	DESIGN BASIS	Nº: I–MD–3000.00–1519–274–P56–001	
PETROBRAS	CLIENT: E&P		SHEET: 1 of 22
	JOB: GENERAL		CC
	ÁREA: GENERAL		PROJECT:
DP&T	TÍTLE: DATA BASIS FOR TITANIUM PULL–IN TUBE TECHNICAL ASSESSMENT		Público ES

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INDEX OF REVISIONS

REV.	DESCRIPTION AND/OR REVISED SHEETS
0	ORIGINAL

	REV. 0	REV. A	REV. B	REV. C	REV. D	REV. E	REV. F	REV. G	REV. H
DATE	02/10/2020								
PROJECT	ES								
EXECUTION	TS8H/U4B8								
CHECK	UP86								
APPROVAL	CLZ2								

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1. INTRODUCTION

FPSOs in operation PPSBS were initially designed to use flexible risers and with conventional SLWRs as a contingency for the Gas Injection Risers. Not all riser supports have the facilities to connect a rigid riser, like hard-piping on the side hull or the hang off locking system at the lower balcony.

The SLWRs made with MLP with the selected CRA Liner material is immune to SCC-CO_2 mechanism and will be used for the second phase of Lula development plan.

To overcome FPSO limitations, an SLWR with Titanium alloy top segment was design to enable pull-in procedure similar to a conventional flexible riser. Although it is an unprecedented solution in the industry, Titanium Stress Joint, is a mature solution providing a good understanding of the design parameters. The solution combines an SLWR with Titanium Stress Joints and a titanium pipe segment, which is flexible enough to bend into the Bellmouth and pass through it up to the upper riser balcony (while limiting the loads transmitted to the support to allowable levels) and, at the same time, has sufficient mechanical strength to withstand extreme and fatigue loads. In addition, the selected Titanium alloy is also immune to SCC-CO_2 mechanism, and do not require internal CRA layer to withstand high sulfide content in convey fluids.

1.1. SCOPE OF THIS DOCUMENT

The Data Basis for Technical Feasibility Study of Titanium Pull–in Tube (TiPT) aims to inform the input data for INTERESTED PARTIES to perform preliminary assessments of the TiPT prior to the upcoming bidding with this technology. Herein are informed data on titanium parts, risers configurations of a Project's specific Gas injection riser, environmental, vessel and a summary of loads results from PETROBRAS Basic Design all data are preliminary.

These data as well as all the products developed in this study do not mean any PETROBRAS´ compromise or obligations.

2. DEFINITIONS AND ABBREVIATIONS

2.1. DEFINITIONS

PETROBRAS	PETRÓLEO BRASILEIRO S/A. – PETROBRAS Where referred to in this Specification, it means both the Company itself and its employees authorized to communicate with CONTRACTOR or SUPPLIER.
INTERESTED PARTIES	The companies participating in the Titanium Pull–in Tube Technical Assessment effort in preparation for a EPCI Project with TiPT technology.
Project	Scope of activities to be performed by an INTERESTED PARTY awarded to design, construct and install the riser system with TiPT top termination. As base case for this assessment, data related to an actual Project is informed.
Shall	Indicates a mandatory requirement.
Should	Indicates a preferred course of action.
May	Is used where alternatives are equally acceptable.

2.2. ABBREVIATIONS

The following abbreviations are used in this document:

BSMF	Boca de Sino Multifuntional
BSN	Boca de Sino Convensional
Cf	Case Factor, from API–RP–2RD
CRA	Corrosion Resistant Alloy
EDTA	Ethylenediamine tetraacetic acid
ELI	Extra Low Interstitials
FR	Resultant shear load
FX	Riser effective tension
FPSO	Floating, Production, Storage and Offload
GI	Gas Injection line
GLDA	Tetrasodium Glutamate Diacetate Salt
MLP	Mechanically Lined pipe
MR	Resultant bending moment
MSL	Mean sea level
PPSBS	Polo Pré–Sal da Bacia de Santos

PU	Polyurethane
RAO	Response Amplitude Operator
SCC-CO2	Stress Corrosion Crack assisted by CO_2
SLWR	Steel Lazy–Wave Riser, definition acc. To ref. [3].
SMYS	Specified Minimum Yield Stress
SMTS	Specified Minimum tensile Stress
TiPT	Titanium Pull–in Tube
TRMS	TiPT Riser Monitoring System
TSJ	Titanium Stress Joint
UNS	Unified Numbering System
WD	Water Depth
WI	Water Injection line

3. REFERENCES

Ref. n°	Document number	Title	Rev.
[1]	[redacted]	[redacted]	[redacted]
[2]	[redacted]	[redacted]	[redacted]
[3]	I-ET-0000.00-0000-274-P9U-001	SLWR Detailed Structural Design Requirements	**C**
[4]	I-ET-0000.00-0000-290-P9U-005	Titanium Pull–in Tube Specification	**A**
[5]	I-ET-0000.00-0000-290-P9U-004	Titanium Stress Joint Specification	**C**
[6]	I-ET-0000.00-5529-850-PEK-003	TiPT Riser Monitoring System (TRMS) – Full Scope	**A**
[7]	[redacted]	[redacted]	[redacted]
[8]	ASTM A381	Titanium and Titanium Alloy Forgings	**2019**

4. TITANIUM PULL–IN TUBE DATA

The Titanium Stress Joint is a forged conical shape for progressive stiffness transition made with Titanium commercial alloy (Ti-6Al-4V-0.1Ru ELI). The bottom segment ends in a steel pup piece to be welded in the first MLP segment. The Titanium Pull-in Tube ends in the FPSO upper balcony in a steel pup piece, which has a hang-off clamp interface (male profile). Both steel pup pieces use a compact flange on one side and a bevel in the other. The flange side is protected under the external Polyurethane (PU) coating avoiding any contact with seawater under the cathodic protection influence.

Refer to below, the Ti Pipe Section (2), the Lower (4) and Upper Titanium Stress Joint (3) are connected by a compact flanges under the watertight external PU coating.

The Titanium Pull-in Tube segment inside the BSN900e uses a double cover to deal with surface contact force and wear inside the trumpet, which also uses PU internal coating to prevent wear and electrical contact. The remaining TiPT length uses forged flanged pipe segments (Spacers Pipe).

