACTOR/SELLER shall define the required wall thickness for the upper and lower I-tubes.

The upper I-tubes shall end in MSS SP-44-2010 FFWN #300 seat flanges matching the respective riser hang-off split collars. These flanges shall be in an elevation high enough above the URB level to allow the provision of three evenly spaced windows (150 mm height x 150 mm width), in order to enable inspection of the flexible riser end-fittings. Removable caps shall be installed on the upper I-tubes flanges and inspection windows.

The lower I-tubes shall also end in flanges, with the respective nominal top angles and azimuths as defined in the “RISER SUPPORTS ARRANGEMENT” and matching the respective bellmouth flanges (flat faces).

The nominal diameters for the I-tubes / bellmouths shall be 32” for umbilicals (except for the umbilical for control and power import*) and 48” for all other flexibles. Details of the pull-in / pull-out rigging will be provided by PETROBRAS during execution phase upon request.

*Note – For control and power import umbilical, the 48” I-tube/bellmouth shall be considered.

The upper and lower I-tubes intermediate ends shall be flared to a conical shape with smooth internal edges. Protection for the exposed parts of the risers shall be designed if indicated by the required safety studies.

The I-tubes shall be identified in three points, evenly spaced, in bas-relief and painted in a contrasting color. The correlation between I-tubes and subsea wells shall be clearly represented in the installation procedures.

CONTRACTOR/SELLER shall provide as-built drawings together with all inspection reports performed during fabrication. The as-built drawings shall inform top angles, dimensions and tolerances. These tolerances shall take the paint thickness into account.

CONTRACTOR/SELLER shall fabricate machined mockups to enable proper fit-up test at shipyard in order to guarantee the correct dimensioning of spool pieces connecting the FPSO piping and flexible risers top connector flanges at the URB level. The mockup drawings shall be submitted for comments.

The mockups shall be fabricated including blind flanges at the top end with the same specification of the riser top flange in order to enable fit-up and N_2 leak tests of the FPSO piping. Such tests shall be performed at the shipyard before final sail-away.

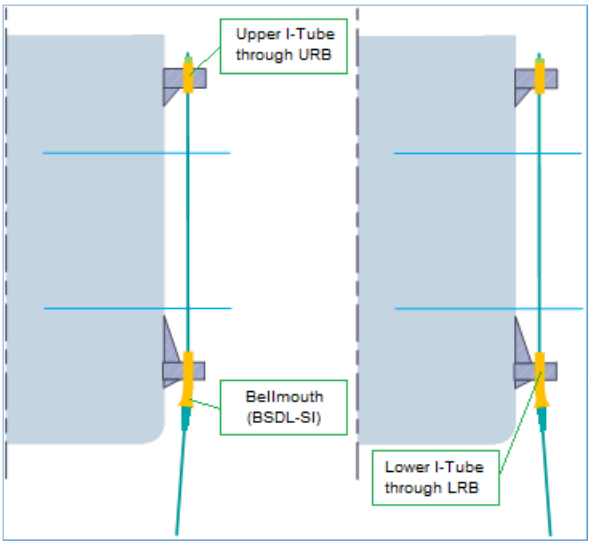


Figure 8 - I-Tube Assembly with Two Sections.

6.4.4. BELLMOUTHS

Bellmouths will be connected to the lower I-Tubes, close to FPSO keel level, and will sustain the bend-stiffeners of flexible risers and umbilicals. Bellmouth sizes are defined in section 6.4.3.

CONTRACTOR/SELLER shall supply diverless bellmouths (BSDL-SI), with automation capabilities for full diverless pull-in and pull-out operations and cathodic protection monitoring. Refer to the GTD for the related specifications, as follows:

- "DIVERLESS BELL MOUTH (BSDL) - GENERAL REQUIREMENTS";
- "BSDL-SI PART LIST";
- "DESCRIPTIVE MEMORANDUM – SUBSEA MONITORING SYSTEM FOR FPSO";
- "HIGH-STRENGTH LOW-ALLOY STEEL FASTENERS FOR SUBSEA APPLICATIONS".

CONTRACTOR/SELLER shall supply all bellmouths already bolted in their positions and with safety locking devices and fully integrated with the automation system.

CONTRACTOR/SELLER shall design the bellmouths in such a way that offshore replacement by divers is possible. All materials and operations will be CONTRACTOR/SELLER's responsibility. The operational procedure shall be submitted for PETROBRAS.

During execution phase, CONTRACTOR/SELLER shall confirm if the original bellmouth drawings are suitable for the expected loads (strength and fatigue) due to WD at the FPSO location. If any design revision is required, PETROBRAS shall receive the technical modification proposal for analysis and acceptance. The final engineering verification, manufacturing drawings and manufacturing processes are CONTRACTOR/SELLER's responsibility.

All weld surfaces inside the bellmouths shall be grinded down to an even and smooth profile, to avoid interference with the bend-stiffener locking devices. Care shall be taken regarding electrical connections between the bellmouth flanges and moving parts (dogs) in order to guarantee continuous cathodic protection from the FPSO.

CONTRACTOR/SELLER shall provide as-built drawings together with all inspection reports performed during fabrication. The as-built drawings shall inform dimensions and tolerances. These tolerances shall take the paint thickness into account.

All bellmouths shall be identified in three points, evenly spaced, in bas-relief and painted in a contrasting color. The correlation between bellmouths and subsea wells shall be clearly represented in the installation procedures.

CONTRACTOR/SELLER shall fabricate dummy caps to perform interference checking after bellmouths are bolted and tightened to the lower I-tubes, according to the bellmouth documentation.

CONTRACTOR/SELLER shall keep spare parts of the bellmouths onboard the FPSO in case replacement is needed.

Note: For BSDL design, in addition to the riser loads, the weight of the cap + PU stiffener shall be considered. Petrobras will provide this information at KoM.

6.4.5. UNIFIED DIVERLESS SUPPORT TUBES (TSUDL)

CONTRACTOR/SELLER shall design, fabricate and integrate diverless support tubes (TSUDLs). The TSUDL is a hybrid support as it incorporates features to connect both rigid risers and flexible risers, for the intended sealines.
Figure 9 illustrates the TSUDL integration to the hull porch structure through its box structure.
For the TSUDL design and supply, CONTRACTOR/SELLER shall apply the following PETROBRAS specifications: (refer to GTD).

- "UNIFIED DIVERLESS SUPPORT TUBE (TSUDL) - GENERAL REQUIREMENTS";
- "UNIFIED DIVERLESS SUPPORT TUBE (TSUDL) PARTS LIST";
- "DESCRIPTIVE MEMORANDUM – SUBSEA MONITORING SYSTEM FOR FPSO";
- "HIGH-STRENGTH LOW-ALLOY STEEL FASTENERS FOR SUBSEA APPLICATIONS".

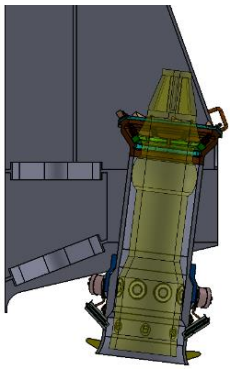


Figure 9 – Unified Support Tube (TSUDL) for Hang-off of Positions for Rigid risers (starboard directions).

Note: The TSUDL drawings and the technical specifications will be updated and final revision will be issued until KoM.
Note: For TSUDL dimensioning, in addition to the riser loads, the minimum weight of the cap (for flexible risers) shall be considered. Petrobras will provide this information at KoM.
Note: The Upper Cone of TSUDL shall have a temporary protection system to safeguard all components of locking system during shipyard construction, and to keep installed during the pull-in operation. See "UNIFIED DIVERLESS SUPPORT TUBE (TSUDL) - GENERAL REQUIREMENTS".

Care shall be taken regarding electrical connections between the TSUDL main body and its moving parts in order to guarantee continuous cathodic protection from the FPSO.
TSUDL will require automation capabilities for diverless pull-in and pull-out operations, as well as for CP monitoring, fully integrated to the Topside. Reference is made to the following PETROBRAS Specifications: (refer to GTD).

- "DESCRIPTIVE MEMORANDUM – SUBSEA MONITORING SYSTEM FOR FPSO".

All materials will be CONTRACTOR/SELLER's responsibility. The operational procedure shall be submitted for PETROBRAS.
CONTRACTOR/SELLER shall design, fabricate, perform operational tests and install the TSUDLs (fully integrated with their automation system).
TSUDLs require sacrificial protection against abrasion (wear bushing) due to the contact and movements of the main wire rope during pull-in / pull-out operations. The design of this protection will be confirmed through full scale load tests to be performed by CONTRACTOR/SELLER. (see PETROBRAS Specification, "WEAR BUSHING FOR RISER UNIFIED DIVERLESS SUPPORT TUBES", refer to GTD).
The TSUDL design shall be configured to include the transition plates with LRB section welded on the factory before final machining (see "UNIFIED DIVERLESS SUPPORT TUBE (TSUDL) - GENERAL REQUIREMENTS", refer to GTD), to avoid distortion inside the TSUDL. Furthermore, checking of internal profile with dummy HOA (see figure 10 and "Unified Diverless Support Tube (TSUDL) Parts List", refer to GTD), is required during the FAT of each TSUDL (see PETROBRAS specification and "UNIFIED DIVERLESS SUPPORT TUBE (TSUDL) - GENERAL REQUIREMENTS", refer to GTD) and, whenever PETROBRAS deems it necessary, after the assembly of the TSUDLs on LRB modules.

