PETROBRAS	TECHNICAL SPECIFICATION	Nº I-ET-3010.00-1300-279-PX9-002
	CLIENT PETROBRAS	SHEET 1 of 81
	JOB	
	AREA	
SUB	TITLE **DIVERLESS BELL MOUTH (BSDL) - GENERAL REQUIREMENTS**	**PUBLIC** SUB/ES/EDA/EAI

REVISION INDEX

REV.	DESCRIPTION AND/OR REVISED SHEETS
0	ORIGINAL. This document is based on the previous technical specification for BSDL-SI: *I-ET-3010.00-1300-279-PPC-350, I-ET-3010.00-1300-279-PEK-002_0, I-ET-3010.00-1300-279-PEK-001_F, I-ET-3010.00-1300-850-PEK-001_H and I-ET-3010.00-1300-850-PEK-002_F.*
A	Minor changes in the references
B	Minor changes where marked.

Note (*): the following team has supported in the development of this Technical Specification:

- (BYE8) SUB/ES/EDA/EAI
- (DVHV) SUB/ES/EDA/EAI
- (B8WL) SUB/ES/EDA/EAI
- (FWN1) SUB/ES/EDA/EAI
- (FGWO) SUB/ES/EDA/EAI
- (CX4H) SUB/ES/EDA/EAI
- (CJLZ)) SUB/ES/EDA/EAI
- (EVJN) SUB/ES/EDA/EAI
- (QM63) SUB/ES/EDA/EAI
- (EVLB) SUB/ES/EDA/EAI
- (BERK) CENPES/PDIDP/ESUB/TDUT
- (CMC1) CENPES/PDIDP/ESUB/TDUT
- (C5E3) CENPES/PDIDP/ESUB/TECES
- (KZ04) CENPES/PDIDP/TIA/TMI
- (BW12) CENPES/PDIDP/TIA/TMI
- (ELYS) SRGE/ESUP/APS/ESC

	REV. 0	REV. A	REV. B	REV. C	REV. D	REV. E	REV. F	REV. G	REV. H
DATE	28/03/2025	17/04/2025	15/09/2025						
DESIGN	EAI - **Note(*)**	EAI	EAI						
EXECUTION	BYE8/DVHV	BYE8/DVHV	BYE8						
CHECK	U4B8/CJLZ	U4B8/CJLZ	DVHV						
APPROVAL	NTHF	NTHF	NTHF						

TABLE OF CONTENTS

1 SUBJECT

This document establishes the Technical Specification and main parameters for DIVERLESS BELL MOUTH (BSDL-SI). The document describes the requirements for design, manufacture, inspections, and automation.

2 ABBREVIATION

AWS	American Welding Society
BSDL-SI	Diverless Bell Mouth - Standard Interface (Portuguese acronym)
CFD	Computation Fluid Dynamics
CRA	Corrosion-Resistant Alloy
DFT	Dry film thickness
DL	Diverless
FAT	Factory Acceptance Test
FEA	Finite Elements Analysis
FPSO	Floating Production Storage and Offloading
FPU	Floating Production Unit
GA	General Assembly (Drawing)
GPS	Global Positioning System
HMI	Human Machine Interface
HPU	Hydraulic Power Unit
ITP	Inspection and Test Plan
JB	Junction Box
MD	Descriptive Memorandum
NDE	Non Destructive Examination
NDT	Non-Destructive Testing
OPC	Open Plataform Communications
PQR	Procedure Qualification Record
PR2	Degree of certification
PSL	Product Specification Level
PTFE	Polytetrafluoroethylene
PUPS	Portable Umbilical Pressurization System
PWHT	Post-Weld Heat Treatment
QA	Quality Assurance
QAP	Quality Assurance Plan
QC	Quality Control
QHSE	Quality Health, Safety and Environment
ROV	Remotely Operated Vehicle
RSMS	Riser Support Monitoring System
RTU	Remote Terminal Unit
SAK	A series of screw-type terminal blocks
SMYS	Specified Minimum Yield Strength
TCP	Transmission Control Protocol
TiPT	Titanium Pullin Tube
TRS	Test Report Sheet
WPS	Welding Procedure Specification
XT	Xmas Trees

3 REFERENCE DOCUMMENTS, CODES AND STANDARDS

This section lists standards and documents applicable to the design of the monitoring system:

3.1 International Standards and Patents

[1] API-RP 2A-WSD – Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms – Working Stress Design