The length between the trumpet and the hang-off collar must be defined in strict tolerances; the length adjustment can be made by cutting the length of top steel pup piece previously to the installation. The bevel side of the top steel pup piece will do the interface with the hang-off collar (also supplied by contractor) as well connect the riser to a API 7 1/6", API 10000 psi, 6BX, BX 156 ID: 152.4 mm.

The general configuration of the TiPT string is shown in Figure 1.

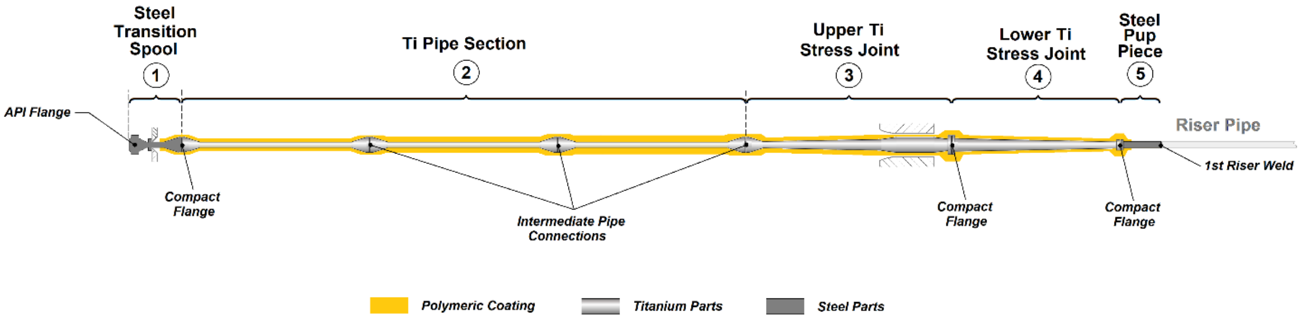


Figure 1 – Schematic View of the Titanium Pull–in Tube Stack–up with its Main Parts.

NOTE: Concept of the parts and/ or configuration depicted in Figure 1 may vary according to SUPPLIER design.

Complete part list of the TiPT is presented in ref. [4].

4.1. TECHNICAL REQUIREMENTS FOR TIPT

Material specification of titanium alloy shall be ASTM B381 grade F29 ELI, with the properties listed in Table 1. Complete material specifications and material selection guideline per ref. [4].

Table 1 – Titanium Mechanical Properties, per ref. [8].

PARÂMETRO	VALUE	UNIT

Young's Modulus	105	GPa
Density	4500	kg/m^3
Elongation at break	10	%
Poison ratio	0.31	-
SMYS	759	MPa
SMTS	828	MPa

Stress de-rating for titanium shall follow the equations below:

$$\Delta f\ y, temp = 0 \qquad 20°C < T$$
$$\Delta f\ y, temp = 1.44 \times T - 28.8 \qquad 20°C < T < 140°C$$
$$\Delta f\ y, temp = 1.24 \times T - 24.8 \qquad 140°C < T < 200°C$$

$$\Delta f\ u, temp = 0 \qquad 20°C < T$$
$$\Delta f\ u, temp = 0.97 \times T + 37 \qquad 20°C < T < 140°C$$
$$\Delta f\ u, temp = 0.83 \times T + 32.6 \qquad 140°C < T < 200°C$$

Titanium fatigue curve qualified by PETROBRAS shall be considered whenever supplier qualified curve is not present or not approved for use in the Project as per sec. 7.7 of ref. [4].

Complete technical requirements for the TiPT are detailed in ref. [4] and ref. [5].

4.2. PRELIMINARY DRAWINGS

Preliminary drawings of the TiPT titanium parts are included in APPENDIX A. The design are the results from riser global analyses performed by PETROBRAS during Project Basic Design with TiPT, for two possible support tubes (I–Tube 7° and BSMF 9°).

Interfacing details of the TiPT and the FPU are shown in Figure 2.