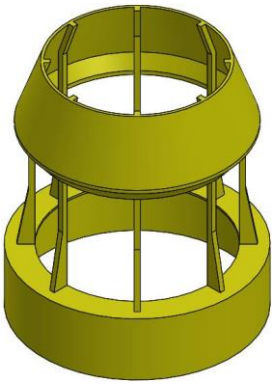


Figure 10 – Dummy HOA.

6.4.5.1 TSUDL HANG-OFF INTERFACES FOR RIGID RISERS

For HOA interface cases, Rigid risers will incorporate a transition piece (HOA) integrated to the Riser Top Joint, to make the connection to their support-tubes (TSUDLs) at the LRB, as shown in Figure 9.
The Top Joint / HOA assembly allows both riser structural connection with TSUDL and piping connection with the HP.
Although the HOA assembly is scope of pipeline installation company, CONTRACTOR/SELLER shall regard its geometry and tolerances on both design and functional testing of the TSUDL to ensure the adequacy of this hang-off system for the intended application.
The TSUDL comprises a top cone featuring locking wedges to support rigid riser axial loads, and a cylindrical body presenting a lateral locking system at its base to suppress radial gaps with the transition piece (HOA) of the rigid riser, in order to avoid relative rotations which could adversely affect the integrity of hang-off interfaces and hullside hardpiping.

6.4.5.2 TSUDL LOCKING INTERFACE FOR FLEXIBLE RISERS

TSUDL fulfills the same functions of a Lower I-Tube/Bellmouth for the pull-in of the flexible riser and attachment of its bend stiffener to the LRB. Moreover, TSUDL employs interface mechanisms and automation features equivalent to BSDL-SI features, to achieve diverless capabilities during pull-in/ pull-out.
Figure 11 presents a sketch of the bend stiffener coupled on TSUDL by means of its metallic extension.
More information regarding geometries of bend stiffeners is presented in Appendix A – riser configuration data.

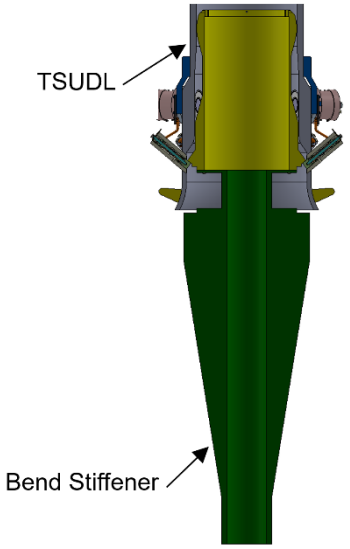


Figure 11 – Bend Stiffener coupling with TSUDL.

6.4.6. HARDPIPING

All balcony positions with TSUDL(s) for rigid risers shall have hullside pipes (hardpiping) in order to connect the riser top connector (stress or flexible joint) in the LRB up to the URB.

In order to reduce diving scope, hardpiping shall be a continuous piece, connected to the risers through a rotation of the pipe (either the whole hardpiping or just its bottom end by means of swivel flanges), requiring only one submerged flange connection.

Hardpiping shall be assembled at the shipyard on their pre-pull-in folded positions, anchored to a cradle support appropriate for sea fastening and long term parking. These folded positions shall not interfere with nor impose restrictions to the pull-in/pull-out operations of nearby risers.

The hardpiping supports shall provide enough degree of freedom to enable fine tuning during underwater fit-up operations. Allowable misalignments between the rigid risers top flanges and the hardpiping interface flanges shall be taken from the flanges design standards.

Hardpiping material selection, design and fabrication shall fulfill the “TECHNICAL SPECIFICATION FOR HARD PIPE” (refer to GTD).

CONTRACTOR/SELLER shall provide a pipe stress analysis of the hardpiping in operational conditions. The assessment shall include construction and assembly tolerances, hull sagging and hogging, hydrodynamic loads acting on the pipe, deflections of the pipe during transit and displacements of the riser balcony structure due to the riser loads. The pipe stress analysis results shall include pipe stress, flange leakage (refer to API 6AF) and the loads acting on the pipe support. The calculations shall be issued for PETROBRAS approval.

Even being defined by PETROBRAS, it is in CONTRACTOR/SELLER scope to check the bottom flange adequacy due to loads imposed by the hardpiping.

During the execution phase, CONTRACTOR/SELLER shall supply the maximum loads the hardpiping will impose into the connection flange in order to allow the design of the top connector.

Vortex Induced Vibration (VIV) and wave fatigue shall be verified and avoided.

The effects of the riser stiffness on the hardpiping should be incorporated in the design analysis. Hull piping should be modelled with the riser top connector and sufficient porch structure to ensure the stiffness of the complete structure is captured.

The design shall speed up the assembly, minimizing diving activities, offshore construction, loads lifting, etc. The hardpiping in their pre-pull-in position shall not interfere with nor impose restrictions to the pull-in / pull-out operations of adjacent risers.

Hardpiping geometry shall not interfere in pigging operations. Refer to “PIG FACILITIES” requirements in GTD.

The lower flanges of the pipes shall be identified in three points, evenly spaced, in bas-relief and painted in a contrasting color. The correlation between hardpiping and subsea wells shall be clearly represented in the installation procedures.

CONTRACTOR/SELLER shall foresee protection against corrosion for hardpiping destinated to risers that will be installed in the future.

CONTRACTOR/SELLER may propose alternative solutions to be evaluated by PETROBRAS during the tender process.

6.4.7. HULLSIDE UMBILICALS FOR LRB INTERFACES

CONTRACTOR/SELLER shall provide multipurpose hullside umbilicals for the circuits of hydraulic, electrical and optical functions required for actuation of mechanisms and monitoring of diverless bellmouths (see item 6.4.4) and TSUDLs (see item 6.4.5) on Lower Riser Balcony, and for operation of Rigid Riser Monitoring System (RRMS) in accordance with ”DESCRIPTIVE MEMORANDUM – SUBSEA MONITORING SYSTEM FOR FPSO” specification (refer to GTD).

CONTRACTOR/SELLER shall take special attention to the mechanical protection of connections underneath the LRB for all these circuits against the severity of offshore environment (particularly wave and current loads and effects).

6.5. PULL-IN SYSTEM

Pull-in / pull-out operations onboard the FPSO and any diver-assisted related operations are in CONTRACTOR/SELLER’s scope of work.

The pull-in package shall consist of all required equipment, materials, handling devices and spare parts in order to enable the risers installation / de-installation procedures onboard the FPSO.

All equipment and instruments shall be compatible with the area classification (hazardous / non-hazardous) and a marine / salty / aggressive environment with water splashes.

The system shall be able to access every riser position and shall not interfere with installed risers.

The pull-in system facilities shall enable the realization of pre and/or post-pull-in activities (e.g., positioning of auxiliary sheaves, closing of interface flanges, pre-commissioning activities, etc.) in different positions simultaneously with main winch operations. The final system design shall be submitted for PETROBRAS.

The pull-in system shall be designed to accommodate and integrate operations performed by an ROV, ensuring safe and adequate access to connection points and riser support systems.

6.5.1. PULL-IN WINCHES

The pull-in rig shall be composed of at least one main winch and one service winch. All winches shall be electro-hydraulic.

The main pull-in winch shall be dimensioned to support the pull-in loads envelope. CONTRACTOR/SELLER shall perform pull-in and pull-out analysis to confirm the loads envelope. The main winch minimum pull capacity shall be 650 mT. The service winch minimum pull capacity shall be 40 mT. The minimum rated speed shall be 2 m/min @ maximum load (top layer).

Pull-in winch design shall consider that umbilicals are usually lighter structures and may be installed by first end pull-in. In this case, pull-in winch shall be able to normally operate with much lower loads than its rated load.

The main winch shall be provided with means to guarantee that the wire rope will always reach the flexible riser supports in a vertical and centralized configuration and the rigid riser supports with the required clearance for a safe operation, as per item 6.5.8.

CONTRACTOR/SELLER is responsible for the verification of the minimum pull capacity required for all winches during execution phase, in accordance with “RISER TOP INTERFACE LOADS ANALYSIS” specification (refer to GTD). For the main winch assessment, an extra load of 50 mT shall be added to the design loads of flexible risers and umbilicals in order to account for the shearing of cables during the bend-stiffener connection to the associated bellmouth.