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

[3] API 6X - Design Calculations for Pressure-containing Equipment

[4] API 17E – Specification for Subsea Umbilicals

[5] API 17F - Standard for Subsea Production Control Systems

[6] API RP 17G - Design and Operation of Subsea Production Systems

[7] API 17Q - Recommended Practice on Subsea Equipment Qualification

[8] API 2RD – Dynamic Risers for Floating Production Systems

[9] API 20F level BSL 2 – Corrosion Resistant Bolting for Use in the Petroleum and Natural Gas Industries

[10] ASME B16.5:2013 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for Low-Temperature Service

[11] ASME B16.5:2013 - Pipe Flanges and Flanged Fittings

[12] ASME Section VIII, Division 1 - ASME Boiler & Pressure Vessel Code

[13] ASME Section VIII, Division 2 - ASME Boiler & Pressure Vessel Code

[14] ASME PCC 1-2010 - Guidelines for Pressure Boundary Bolted Flange Joint Assembly

[15] DNVGL-RP-B401:2017 - Cathodic Protection Design

[16] IEC 60529 (latest revision) - Degrees of Protection Provided by Enclosures (IP Code)

[17] IEC 60079 (latest revision) - Explosive atmospheres

[18] ISO 13628-6:2006 - ISO 13628-6:2006

[19] API RP 2X - Recommended Practice for Ultrasonic and Magnetic Examination of Offshore

[20] ASTM A370 – Standard Tests Methods and Definitions for Mechanical Testing of Steel Products

[21] ASTM A517 – Standard Specification for Pressure Vessel Plates, Alloy Steel, High- Strength, Quenched and Tempered

[22] ASTM A578 – Standard Specification for Straight-Beam Ultrasonic Examination of Rolled Steel Plates for Special Applications

[23] ASTM B841 – Standard Specification for Electrodeposited Coatings of Zinc Nickel Alloy Deposits

[24] ASTM A703M - Standard Specification for Steel Castings, General Requirements, for Pressure Containing Parts

[25] ASTM A707M - Standard Specification for Forged Carbon and Alloy Steel Flanges for Low Temperature Service

[26] DNVGL-RP-C205 – Environmental Conditions and Environmental Loads

[27] AWS D1.1 – American Welding Society Structural Welding Code

[28] DNV-RP-0034 – Steel forgings for subsea applications

[29] DNV-RP-B401 – Cathodic protection design

[30] DNV-RP-C203 – Fatigue design of offshore steel structures

[31] EN 473 – Qualification and certification of non-destructive testing personnel – general principles

[32] EN 15800 – Cylindrical helical springs made of round wire. Quality specifications for cold coiled compression springs

[33] ISO 13628-7 – Petroleum and natural gas industries — Design and operation of subsea production systems — Part 7

[34] ISO 8501 – Preparation of steel substrates before application of paints and related products – Visual assessment of surface cleanliness

[35] ISO 8504 – Preparation of steel substrates before application of paints and related products – Surface preparation methods

[36] ISO 9001 – Quality management systems – Requirements

[37] ISO 9712 – Non-destructive testing – Qualification and certification of NDT personnel

[38] ISO/IEC 17024 – Conformity assessment – General requirements for bodies operating certification of persons

[39] ISO/IEC 17020 – Conformity assessment – Requirements for the operation of various types of bodies performing inspection.

[40] ISO/IEC 17024 - Conformity assessment – General requirements for bodies operating certification of persons

[41] ISO GUIDE 65 – General Requirements for Bodies Operating Product Certification Systems

[42] SSP-SP1 – Solvent Cleaning

[43] SSPC-SP10 – Near-White Metal Blast Cleaning

[44] BR 10 2021 017362-9 – Patent: “SISTEMA DE ATUAÇÃO HIDRÁULICA PARA BOCA DE SINO”

3.2 Petrobras Technical Specifications

[45] I-ET-3000.00-1500-251-PEK-001 – High-strength low-alloy steel fasteners for subsea applications

[46] I-ET-3010.00-1200-800-P4X-015 - Requirements for tubing and fitting (aligned to iogp-jip33 s-716)

[47] I-ET-3010.00-1200-251-P4X-001 - Requirements for bolting materials

[48] I-ET-3010.00-1200-956-P4X-003 - Thermal Spray Coating Application of Aluminum

[49] I-ET-3000.00-1500-29B-PAZ-003 - 3/8" & 1/2” id hydraulic hoses

[50] I-ET-3000.00-1519-29B-PZ9-002 - Low voltage/signal electric cables and terminations for subsea umbilical systems