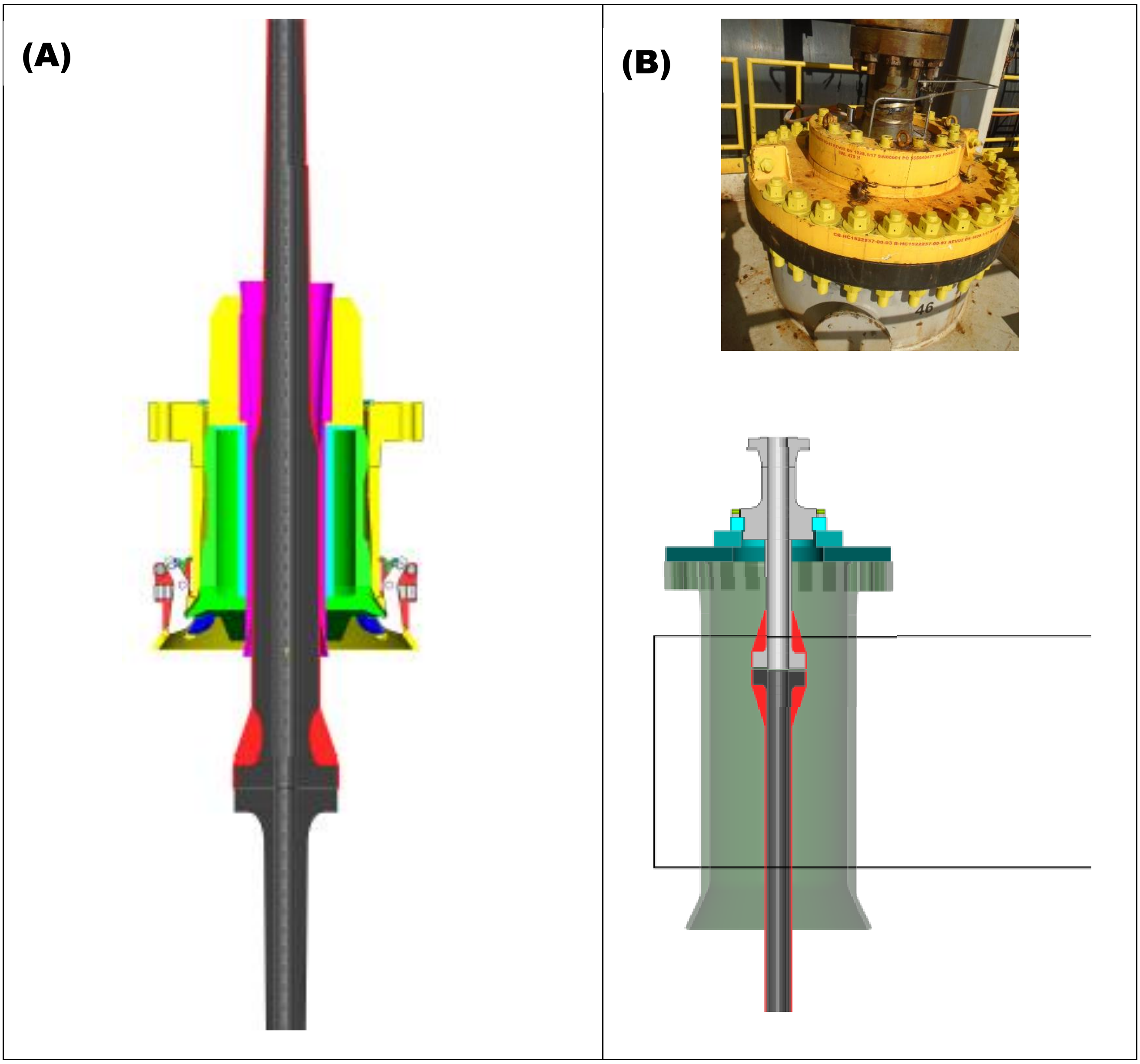


Figure 2 – Interfaces Between TiPT and FPU Structures: (A) Support Tube Interface; (B) Top I–Tube (hang–off) Interface.

The configuration of the top portion of the TiPT, prior to the pull–in is detailed in Figure 3. More details of the pull–in are shown in section 6.4.

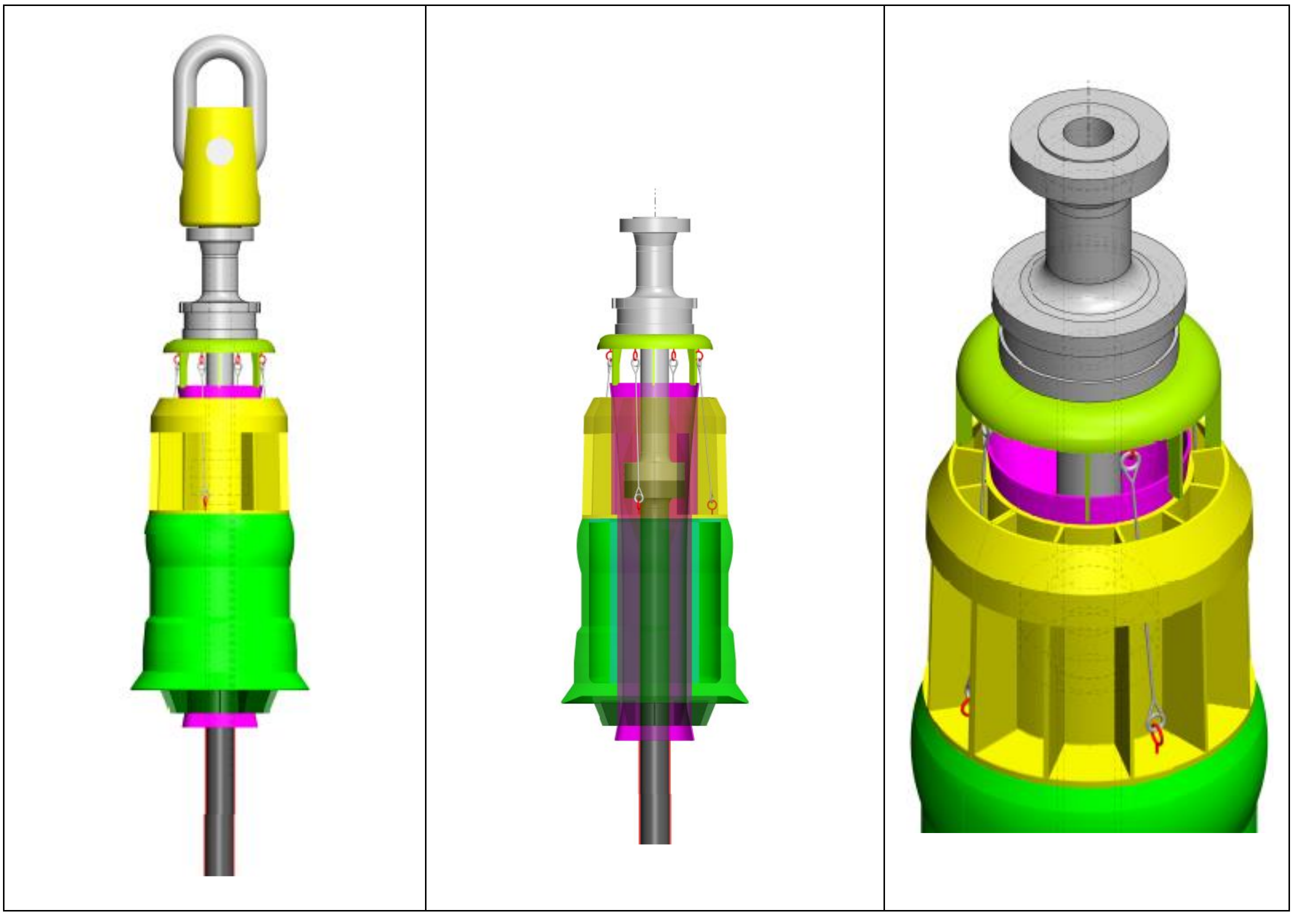


Figure 3 – Views of the Top TiPT Configuration Prior to the Pull–in.

4.3. TIPT MONITORING SYSTEM (TRMS)

Requirements on the TiPT monitoring System can be found in ref. [6].

5. STEEL RISER DATA

5.1. DESIGN LIFE

Pipelines shall be designed for 30 years of operation plus all temporary phases which occur prior to operation (installation, pre-commissioning etc), and decommissioning.