The main winch shall be able to pay-out at least 800 m of wire rope hanging below LRB level. The service winch shall be able to pay-out at least 650 m of wire rope hanging below LRB level. The winches shall be capable of paying-in / out small lengths of wire rope, to allow accurate positioning of the risers into their slots.

All winches and storage drums shall be provided with an automatic braking system, to be engaged when paying-in/out operations have stopped, at power failure, control failure or at emergency stop. Technical or operational failures shall not lead to uncontrolled cable pay-out. An emergency brake release system (e.g., manual pumps) shall also be provided.

The winches shall be provided with a tension release control mode to enable easy and safe rigid risers pull-in operations.

Storage drums of linear pull-in winches shall be automatically synchronized with the speed and the required back-tension of the wire rope coming from the winch, even in manual operation mode. Alternative arrangements may be proposed.

Multi-layer drums shall be Lebus grooved. The maximum number of rope layers shall be 7.

6.5.2. PULL-IN ROPES

The pull-in wire ropes shall be dimensioned considering the smallest diameter that meets the required SWL with a SF = 2.5 on the respective winch nominal pull capacity.

The wire ropes shall be specified according to the following characteristics (or similar): EIPS steel (1960 MPa), galvanized, rotation-resistant, right hand Lang’s lay, compacted strands, heavy duty lubrication, crushing and bending fatigue resistant, provided with Closed Spelter sockets for main winch and Open or Closed Spelter Sockets for auxiliary winches (to be confirmed by PETROBRAS during execution phase).

Fiber ropes are also acceptable for the auxiliary system. In this case, the specification shall be informed to PETROBRAS for prior evaluation.

The ropes shall be furnished in the winch drums and already tensioned, according to the required back-tension specified by wire rope manufacturers.

CONTRACTOR/SELLER shall present evidence of compliance with the technical requirements of wire rope manufacturers. The ropes shall be supplied with certificates verifying:

- Grade and strength
- Quality in compliance with the appropriate standards
- CS requirements

CONTRACTOR/SELLER shall also deliver one spare rope for each winch. Means for spooling the spare ropes onto the winches and meet the required pre-tension with the FPSO at the final location shall be provided. CONTRACTOR/SELLER shall issue a detailed procedure and provide all necessary equipment and accessories.

6.5.3. DEVIATION SHEAVES

Effective devices shall be provided to prevent the wire ropes from escaping the sheaves.

Minimum sheave diameter shall be 16 times the respective wire rope nominal diameter.

Sheaves efficiency shall not be less than 98%.

6.5.4. SERVICE FACILITIES

CONTRACTOR/SELLER shall provide facilities to assist pull-in / pull-out operations, e.g., for the assembly / disassembly of flexible riser hang-off systems and spool pieces at URB, connection / disconnection of pull-in riggings, deployment / retrieval of messenger ropes to / from installation vessels (specially for keel-hauling operations), main pull-in wire rope handling and routing through deviation sheaves, connection / disconnection of PLRs and riser top valves, etc.

CONTRACTOR/SELLER shall provide a davit / crane SWL 15 mT for onshore lifting / 12 mT for subsea lifting @ 8 m capable of operating independently of the main winch system in order to, for example, support diving operations in different positions simultaneously with main winch operations. Other arrangements may be proposed.

6.5.5. HYDRAULIC POWER UNITS

Hydraulic Power Units (HPUs) shall be supplied and installed in suitable locations near the risers pull-in systems.

The HPUs shall be dimensioned to supply enough power to simultaneously operate all the equipment necessary as defined in the operational procedures. A minimum of 2 x 100% or 3 x 50% hydraulic pumps shall be provided for redundancy.

The HPUs shall be self-contained skid units with adequate access and sufficient ventilation for maintenance purposes. The units shall incorporate easy access for removal of replaceable equipment and for routine maintenance activities.

6.5.6. DIVING FACILITIES

Diving activities required for pull-in / pull-out operations are CONTRACTOR/SELLER's scope. The diving team will be sized to operate 1 front x 24 hours/day uninterruptedly during the risers installation campaign.

In order to assist pull-in operations, at least two stations near the riser balcony shall be provided. Both stations shall be equipped to avoid time concerns related to diving operations.

The pull-in diving stations shall be positioned considering 33 m as the maximum allowable outreach for diving operations at night (measured from the diving bell).

The underneath of the LRB shall be provided with four pad eyes for each I-tube (minimum SWL 15 mT) and a handrail system in a closed pattern near each bellmouth.

Grab handles shall be provided on the LRB, for each bellmouth, positioned and sized in such a way that an ROV arm can reach and keep taking hold during the intervention. Grab handles shall be designed according to ISO 13628-8 - Petroleum and natural gas industries — Design and operation of subsea production systems — Part 8: Remotely Operated Vehicle (ROV) interfaces on subsea production systems.

CONTRACTOR/SELLER shall provide, maintain and operate a ROV system and all associated facilities to enable monitoring of pull in operations, risers inspections and replace diving operations when possible. The specifications and requirements of the ROV will be informed by PETROBRAS during execution phase.

CONTRACTOR/SELLER shall also provide all other resources required to enable the diving activities described below. Refer to the CONTRACT for the detailed scope.

- Pull-in / pull-out preparation (messenger lines installation, handling of cables, connection / disconnection to transfer riggings, bellmouths, TSUDLs inspection, etc.)
- Bend-stiffener connection / disconnection to bellmouths (contingency cases)
- Bellmouths replacement
- Support of rigid risers pre-commissioning operations (PLR and riser top valves assembly / disassembly and operation, etc.)
- Connection / disconnection of hardpiping to the stress / flexible joints top flanges (handling, bolts tensioning, seal test, etc.)
- Installation of the rigid risers monitoring system in accordance with "DESCRIPTIVE MEMORANDUM – SUBSEA MONITORING SYSTEM FOR FPSO" specification (refer to GTD).

Diving activities shall be minimized to the greatest extent possible by prioritizing the use of ROVs to perform subsea operations, such as inspection, tools manipulation, and verification of bellmouths and TSUDLs. The CONTRACTOR/SELLER shall be responsible for operating the ROV and ensuring its availability and functionality throughout the riser installation campaign.

6.5.7. LOOSE ITEMS

CONTRACTOR/SELLER shall provide messenger wire ropes with 200 m length and 23 mm diameter for the pull-in / pull-out operations. CONTRACTOR/SELLER shall also supply four polypropylene ropes with 220 m length and 32 mm diameter and all other materials necessary to enable pull-in / pull-out operations on the FPSO side.

CONTRACTOR/SELLER shall supply spare sockets for the offshore re-termination of the pull-in ropes (minimum one spare socket per cable).

The use of snatch blocks for installation and de-installation procedures is not acceptable. Sheave blocks, fairleads, swiveling blocks, etc., shall be used instead.

CONTRACTOR/SELLER shall also design and supply the riggings for the auxiliary cables for the hauling-in of the main rigging/socket of rigid risers into the TSUDLs (rigid risers pull-in). Detailed information will be provided by PETROBRAS during execution phase.