5.2. RISER CONFIGURATION

The INTERESTED PARTY should consider the range of internal diameters (taking into account the CRA material) allowed for rigid riser according to Table 2.

Table 2 – Range of internal diameters for rigid riser.

Riser function	Inner diameter (inches)
Gas Injection	6 – 6.5

Configurations shall be defined by the INTERESTED PARTY during bidding. The proposed configurations shall be SLWR with TiPT, as depicted in Figure 4. For this technical assessment, the configurations shall be considered as per sections 5.2.1 and/or 5.2.2, based on the Project Basic Design, for supports' top angles of 7° (conventional bell mouth) and 9° (BSMF). Procedure of ref. [3] should apply for riser global analyses in this assessment.

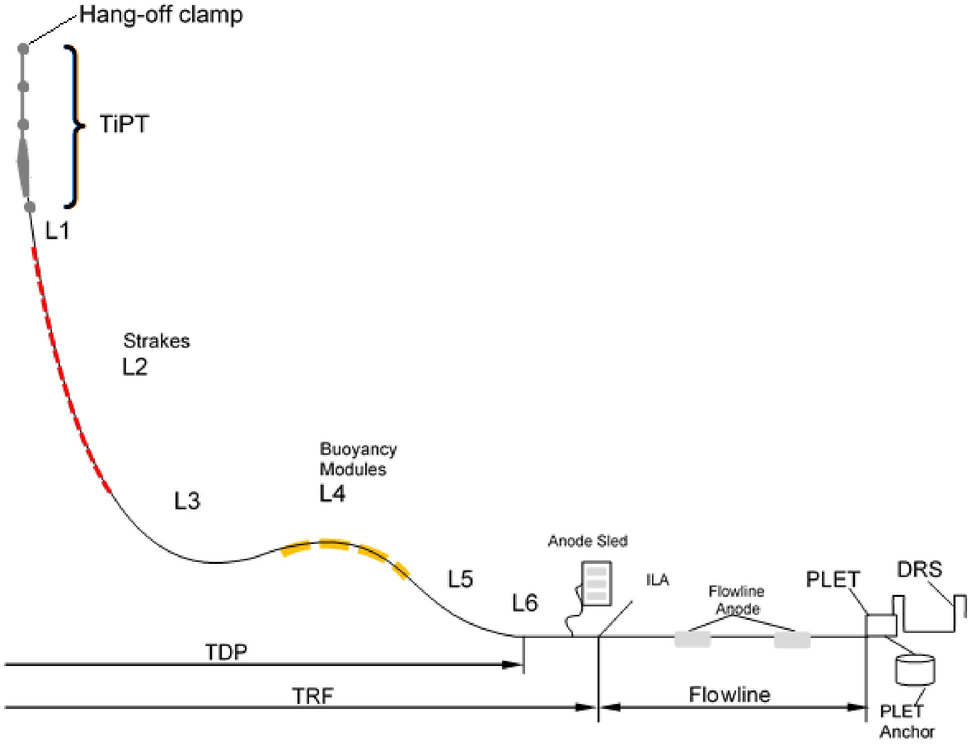


Figure 4 – Gas Injection 6" Pipeline (Schematic Drawing Only).

5.2.1. 7° TOP ANGLE BELL MOUTH RISER

Table 3 – Pipeline Data Bell Mouth Riser.

(HOLD)

Table 4 – Riser Data Bell Mouth Riser.

(HOLD)

5.2.2. 9° TOP ANGLE BSMF RISER

Table 5 – Pipeline Data BSMF Riser.

Parameter	
ID (mm)	152.4
CRA Internal Layer Thickness (mm)	3
CRA Internal RzDIN roughness mean peak-to-valley height	60 µm
ID (Carbon Steel Pipe) (mm)	158.4
WT (Carbon Steel Pipe) (mm)	25
External Coating	5LPP
External Coating Thickness Riser / Flowline (mm)	16.2 / 27.2
Pipe Specification (MLP)	DNVGL SMLS 450 SFPDU L – UNS N06625
(MLP) Riser Length (m)	3588
Flowline Length (m)	765 – 6685
Total Pipeline Length (Includes LTSJ) (m)	4353 – 10273

Table 6 – Riser Data BSMF Riser.

Parameter		Notes
FPSO Slot	21	Ref. [7]
Keelhauled	No	Rise azimuth towards opposite FPSO side
TiPT Nominal Length (m)	See Item sec.4.1	
Suspended Length (m)	3161	Includes LTSJ
Total Riser Length (m)	3596.5	Includes LTSJ
Horizontal projection from FPSO to TDP (m)	1725	Mean fluid density, neutral position
Horizontal projection from FPSO to TRF (m)	2161	Mean fluid density, neutral position
TSJ Length (m)	8.456	
MLP Pipe Length (m)	See Table 5	
Strake Length – Total (m)	2536	
Strake Length – FPSO to HOG (m)	1960	Includes 485m in between Buoyancy Modules
Strake Length – FPSO to TDP (m)	576	
HOG height (m) / Projection from FPSO (m)	1105 / 841	Mean fluid density, neutral position
SAG height (m) / Projection from FPSO (m)	1010 / 539	Mean fluid density, neutral position
Quantity of Buoyancy Modules	42	
Buoyancy Modules Volume (m3)	10.7	
Buoyancy Modules End of Life Net Uplift (ton)	4.4	
Dimensions of Buoyancy Modules (HD x L) (m)	2.3 x 2.6	
Mean Top Angle (deg)	9	Mean fluid density, neutral position
Support Top Angle (deg)	9	
BSN Top Azimuth (True North)	114	
Riser Azimuth	115	

5.3. MATERIAL

The production and WAG injection risers should be made of C-Mn steel internally coated with CRA UNS 006625. However, INTERESTED PARTY may propose other material for PETROBRAS assessment.

5.4. PRESSURE, TEMPERATURE AND FLUID DENSITY

The pressure, temperature and fluid density are detailed in ref. [1].

Operational profiles were generated for maximized pressure and maximized temperature, for each flowline length, for each configuration, for each function.

For gas injection scenario 3 sets of profiles were generated, with CO_2 content of 44%, 60% and 85%.

Top of riser refers to a point located 20 m above MSL.

5.4.1. STEADY STATE CONDITIONS

For gas injection scenario pressure, temperature and density profiles, refer to Table 7, and indicated annexed files.

Table 7 – Steady State Conditions for Gas Injection Pipelines.

PARAMETER	VALUE	UNIT	Note(s)	Full Profile Satellite Wells
Minimum Pressure	0	MPa	• Empty pipeline or depressurized gas scenario.	-
Incidental Pressure	70.2	MPa	• Reference value at Top of riser. • For full profile and correlated specific mass; refer to Annex 1 and Annex 3.	Annex 3 Worksheet A.1
System Test Pressure	73.7	MPa	• Top of riser.	-
GI Operational Pressure and Temperature profiles	55	MPa	• Reference value at Top of riser (Pressure) and along riser (Temperature).	Annex 1 Worksheets A.2, A.3 and A.5;
GI Operational Temperature profiles	62	°C	• For full profiles and correlated specific mass, refer to Annex 1 and Annex 3.	
Diesel circulation (GI to WI pipeline)	27.5	MPa	• Reference value at Top of riser	Annex 5 Worksheet A.2
Diesel circulation (WI to GI pipeline)	24.1	MPa	• Reference value at well-head	
Diesel hibernation pressure	0.1	MPa	• Reference value at Top of riser	
Maximum Temperature in GI operation	62	°C	• Max. Value along riser. • For complete profile refer to Annex 1 and Annex 3.	Annex 1 Worksheets A.2
Minimum Temperature	-20	°C	• Min. Value along riser in transient condition. • For full profile, refer to Annex 2	-

5.4.2. TRANSIENT CONDITIONS

Data to be provided during bidding phase.

5.4.3. THERMAL PROPERTIES

Thermal properties are presented for all profiles generated, as defined in item item 7.9 of ref. [4].

Table 8 – Fluid Thermal Properties.

PARAMETERS	GAS INJECTION	UNIT
Flow Velocity	8.6	m/s
Thermal Conductivity	0.198	W/m.K
Specific Heat	2850	J/Kg.K
Viscosity	0.06	cP

5.4.4. EROSIONAL DATA

For Gas injection pipeline erosional data, refer to Table 9.

Table 9 – Erosional Data for Gas Injection Pipelines

PARAMETER	VALUE	UNIT
Maximum In Situ Gas Flow	13600	m^3/day
In Situ Gas Density	See sec. 5.4.1	kg/m^3
In Situ Gas Viscosity	0.06	cP

5.4.5. COMPOSITION

For maximum concentration of H_2S and CO_2 and pH in the natural gas mixture, for gas injection scenario, refer to Table 10.

Table 10 – Natural Gas Mixture Composition: Gas Injection Scenario

COMPONENT	VALUE	UNIT
H_2S	100	ppmv
CO_2	60	%
pH	4.3	-
H_2O	40	ppm

For chemical injection data, to check for SUPPLIER chemical compatibility assessment of titanium alloy, refer to APPENDIX C.

6. VESSEL DATA

6.1. GENERAL

For FPSO data, refer to ref. [7].

6.2. VESSEL OFFSETS

The vessel offsets values for extreme storm (100y and 1y) and fatigue analyses are presented in Table 11. The offsets informed already consider vessel positioning errors.

Table 11 – Vessel Offsets for Extreme Storm Analysis.

Environmental Condition	Mooring System	Vessel Offset [% WD]
100-year	Intact	9.0
100-year	One line broken	9.5
1-year	Intact	7.0

6.3. MOVEMENTS

For RAOs, offsets and accidental heeling and trim angle, please refer to ref. [7].

6.4. INSTALLATION AND PULL–IN FACILITIES

The installation methods allowed for construction, in the vicinity of the FPU, are J-Lay and Reel-Lay.

For Pull-in facilities characteristics, see ref. [7].

The connection of the FPU main pull-in cable to the riser is CONTRACTOR's responsibility and the pull-in rig length and width is limited, see ref. [7].

During the hand-over (load transfer) step, the FPSO main cable shall not be paid-in or out.

Schematic sequence of the TiPT passage through FPSO support–tube is show in Figure 5, for information.