6.5.8. ADDITIONAL PROVISIONS FOR RIGID RISERS

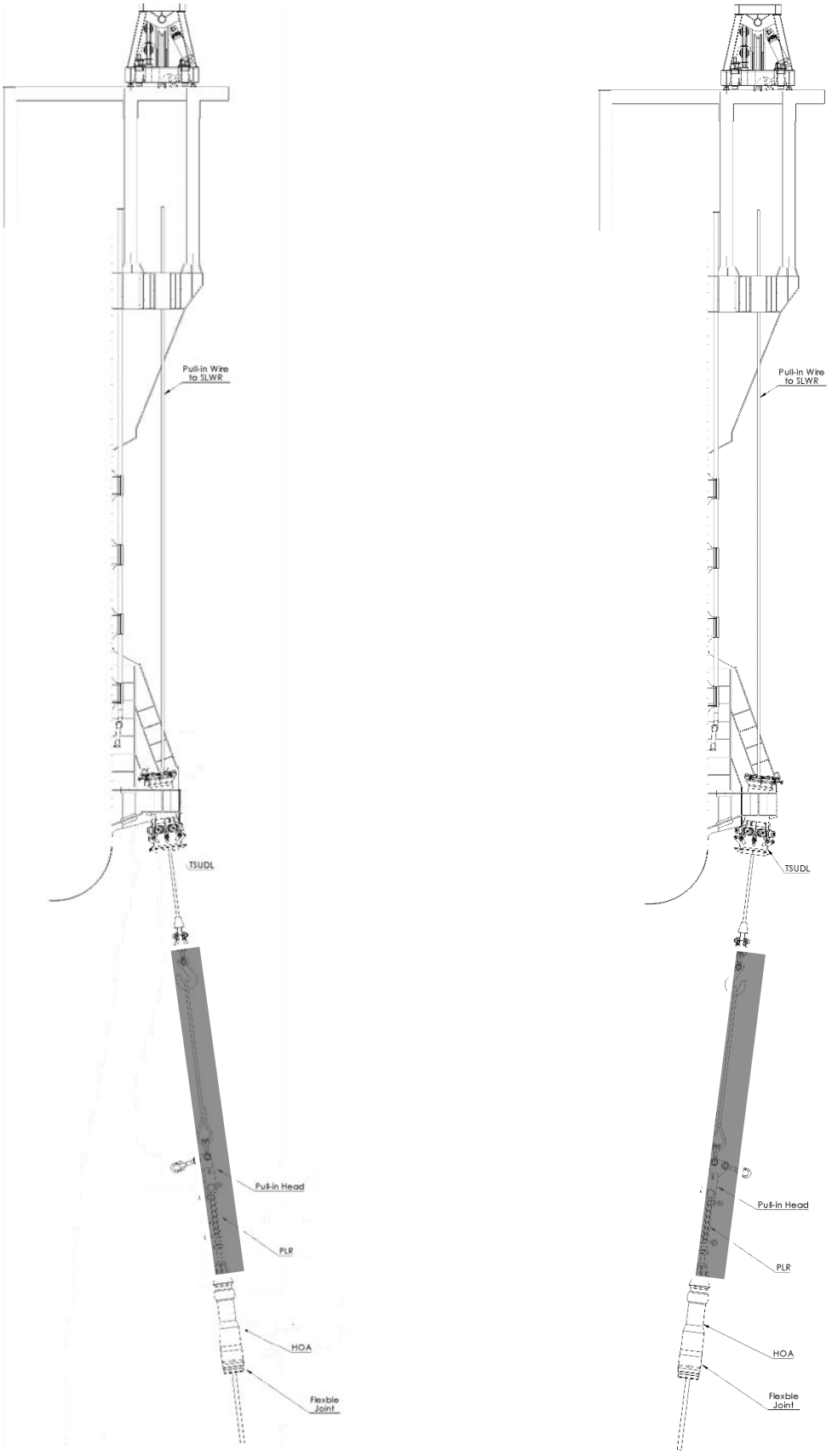
Pull-in operations of rigid risers include the preparation and pre-commissioning activities listed below. Refer to the CONTRACT for detailed information.

- Handling of main and auxiliary cables, assembly of riggings, positioning of auxiliary sheaves, inspection of supports, hardpiping and top spool assembly, seal test, etc.
- PLR valves operations, PLR and pull-in head recovery and transfer to installation vessel, interface flanges connection and seal test, etc.

6.5.8.1 RIGID RISER PULL IN THROUGH TSUDL

Figure 12 illustrates the rigid riser pull-in through TSUDL devised by PETROBRAS.

The main pull-in winch pulls up the riser until HOA passes through TSUDL top cone, then the pull-in winch lowers the riser slowly seating HOA on top of Top Cone Locking Wedges.
Both direct approach and keelhauling rigid risers will be pulled through the upper Itube. The pull-In cable will be in vertical position. No deviation sheaves nor auxiliary sheaves are predicted for the pull in of rigid risers through TSUDLs.
CONTRACTOR/SELLER shall consider a maximum length of 20 m for the main rigging: this length does not include the HOA. Detailed information will be provided by PETROBRAS during contract execution.
CONTRACTOR/SELLER shall design the system to enable the safe execution of pull-In and Pull-Out operations. Clashing between the pull-in cable, riggings or rigid riser and the FPSO structures during pull-in / pull-out operations is not acceptable.
CONTRACTOR/SELLER shall design the FPSO to enable the rigid riser's pre commissioning provisions for risers in TSUDL, described on items 7.3 and 7.4.



(a) Direct approach Rigid Risers through TSUDL

(b) Keel Hauling Rigid Risers through TSUDL

Figure 12 – Rigid Risers Pull-In through TSUDL.

7. OPERATIONAL PROCEDURES

7.1. GENERAL

The risers pull-in package shall be provided with descriptive, operating and maintenance manuals.

All operational procedures for the risers pull-in / pull-out operations on the FPSO side shall be designed by the CONTRACTOR/SELLER and issued for PETROBRAS approval at least 12 months before the FPSO Provisional Acceptance date. These procedures shall cover, as a minimum, the following:

- Maximum allowable environmental condition;
- Required preparations works at shipyard and offshore;
- Personnel to be mobilized;
- Special assemblies, required materials and installation aids, equipment setup, etc.;
- Checklists for starting the operations;
- Step-by-step procedures, with sketches and all necessary information (calculations, standards, etc.) for its correct understanding.

7.2. RISERS INSTALLATION AND DE-INSTALLATION

CONTRACTOR/SELLER is responsible for the final riser pull-in (from installation vessel rigging disconnection) and pull-out procedure (until load transfer for installation vessel).

The procedures shall consider that pull-in / pull-out operations can be performed either first-end connection or second-end connection.

- **First end pull-in:** The PLV starts the laying from the Unit to a subsea equipment.
- **Second end pull-in:** The PLV starts the laying from a subsea equipment to the Unit.

CONTRACTOR/SELLER shall consider rigid risers being installed in second-end pull-in and that flexible risers and umbilicals may be installed both in first-end or second-end pull-in.

The riser installation and de-installation procedures shall be issued by the CONTRACTOR/SELLER considering the following requirements:

- Thermal radiation emitted by the FPSO flare shall not compromise the installation vessel operations.
- Hot work onboard the installation vessel will be required inside the FPSO 500 m exclusion zone (welding of the flexible / stress joint of rigid risers). The installation vessel will be required to provide gas detectors to mitigate related risks. The minimum acceptable distance for this work shall be agreed with PETROBRAS during execution phase.
- Pull-in / pull-out operations may be performed with the risers empty, partially or fully flooded with water.
- Pull-in / pull-out operations shall not interfere with any pre-installed adjacent risers.
- No mooring line tension adjustments can be performed during pull-in / pull-out operations.
- The FPSO shall be considered in any draft, with process plant and all facilities operational.
- The FPSO shall be considered moored with no riser installed up to all risers installed.

- Contact forces and deflection angles of the pull-in main winch cable inside the bellmouths (BSDLs) and TSUDLs shall be evaluated. CONTRACTOR/SELLER shall ensure integrity of cables and FPSO structures under the specified pull-in / pull-out procedures.
- Flexible risers will be pulled by means of a pull-in head or a bull nose (umbilicals), located on its top end, where a shackle connects it to the main pull-in cable. Flexible risers and umbilicals will be equipped with bend-stiffeners. Detailed information will be provided by PETROBRAS during execution phase.
- Rigid risers will be pulled by means of a rigging connected to the rigid riser stress / flexible joint top flange. A hook will be connected to the main cable socket. Detailed information will be provided by PETROBRAS during execution phase.
- Considering the harsh environment and the typical small weather windows predicted in the area, pull-in / pull-out procedures shall minimize diving operations.
- Preparation activities shall be fulfilled in advance, before the installation vessel reaches the non-returning point (to be agreed with PETROBRAS during execution phase).
- Readiness for subsequent pull-in operations encompasses all preparation activities, including pull-in head recovery and transfer to the installation vessels.

CONTRACTOR/SELLER shall perform pull-in and pull-out analysis in order to confirm that:

- The geometrical limits defined in section 6.5.8 are fulfilled;
- No clashing occurs between the riser, adjacent risers, installation ropes and accessories and FPSO hull occurs;
- No clashing between pull-in riser and rigging (for keel hauling operations) occurs with the FPSO seawater lift hoses;
- The main winch capacity is adequate for pull-In and pull-out operations.
- Riser installation and de-installation procedures shall include the use of a ROV to minimize diving operations. The CONTRACTOR/SELLER shall detail the activities to be performed by the ROV at each stage of the process, ensuring system integrity and operational efficiency.

7.3. RIGID RISER PRE-COMISSIONING ACTIVITY (EXCEPT FOR GAS EXPORT / TRANSFER)

This section presents an overview of the foreseen rigid riser pre-commissioning activity. Necessary details about the operation will be provided during execution phase.

Risers may be installed empty, partially or fully flooded. In case of flooded installation, the water content will be filtered seawater (without any chemical treatment) or potable/industrial water.

In case of empty installation, the first activity will be to flood the pipeline with filtered seawater. This operation is performed by installation company usually from the PLET to the FPSO.

PLR valve operation by CONTRACTOR/SELLER's divers may be required depending on the pre-commissioning/installation strategy.

The riser connection onto FPSO hardpiping shall be performed by CONTRACTOR/SELLER's divers.

Once the rigid risers and flowlines are installed, each of them will be filled with inhibited or filtered seawater, cleaned, gauged and hydrostatically tested.

The FPSO shall be prepared to receive the Pigs, which will be run from the PLET to FPSO scraper (PIG Launcher/ Receiver) or to the temporary Pig Launcher/ Receiver (PLR).