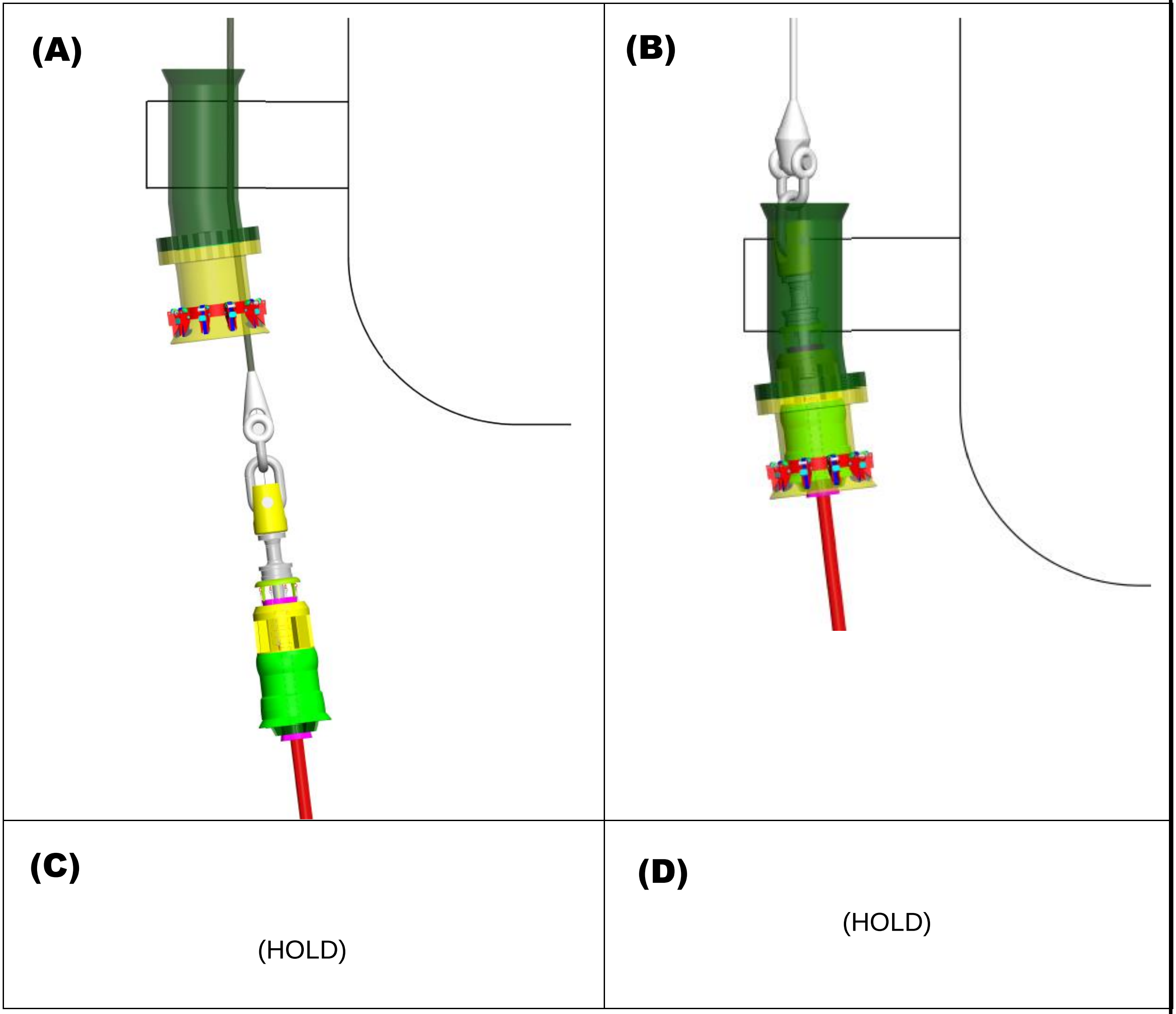


Figure 5 – TiPT Pull–in Sequence Through Support–Tube. (A) Locking of the Adaptor Cap into de Support–Tube; (B) Fuse cables break and start of the TiPT pipe bending; (C) Veticalization; (D) Pull–in termination with UTSJ positioned.

7. ENVIRONMENTAL DATA

7.1. CURRENT DATA

The current data is presented on Meteocean Data ref. [1].

7.2. WAVE DATA

The extreme and fatigue sea states are presented in Meteocean Data ref. [1] and Fatigue sea state ref. [2] respectively.

7.3. SOIL DATA

The soil data is presented in Table 12.

Table 12 – Soil Parameters.

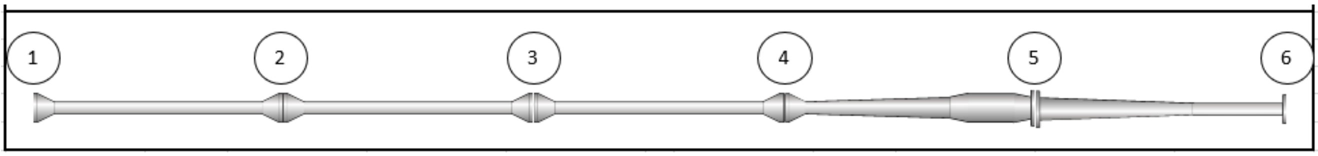
Production / WAG Injection	Burial	
	25%	100%
Axial Elastic deflection Limit [m]	0.03	
Lateral Elastic Deflection Limit [m]	0.32	
Axial Friction Coefficient (η = 0.7)	0.71	1.31
Lateral Friction Coefficient	1.01	0.86
Vertical Spring Stiffness [kN/m/m]	1370	1868

8. LOAD RESULTS FROM BASIC DESIGN

8.1. RISER LOADS

Interface loading calculated during Basic Design are shown in Table 13, per load case, and may be used by the INTERESTED PARTY in consults with Titanium STRESS JOINT SUPPLIERS for check of component pre–sizing and revision of flange calculation procedure. APPENDIX A shows the final dimension of TiPT titanium parts resulted from the Basic Design, and may be used in consults with TSJ and Titanium forging companies.

Table 13 – TiPT Compact Flanges Loads – PETROBRAS Basic Design.



Flange 01				
Loading	**Cf**	**FX [kN]**	**FR [kN]**	**MR [kN-m]**
ULS2	1.2	1720.7	39.5	81.1
ALS3(15°)	1.5	1469.2	35.6	82.5
ALS3(10°)	1.5	1494.5	38.0	80.7

Flange 02				
Loading	**Cf**	**FX (kN)**	**FR [kN]**	**MR [kN-m]**
ULS2	1.2	1713.9	2.8	5.7
ALS3(15°)	1.5	1463.0	1.0	2.4
ALS3(10°)	1.5	1488.2	2.6	5.5

Flange 03				
Loading	**Cf**	**FX (kN)**	**FR [kN]**	**MR [kN-m]**
ULS2	1.2	1706.4	8.7	18.1
ALS3(15°)	1.5	1455.9	6.4	14.9
ALS3(10°)	1.5	1481.0	6.6	14.1

Flange 04				
Loading	**Cf**	**FX (kN)**	**FR [kN]**	**MR [kN-m]**
ULS2	1.2	1698.8	89.7	186.5
ALS3(15°)	1.5	1446.6	82.4	194.2
ALS3(10°)	1.5	1471.6	88.6	191.1
Installation	1.2	1347.2	79.2	372.8

Flange 05				
Loading	**Cf**	**FX (kN)**	**FR [kN]**	**MR [kN-m]**
ULS2	1.2	1660.7	600.4	1276.1
ALS3(15°)	1.5	1418.0	675.4	1623.0
ALS3(10°)	1.5	1440.2	559.9	1233.7

Flange 06				
Loading	**Cf**	**FX (kN)**	**FR [kN]**	**MR [kN-m]**
ULS2	1.2	1657.2	46.8	99.6
ALS3(15°)	1.5	1455.6	64.6	151.2
ALS3(10°)	1.5	1453.6	52.4	114.4

Flange 01 is attached to FPSO top spool, and Flange 06 is the TSJ-to-riser flange
FX is the riser effetive tension
FR is the resultant shear load at flange
MR is the resultant bending moment at flange.
ULS2 is the extreme (100yr-RP) load case
ALS3 is the accidental (1yr-RP, FPSO heeled) load case. Two static heel angles evaluated: 10° and 15°.
Cf as per API-RP-2RD
Flange 04 is the most loaded during installation

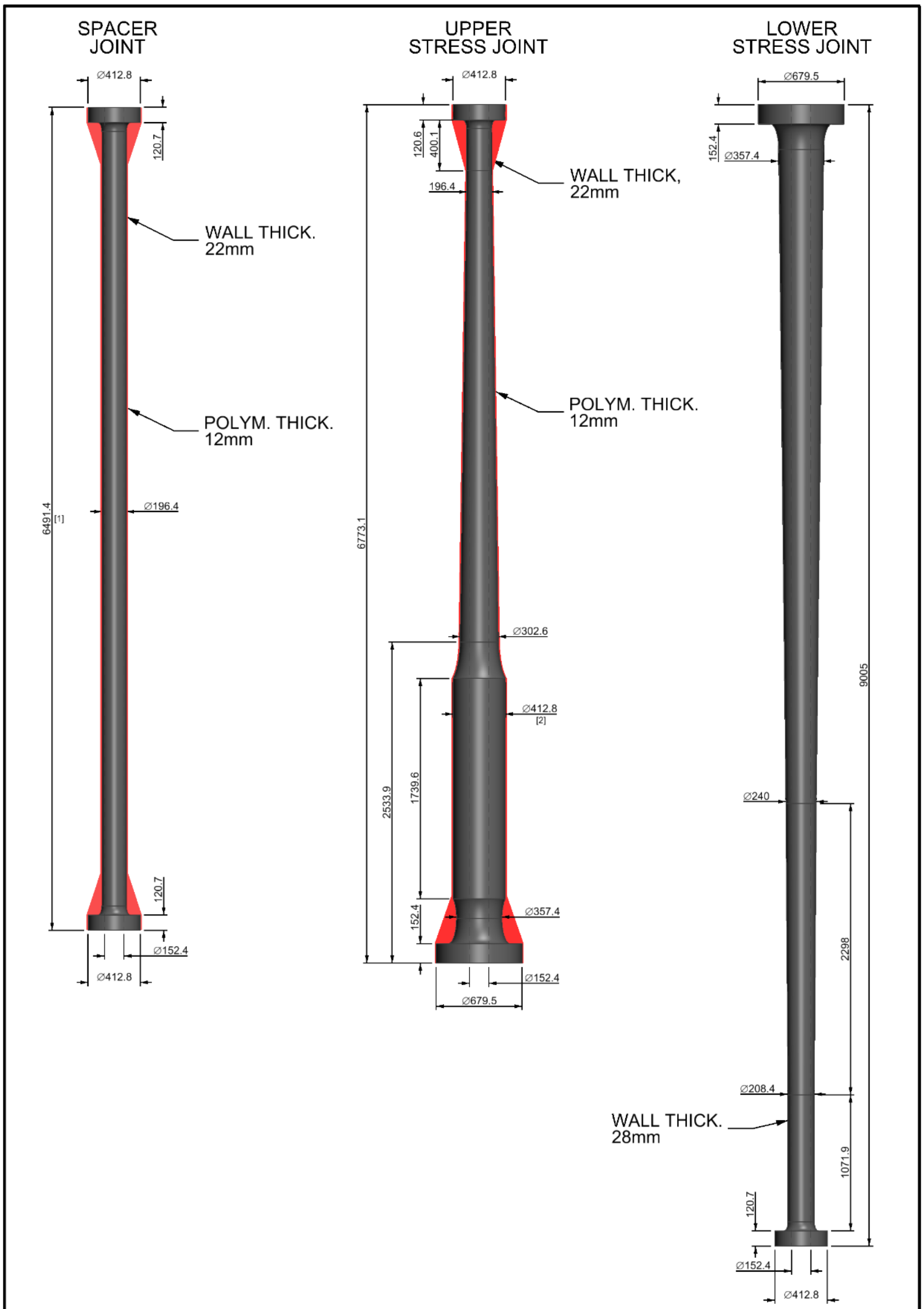
8.2. TOP LOADS LIMITS BALCONY

Top loads shall be limited to the load components presented in ref. [7].