This will be done by pipeline installation company using subsea pumping equipment.

Two locations for the temporary PLR are envisaged:

(1) For the rigid riser attached to the TSUDL (HOA case), the temporary PLR may be integrated to the riser pull-in head. As a contingency, a vertical temporary PLR may be installed onboard FPSO after pull-in, directly connected to the riser termination flange on LRB or directly connected to the hard pipe termination flange on URB.

(2) For the rigid riser attached to the URB (TiPT case), a vertical temporary PLR will be installed onboard FPSO after pull-in, directly connected to the riser termination flange, on URB.

The FPSO shall also be prepared to launch the Pigs, which will be run from the FPSO scraper (PIG Launcher/ Receiver) to the PLET.

Activities on FPSO include but are not limited to:

- Receive treated or filtered seawater used for flooding & hydrotesting.
- Hydrotesting from FPSO.
- Receive the PIGs on the FPSO scraper (PIG launcher/receiver), as a contingency for temporary PLR installations.

The Unit shall provide facilities (access, scaffolding, hoisting/material handling and utilities) and sufficient laydown areas to allow the installation / operation of temporary PLR's and the pressurization equipment to be provided by pipeline installation company.

CONTRACTOR/SELLER shall be responsible for the following provisions on FPSO facilities:

- Air supply: Air flowrate 350scfm (approx. 590m^3/h) @ 7bar.
- Seawater flowrate 2m^3/h.
- Power/ electricity: 220V 3phases 50Hz 60A or 440V 3phases 50Hz 60A.
- Deck Space: from 100m^2 to 120m^2.

Fitting and/or manufacture of temporary pig traps for the pre-commissioning activities, if applicable (see "TECHNICAL SPECIFICATION FOR HARD PIPE", refer to GTD), will be provided by pipeline installation company.

The final procedure for pre-commissioning activities shall be agreed by both Parties and approved by PETROBRAS during execution phase of FPSO construction.

7.4. GAS EXPORT AND GAS TRANSFER PRE-COMISSIONING ACTIVITY

This section presents an overview of the foreseen rigid riser pre-commissioning activity for the gas export and gas transfer pipeline. Necessary details about the operation will be provided during execution phase.

The beginning of the operation is similar to the other risers, up to the flooding operation. After that, riser hydrostatic test may be performed prior or after the hardpiping installation (using the PLR installed at the top of the riser, near the LRB, or the temporary PLR at the URB). Hardpiping installation is at CONTRACTOR/SELLER's scope.

A team from pipeline installation company will be onboard of FPSO to perform the pre-commissioning activities. Also, the material necessary for the operation will be delivered to the FPSO (an area estimated in 10 x 10m shall be provided by FPSO to receive this material).

A temporary PLR (estimated length of 5 m) will be installed over the top of the hardpiping (near the URB). This operation requires assistance from the FPSO crew for equipment overboard and handling, mechanical operations, scaffolding installation and any other necessary support.

A drain hose (supplied by pipeline installation company) will be connected from the PLR and routed to the sea in order to drain the pipeline water content.

PIGs are run by pipeline installation company. The water content used for gas export or gas transfer risers pigging operation usually contains only fluorescein dye.

The PLR shall be disassembled in order to evaluate PIG inspection results and reassembled for dewatering, MEG conditioning and nitrogen purging procedures.

The drain hose is connected back to the PLR and a dewatering PIG is run from PLET to FPSO (water content is discharged to the sea). In case of biocide and oxygen scavenger necessity for the water content, CONTRACTOR/SELLER shall be prepared to receive it onboard.

Together with the dewatering PIG, MEG is run from PLET to FPSO. It is a responsibility of pipeline installation company to receive and store this MEG gel for future discharge.

For corrosion protection, pigging operation is performed with inert gas (usually, above 95% pure nitrogen). CONTRACTOR/SELLER shall be able to properly handle/vent this gas. A silencer device (supplied by pipeline installation company) shall also be properly positioned.

7.5. FLEXIBLE RISER PRE-COMISSIONING

Flexible risers are hydrostatic tested in the installation vessel. No pre-commissioning activity is foreseen for flexible pipes.

Flexible pipes are usually installed filled with potable/industrial water from shore.

7.6. INSPECTION, MAINTENANCE AND REPAIR

CONTRACTOR/SELLER shall assure the FPSO will have suitable facilities to enable in-service maintenance and repair of the risers pull-in systems during the operational life of the system.

The safety requirements, methodology and frequency of inspection and maintenance activities shall be clearly stated in the IMR manuals. The manuals shall include all IMR procedures of the overall packages and the individual components contained in the package, including means of troubleshooting and dismantling/re-assembling the equipment.

Components that may require replacement within the FPSO design life shall be identified as such, along with all necessary procedures to achieve the required life.

The maintenance manual shall also include a preservation procedure for long term storage in offshore condition.

Lubrication systems shall be centralized for ease of maintenance and access. CONTRACTOR/SELLER shall supply a lubrication chart and list with recommended lubricants for all supplied equipment.

CONTRACTOR/SELLER shall provide sufficient fluorescent luminaries, inside and around the equipment and HPUs (as applicable) to enable safe operations at night.

The CONTRACTOR/SELLER shall ensure that the provided ROV is suitable for performing subsea inspection and maintenance during the operational life of the riser system. The equipment shall be maintained in operational condition and available for planned or emergency interventions.

8. TESTING AND COMISSIONING

The purpose of testing is to prove that all equipment and components operate satisfactorily and comply with the requirements of the project specification.

CONTRACTOR/SELLER shall provide the schedule of inspections and tests (FATs and commissioning) of risers pull-in systems for PETROBRAS.

All standard items shall be provided with certificates guaranteeing grade, strength, conformity with the applicable standards and CS requirements.

Each equipment and its associated components shall be inspected and tested to verify proper form, fittings, dimensions and functioning. All tests shall be performed in accordance with written procedures to be approved by PETROBRAS.

As a minimum, the following tests shall be performed:

Instrument / Electrical Tests

All instruments shall be tested and calibrated, including relief valves.

Pressure Tests

All components shall be tested, except previously factory-tested components with testing documentation (e.g., control / relief valves, which shall be calibrated). The test pressure shall be in accordance with component specification.

Leak Tests

The complete hydraulic circuit shall be leak tested after assembly in accordance with GTD requirements.

Load Tests

Any lifting equipment provided by CONTRACTOR/SELLER shall be subject to a static load test at stall load capacity and a dynamic load test at nominal load capacity. Sheaves shall also be load-tested. The equipment shall be clearly marked with its SWL.

Functional Tests

The complete assembly functional test shall be performed together with the system HPU, at the shipyard, and shall include:

- Running test for 24 h (no load on the winches) in order to tune up all electro-hydraulic system, verify synchronization of all equipment, check tightness of hydraulic connections, electrical isolation, noise and vibration levels, cooling system performance, etc. A ‘flow vs. pressure diagram’ shall be plotted for each assembled motor pump to verify the performance and settings
- A representative load and function test for each operating mode
- Static brake / stoppers tests above the stall load capacity
- Low load conditions
- Emergency stop tests
- Manual controls tests
- Functional testing of instruments, alarms and controls
- Verification of interlock functions
- Calibration of relief valves (calibration certificates shall be available)

- Calibration of load measuring devices
- Skidding and parking systems (if applicable)
- Trial fittings of sheaves and other items (if applicable)

BSDL-SI /TSUDL Hydraulic Systems Tests

CONTRACTOR/SELLER shall perform the validation testing (including underwater testing) of the hydraulic system for BSDL-SI and TSUDL to verify its functionality, according to “DIVERLESS BELL MOUTH (BSDL) - GENERAL REQUIREMENTS” and “UNIFIED DIVERLESS SUPPORT TUBE (TSUDL) - GENERAL REQUIREMENTS”, refer to GTD.

9. RESPONSIBILITIES

CONTRACTOR/SELLER shall be responsible for:

- Developing the risers pull-in / pull-out, bellmouths replacement, pull-in cables replacement and all other operational procedures necessary for the FPSO on-site installation, including CS approval when applicable.
- Storing spare materials, including the spare pull-in cables, during the CONTRACT period. These materials shall be made available whenever required.
- Delivery and unloading of gears, ancillaries and other risers pull-in / pull-out materials within 600km from Rio de Janeiro, Brazil. The materials shall be delivered customs-cleared 30 months after issuance of the LOI.
- Enable readiness for pull-in in at most 18 days after hook-up of the first mooring line. Exception cases such as stand-by not caused by the FPSO or poor performance of PETROBRAS AHVs shall be discussed during execution phase.
- Pull-in / pull-out operations onboard the FPSO 24 hours / day, including diving activities.
- Enable one riser pull-in every 5 days.
- Providing the readings of the GPS and MRU (Motion Reference Unit) systems in real-time for the installation vessel during the pull-in and pre-commissioning operations.
- Enable receiving and retrieving the riser pull-in/pre-commissioning materials (riggings, PLRs/Pigs, etc.) (diving required).
- Enable returning the risers pull-in materials (riggings, PLRs, etc.) to the installation vessel in up to 15 days after pre-commissioning operations by means of the FPSO main cranes.
- Enable opening the PLR and riser top valves in up to 5 days after the rigid risers is installed (diving required).
- Enable closing the PLR and riser top valves in up to 2 days after the rigid riser is flooded for hydrostatic test (diving required).
- Receiving the risers water content and onboard the FPSO.
- Installation of rigid riser monitoring system.
- Notification in advance for the realization of the following tests (for PETROBRAS witnessing):

  - Bellmouth and TSUDLs FATs, interference and actuation system tests at fabrication site or shipyard;

  - Bellmouth and TSUDL installations at shipyard;

- Hard piping and spool piece fit-up and leak tests;
- Pull-in system tests.