APPENDIX A – TIPT PRELIMINARY DRAWINGS

- TiPT for 7° Support Top Angle

TiPT - T.A. 7°



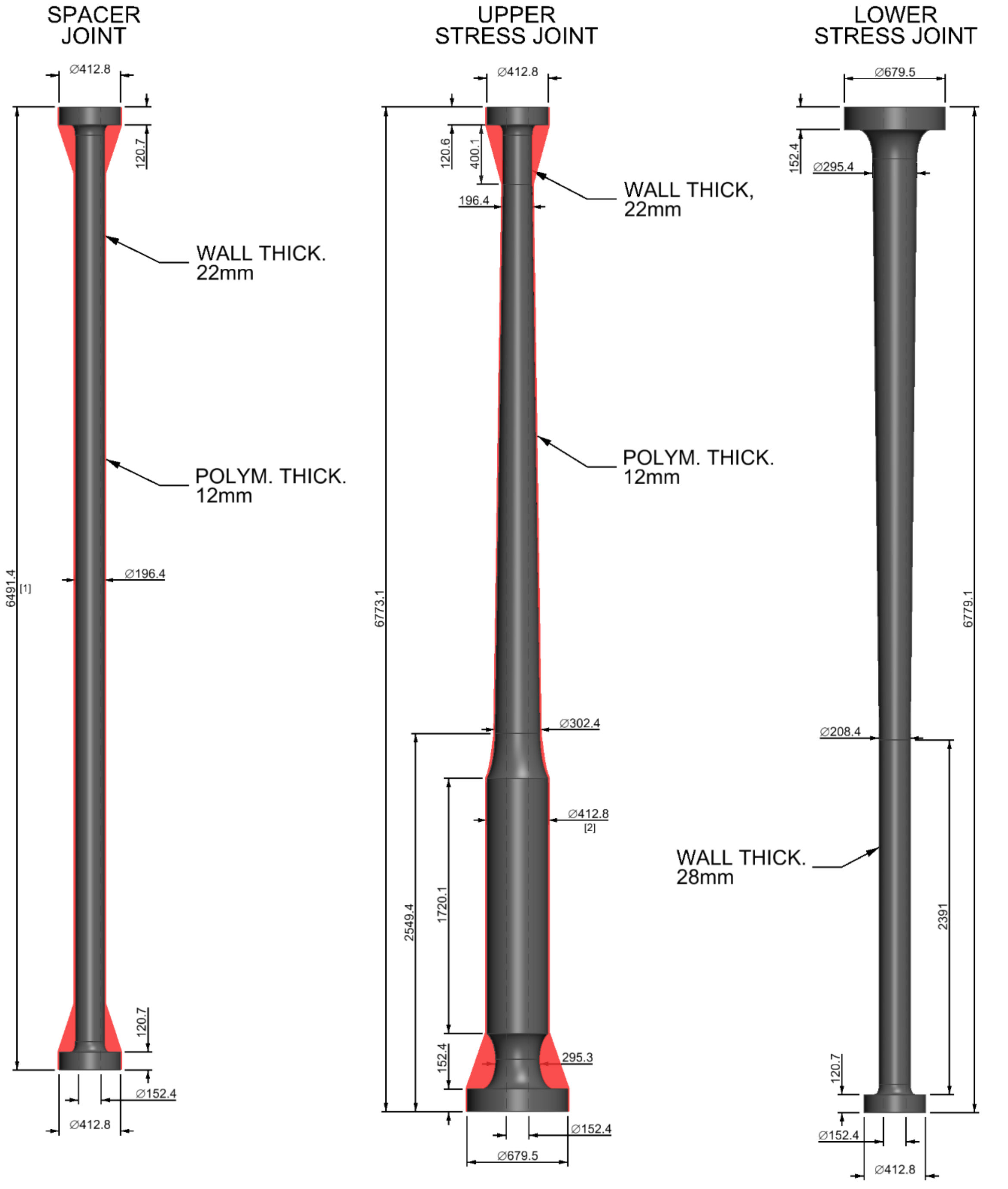
(1) - SPACER JOINT MINIMUM LENGTH. CONTRACTOR SHALL SEEK TO MAXIMIZE THE SPACER LENGTH TO REDUCE THE QUANTITY OF FLANGED UNIONS.

(2) - THE DIAMETER OF THE CILINDRICAL SECTION OF THE UTSJ SHALL BE EQUAL OR GREATER THAN THE SPACER JOINT'S FLANGES DIAMETERS, TO ADJUST INTO THE CAP ID WITH THE REQUIRED GAP OF 3mm.

(3) - DIMENSIONS SHOWN IN THIS DRAWING ARE BASED ON PETROBRAS BASIC DESIGN LOADS. ALL DIMENSIONS SHALL BE CONFIRMED BY CONTRACTOR BASED ON DETAILED GLOBAL ANALYSIS DURING EPCI PHASE.

- TiPT for 9° Support Top Angle

TiPT - T.A. 9º



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APPENDIX B – STEADY STATE FLOW CONDITIONS FOR GI COMPLETE PROFILE

(HOLD)

APPENDIX C – INJECTED CHEMICAL DATA

For chemical injection data, refer to Table 14 and Table 15. If additional data is needed, bidder is requested to send a technical query.

Due to pumping system conditions, fluids may be injected with concentrations up to 20x higher.

Due to pumping system conditions, fluids may be injected with concentrations up to 20x higher.

Table 14 – Chemical Injection Data.

Function	Base-Fluid	Injection Point	Injection Cicle Frequency	Injection Period	Concentration	Nominal Temperature
Acidification	See Acidizing Table	Perforations and formation	Every 2 years	1 day	See Table 15	30°C (60°C as return fluid)
Anti-foam	Natural Gas	Upstream from separator	-	-	5 - 60 ppm	-
Corrosion inhibitor	Natural Gas	Topside	-	-	0.5 - 2 l/Mscf	-

Table 15 – Chemical Injection Complementary Data.

Function	Base fluid	Comercial denomination	Base fluid concentration	pH	Other fluids
Acidification	HCl (water solution)	Hydrochloric acid	15% mass	0	- Aminic corrosion inhibitors 2%; - Tensoactives: 0.4% condensed ethylene oxyde and quaternary ammonium salts - Mutual solvent (butyl glycol or symilar): 10%
Acidification	Hfor (water solution)	Formic Acid	10% mass	1.5 - 5	- Aminic corrosion inhibitors 1%; - Tensoactives: 0.4% condensed ethylene oxyde and quaternary ammonium salts - Mutual solvent (butyl glycol or symilar): 10%
Acidification	Acid chelators (water solution)	EDTA diamoniacal and GLDA monosodic	-	4 - 5	- Tensoactives: 0.4% condensed ethylene oxyde and quaternary ammonium salts - Mutual solvent (butyl glycol or symilar): 10%
Acidification	Formic acid + Acetic Acid (water solution)	-	9% mass (Hfor) + 13% mass (Acetic Acid)	1.7	- Aminic corrosion inhibitors 1%; - Tensoactives: 0.4% condensed ethylene oxyde and quaternary ammonium salts - Mutual solvent (butyl glycol or symilar): 10%
Acidification	Acetic acid (water solution)	-	20% mass	2.1 - 5	- Aminic corrosion inhibitors 1%; - Tensoactives: 0.4% condensed ethylene oxyde and quaternary ammonium salts - Mutual solvent (butyl glycol or symilar): 10%
Acidification	Alkaline chelator (water solution)	-	10-20% mass	10 - 13	- Tensoactives: 0.4% condensed ethylene oxyde and quaternary ammonium salts - Mutual solvent (butyl glycol or symilar): 10%
Acidification	sodium hydroxide (water solution)	-	100 ppm	8 - 9	
Anti-foam	Natural Gas	-	-	-	- propylene glycol monomethyl ether
Corrosion inhibitor	Natural Gas	-	-	-	-amine derivative 10-30%; - Ethylene glycol 10-30%; - Sulfur compound 10-30%; - Organic ester salt 5-10%; - Quaternary ammonia compound 1-5%; - Morpholine 1-5%; - Propanediol 1-5%