- Installation of diving equipment on the designated stations for all diving operations.
- Providing and operating a Remotely Operated Vehicle (ROV): The CONTRACTOR/SELLER shall provide and operate an ROV with the necessary technical capabilities to perform subsea operations, including inspections, manipulations, and connections in the riser support system. The use of the ROV shall aim to minimize or eliminate the need for diving activities during pull-in and pull-out operations. The ROV must be equipped with appropriate tools and comply with the performance requirements specified by PETROBRAS.
- Providing accommodations for the PETROBRAS team during the risers pull-in / pull-out campaign and inspection / maintenance campaigns.

PETROBRAS shall be responsible for:

- Supply of the main rigging for pull-in / pull-out operations.
- Receive and discharge MEG gel used during gas export and gas transfer pipeline drying.
- Diving activities for risers inspection campaign.

APPENDIX A – RISER CONFIGURATION DATA

All information herein provided is preliminary and may be updated in project KOM.

The riser configurations herein informed consider the field WD and connection points at 2.80 m (flexible risers), 1.80 m (rigid risers) above keel in a typical FPSO at ballast draft (11.2 m) and 2000 m. The operational fluids informed in Table A.1 were also considered to establish the riser configurations.

Table A.1 – Operational fluids

Riser	Operational Fluid	γ [kgf/m³]
Production	Oil	990
Water/Gas Injection	Water	1050
Service	Diesel	850
Gas Exportation	Gas	300
Gas Transfer	Gas	300

For the mooring analysis, the specific masses above shall be considered.

For the top loads estimation, all risers shall be analyzed for the full of water and empty conditions. All risers shall be considered full of water for the pull-in system assessment. See I-ET-RISER TOP INTERFACE LOADS ANALYSIS.

FLEXIBLE RISERS

All flexible risers shall be considered in free-hanging configuration as shown in Table A.2 The riser top angle is the same as the support angle.

Table A.2 – Configuration

Function	Configuration	Top Angle
PO 8”	Free-Hanging	7º
PO 6”	Free-Hanging	7º
IG 6”	Free-Hanging	7º
IA 6”	Free-Hanging	7º
Service/GL 4”	Free-Hanging	7º
IA 8”	Free-Hanging	7º
UEH	Free-Hanging	7º
UEH Power Import	Free-Hanging	7°

Tables A.3 presents the riser mechanical properties to be considered for the analyses.

Table A.3 – Riser structures

Function	Est. Topo	ID [mm]	OD [mm]	Internal Volume [l/m]	Dry Weight Empty [kgf/m]	Axial Stiffness [kN]	Bending Stiffness [kN.m²]
PO 8" Top	TCP 203.51308	211.80	404.92	35.23	330.88	2.65E+06	334.51
PO 8" Inter	TCP 203.51291MOD	213.10	369.74	35.67	249.68	1.44E+06	309.81
PO 8" Bot	TCP 203.51305MOD	213.10	407.26	35.67	347.69	1.84E+06	384.21
PO 6" Top	TCP 152.53421	152,40	333,94	19,68	211,58	1,70E+06	127,34

PO 6" Inter	TCP 152.53717	152,40	367,44	19,68	182,84	9,51E+05	165,04
PO 6" Bot	TCP 152.53677	152,40	391,06	19,99	205,19	7,90E+05	192,43
IA 6" Top	TCP 152.52496	152.40	326.68	19.68	213.54	1.82E+06	113.91
IA 6" Inter	TCP 152.52521	152.40	241.74	19.68	107.40	7.50E+05	18.03
IA 6" Bot	TCP 152.52553	152.40	253.06	19.99	125.37	4.92E+05	21.54
GL 4" Top	TCP 101.51150	101.60	232.12	8.88	114.63	1.00E+06	24.42
GL 4" Inter	TCP 101.51348	101.60	191.34	8.88	69.56	5.19E+05	10.79
GL 4" Bot	TCP 101.51335	101.60	191.34	8.88	69.56	5.19E+05	10.79
IG 6" Top	TCP 152.52836	152.40	347.32	19.38	282.59	2.14E+06	120.54
IG 6" Inter	TCP 152.52307	152.40	287.54	19.68	177.95	8.01E+05	53.22
IG 6" Bot	TCP 152.52294	152.40	284.34	19.68	169.14	5.60E+05	51.36
IA 8" Top	TCH 20352637	210.00	361.00	34.33	276.96	2.56E+06	99.9
IA 8" Inter	TCH 20352644	210.00	316.00	34.72	186.19	1.45E+06	52.7
IA 8" Bot	TCH 20352646	210.00	320.00	35.94	184.83	6.41E+05	52.78
UEH	FDT-0606	-	163.80	-	50.80	4.80E+05	12.00
UEH Power Import	HISEP MERO3	-	224.0	-	87.70	7.50E+05	53.49

Table A.4 presents the free-hanging riser compositions to be considered for the analyses.

Table A.4 – Free-hanging Riser compositions

Riser	L [m]			
	Top Angle	Top Section	Intermediate Section	Bottom Section
PO8	7º	400,0	1800,0	1000,0
PO6	7º	400,0	1800,0	1000,0
IG6	7º	1000,0	1000,0	1200,0
IA6	7º	500,0	1660,0	1000,0
GL4	7º	1000,0	1000,0	1200,0
IA8	7º	900,0	1000,0	1250,0
UEH	7º	1000,0	1000,0	1200,0
UEH Power Import	7°	1000,0	1000,0	1200,0

Markup factors for the estimated flexible riser loads shall be as per I-ET-RISER TOP INTERFACE LOADS ANALYSIS, except for the Umbilicals Bending Moments, whose markup factor shall be 1.8.

Table A.5 presents the data related to the bend stiffeners for each riser function. To design the bellmouths (BSDLs) and TSUDLs, CONTRACTOR shall consider the use of extenders, as shown in Figure A.1.

Table A.5 – Bend-stiffener data

Riser	Bend-stiffener data				
	Db [mm]	Din [mm]	L [m]	d [m]	E [MPa]
PO8	1440.0	430,3	3,5	1,5	77,0
PO6	1370,0	401,0	3,3	1,5	77,0
IA6	1220,0	350,0	3,3	1,5	77,0
GL4	960,0	257,5	2,3	1,5	77,0
IG6	1220,0	372,7	2,8	1,5	77,0
IA8	1360,5	440,0	3,3	1,5	77,0
UEH	500,0	160	3,2	1,2	77,0
UEH Power Import	1200,0	230,0	6,9	1,2	77,0

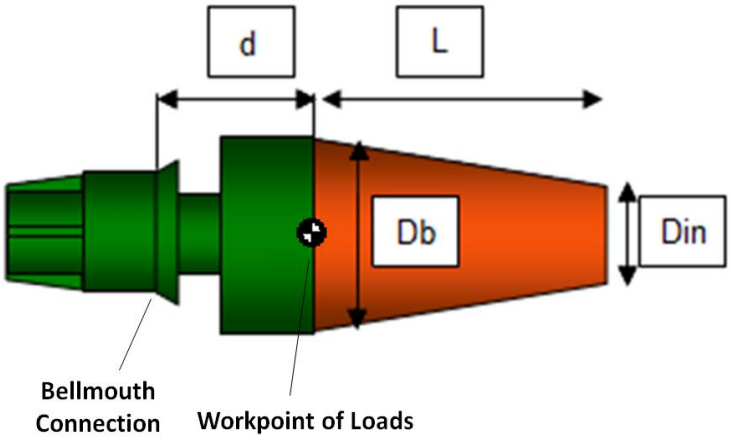


Figure A.1 – Bend-stiffener dimensions and workpoint

RIGID RISERS

The rigid pipe properties, hydrodynamic coefficients, stress joint/ flexible joint parameters and global parameters (water-flooded and empty conditions) for rigid risers are presented in tables A.6, A.7, A.8, A.9, A.10, A.11 and A.12. Both water-flooded and empty conditions shall be considered in the analyses.

All the Production, PWAG and WAG risers shall be analyzed with the 8” structures. PWAG risers shall be analyzed with both Production 8” and WAG8” structures. Gas Transfer and gas Export risers shall be analyzed with the Gas Export 9” structure.

Figures A.2, A.3 and A.4 present a straked cross-section schematic, the stress joint located in the support and reference point for the riser top interface load results (r.p.) and riser configuration parameters, respectively.

Table A.6 – Rigid pipe properties

Wall thickness and diameters details		**Carbon steel**
Production 8”	External diameter [mm]	271.2
	Internal diameter [mm]	203.2
	Wall thickness [mm]	34
WAG 8”	External diameter [mm]	269.2
	Internal diameter [mm]	203.2
	Wall thickness [mm]	33
Gas Export 9”	External diameter [mm]	284.6
	Internal diameter [mm]	228.6
	Wall thickness [mm]	28
Material properties		
Carbon steel	Density [kg/m3]	7850
	Young’s Modulus [GPa]	207
External coating properties		
Production 8”	Thickness [mm]	40
	Specific weight [kN/m3]	7.85
WAG 8”	Thickness [mm]	3
	Specific weight [kN/m3]	9.32
Gas Export 9”	Thickness [mm]	3
	Specific weight [kN/m3]	8.826
Buoyancy Module Properties		
Production 8”	Length [m]	2.40
	Diameter [m]	2.30
	Uptrust per Buoyancy Module [kN]	34.8
	Associated weight [kN]	64.0
	Modules	6
	Distance between center to center of the Modules [m]	2x12 + 1x24 +2x12
WAG 8”	Length [m]	2.40
	Diameter [m]	2.30
	Uptrust per Buoyancy Module [kN]	34.8
	Associated weight [kN]	64.0
	Modules	6
	Distance between center to center of the Modules [m]	2x12 + 1x24 +2x12
Gas Export 9”	Length [m]	2.50
	Diameter [m]	2.03
	Uptrust per Buoyancy Module [kN]	29.58
	Associated weight [kN]	43.77
	Modules	24

	Distance between center to center of the Modules [m]	12
Strake properties		
Production / WAG Injection/ Service	Shell Wall Thickness [mm]	15
	Strake Vane Height [mm]	60
	Density [kg/m3]	1149

Table A.7 – Hydrodynamic Coefficients

Hydrodynamic coefficient for		**Extreme Analysis**	**Fatigue Analysis**
Coated pipe	Normal drag	1.2	0.7
	Tangential drag	0.001	
	Inertia Coefficient	2.0	
Coated pipe with strake	Normal drag	1.4	
	Tangential drag	0.001	
	Inertia Coefficient	2.5	
Coated pipe with buoys	Normal drag	1.2	0.7
	Tangential drag	0.9	
	Inertia Coefficient	2.0	
Structural damping			
Structural damping [%]		0.3	

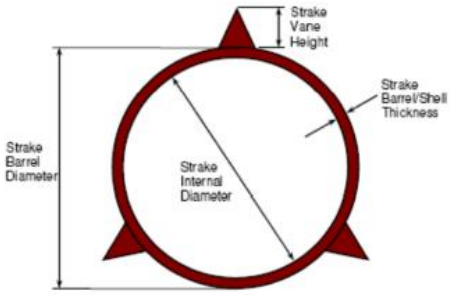


Figure A.2 – Strake cross-section schematic

Table A.8 presents for each rigid riser function the inner diameter, the riser support and the stiffener type.

Table A.8 – Stress joint parameters

Riser function	ID [inch]	Riser support	Stiffener type
Production	8.0	TSUDL	Stress Joint
PWAG	8.0	TSUDL	Stress Joint
WAG	8.0	TSUDL	Stress Joint
Gas Export	9.0	TSUDL	Flexible Joint

Table A.9 presents the stress joint parameters and Figure A.3 presents the stress joint located in the support and reference point for the riser top interface load results (ToT).

Table A.9 – Stress joint parameters

Titanium Stress Joint data			
Production/W AG 8”	Length [m]	Taper Section (LA)	7.5
		Straight Section (LB)	2.5
		Total Active Section (L)	10.0
		Distance from stress joint r.p. (d) [m] Note: only for TSUDL	1.2
	Top Wall Thickness (TWT)[mm]		135
	Bottom Wall Thickness (BWT)[mm]		34
	E [GPa]		105
	Density [kg/m3]		4500

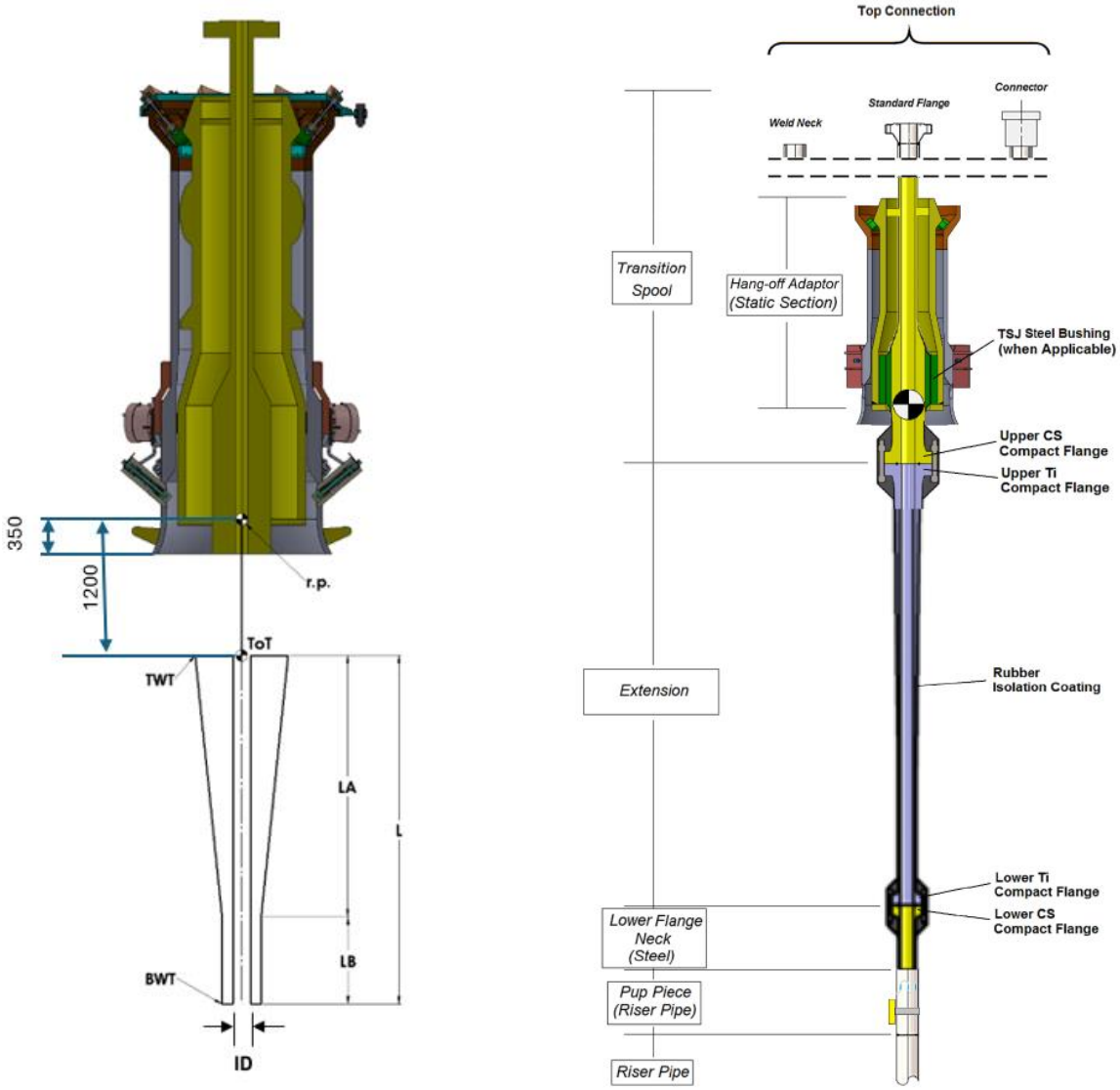


Figure A.3 – Stress joint dimensions and reference point ToT in TSUDL

Table A.10 and Table A.11 present the flexible joint geometry and parameters. Figure A.4 and Figure A.5 present the flexible joint located in the support and reference point for the riser top interface load results (CoR).

Table A.10 – Flexible joint geometry

Flexible Joint Geometry Data		
Gas Export 9.0”	Length [m]	6+1
	Top Wall Thickness (TWT)[mm]	Riser Wall Thickness x 1.5
	Bottom Wall Thickness (BWT)[mm]	Riser Wall Thickness x 1.0

Table A.11 – Flexible joint parameters

Riser	Stiffness	Extreme Analysis	Wave Fatigue Analysis
Gas Export 9.0”	Translational [kN/m]	3.08E+8	
	Static Bending [kN.m/deg]	33.9	
	Dynamic Bending [kN.m/deg]	100	200
	Torsional [kN.m/deg	2.00E+3	2.00E+3

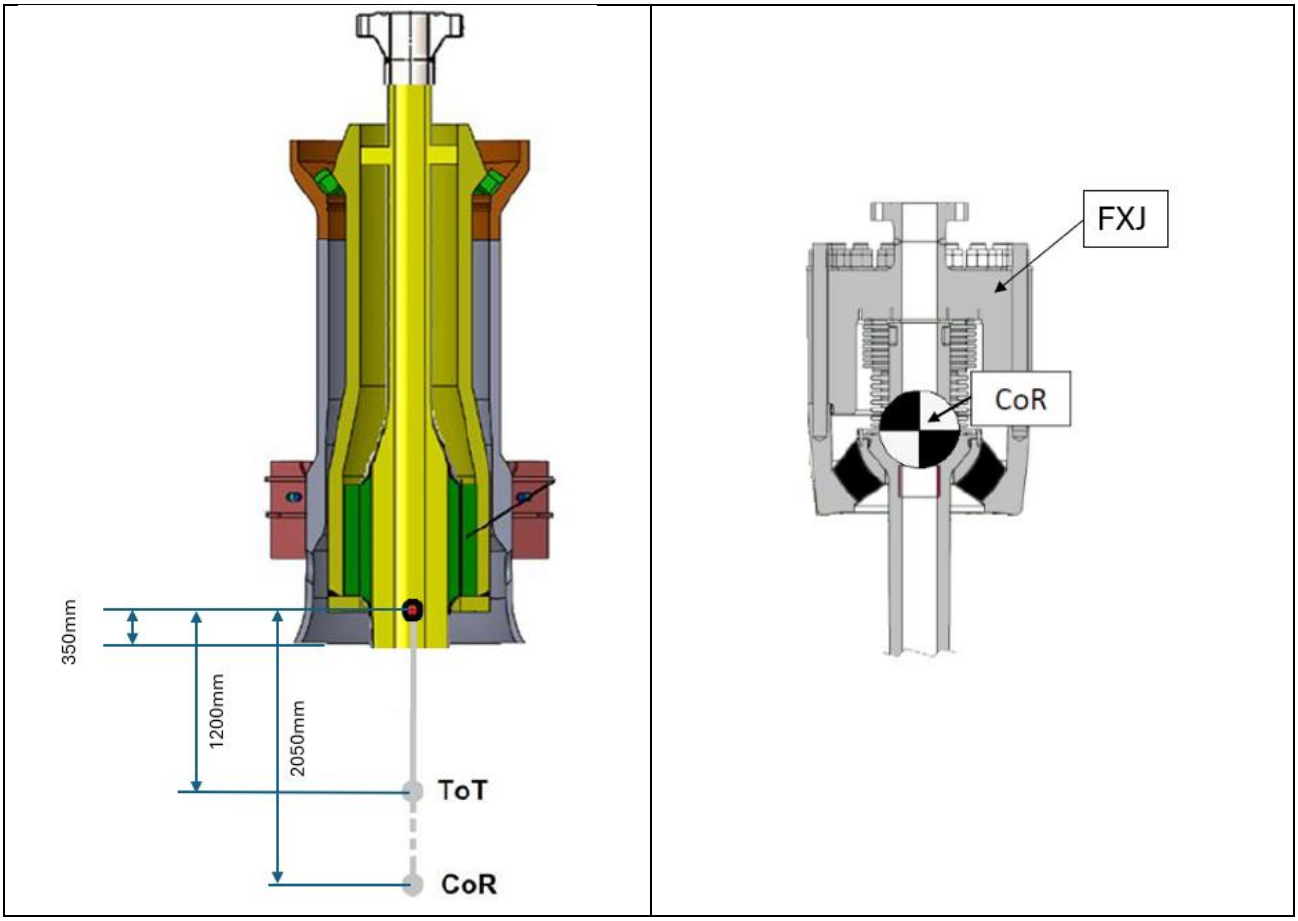


Figure A.4 – Stress joint dimensions and reference point ToT in TSUDL

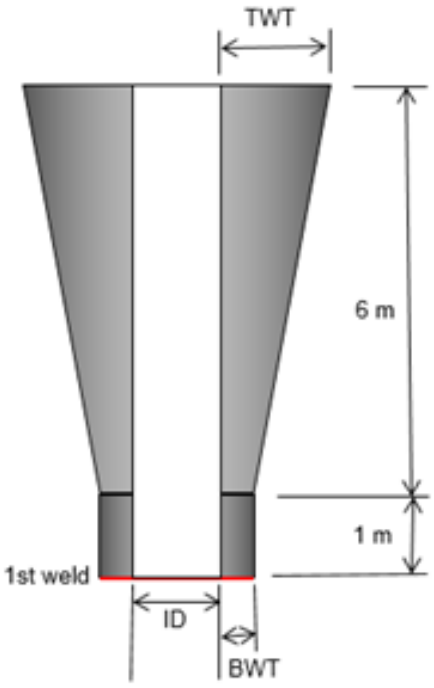


Figure A.5 – Flexible joint dimension

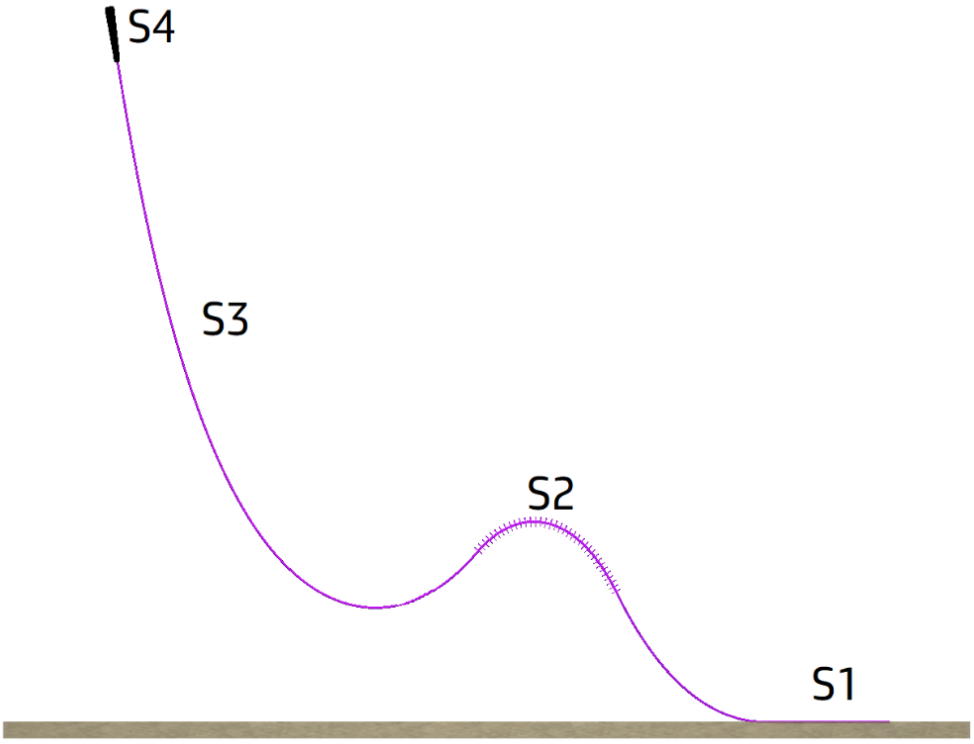


Figure A.6 – Riser configuration parameters

Table A.12 presents the static configuration for each rigid riser function.

Table A.12 – Global parameter for rigid risers

Parameter			Static configurations for fluid contents	
			Empty	Flooded of water (or Operational fluid)
WAG 8”	S1[m]	Coated pipe	884	
	S2 [m]	Coated pipe with buoys	72	
	S3 [m]	Coated pipe with strake	2065	
	S4 [m]	Stress Joint	10	
	Total length [m]		3031	
	Horizontal projection [m]		1485	
	Top angle [°]		6.0	6.2
	Top tension [kN]		2946	3715
Production 8”	S1 [m]	Coated pipe	884	
	S2 [m]	Coated pipe with buoys	72	
	S3 [m]	Coated pipe with strake	2077	
	S4 [m]	Stress Joint	10	
	Total length [m]		3043	
	Horizontal projection [m]		1568	
	Top angle [°]		7.5	7.7
	Top tension [kN]		2979	3812
Gas Export 9”	S1 [m]	Coated pipe	668	
	S2 [m]	Coated pipe with buoys	276	
	S3 [m]	Coated pipe with strake	2250	
	S4 [m]	Flexible Joint	6	
	Total length [m]		3200	
	Horizontal projection [m]		1682	
	Top angle [°]		6.1	5.9
	Top tension [kN]		2343	3316

Note: Water depth of 2,000 meters