[51] I-ET-3000.00-1519-29B-PZ9-012 - Topside arrangement and interfaces with subsea umbilical systems

[52] I-ET-3010.00-5139-172-PX9-001 - Portable umbilical pressurization system (pups) – FPU scope

[53] I-ET-3010.00-5537-850-PEA-001 - Positioning and navigation system

[54] I-ET-3010.00- 1500-274-PLR-001 - Riser top interface loads analysis

[55] I-ET-3010.00-1200-955-P4X-001 – Welding

[56] I-ET-3010.00-1200-956-P4X-002 – General Painting

[57] I-ET-3010.00-0000-970-P4X-003 – Requirements for Personnel Qualification and Certification

[58] I-ET-3010.00-5267-750-P4X-001 – Technical Specification for Cathodic Protection

3.3 Petrobras Additional Documents

[59] I-LI-3010.00-1300-279-PPC-350 – BSDL-SI PART LIST

3.4 Brazilian Documents

4 DEFINITIONS

FPU CONTRACTOR/SELLER	The entity that is responsible for the Engineering Procurement, and Construction of the Floating Production Unit (FPU) as established in the contract of the FPU.
SUBCONTRACTOR	Company contracted by FPU CONTRACTOR/ SELLER, to supply the entire BSDL subsystems or part of them.

INTEGRATOR	Company contracted by FPU CONTRACTOR/SELLER responsible for all SUBCONTRACTORS interfaces during design, supply, tests and commissioning (Subsea and Topside scopes).
MAY	It is used when alternatives are equally acceptable
SHOULD	It is used when a provision is not mandatory, but is recommended as a good practice
SHALL	It is used when a provision is mandatory
BELL MOUTH	BELL MOUTH is a device used for supporting and locking bend stiffeners for flexible risers.
BEND STIFFENER	Bend Stiffeners are conically shaped polyurethane mouldings designed to add local stiffness to a riser, flowline, cable or umbilical.
CAP DL - SI	Bend Stiffener´s metallic component that provides alignment of this equipment inside the BELL MOUTH, containing an interface geometry for the locking system (Latch Bars).
DIMENSIONAL GAUGE	Mechanical gauge to verify BELL MOUTH inner diameters after Riser Balcony Integration
Diverless Bell Mouth with Standard Interface – BSDL-SI	It is a BELL MOUTH designed to allow pull-in and pull-out (if Hydraulic Actuation System is requested) operations with little diver assistance, and with a Bend Stiffener standard interface geometry with previous Buyer Bellmouth designs.
DFT	Dry film thickness: the thickness of a coating as measured above the substrate.
DUMMY CAP	Mechanical part that replaces the Bend Stiffener's Cap DL-SI and its docking process into the BELL MOUTH during the FAT.
HANDLERS	Handlers are sets including a lever and a cam that are used in the latch bar locking mechanisms.
HYDRAULIC ACTUATOR SYSTEM	Simple action hydraulic actuator, which can be installed on BSDL-SI Round Blocks, providing means for remote control to unlock the Latch Bar for pull-out operations.
PULL IN	Riser transfer operation from pipe laying vessel to the FPSO.
PULL OUT	Riser removal operation
RISER	A length of flexible or rigid pipeline used to connect the subsea collecting/exporting system to the FPSO.
TESTING STAND	Testing Stand is a test bench used to simulate the fastening of the BELL MOUTH on the I-Tube.

5 TECHNICAL CARACTERISTICS

5.1 Overview

5.1.1 BSDL final design is FPU CONTRACTOR/SELLER responsibility. FPU CONTRACTOR/SELLER shall detail the concept, including and not restricted to: structural analysis, general geometric dimensioning and tolerance analysis, complete mechanical design including standards mechanical fixation elements (e.g. screws, bolts, nuts) and its quantities, surface coating thickness, cathodic protection design for moving parts, pre-selected materials, manufacturing process, or any other detailing issue for final manufacturing drawings.

5.1.2 FPU CONTRACTOR/SELLER shall generate its own drawings, according to its design and manufacturing methodology, and shall submit them to PETROBRAS for review and approval.

5.1.3 FPU CONTRACTOR/SELLER shall be attentive to the revision of the manufacturing drawings. Any questions, PETROBRAS shall be consulted.

5.1.4 FPU CONTRACTOR/SELLER shall only start manufacturing the BSDL after approval of manufacturing drawings by PETROBRAS.

5.1.5 FPU CONTRACTOR/SELLER is responsible for defining an internationally accepted design code to guide the whole design. If any potential failure mode is not predicted on the selected code, complementary codes shall be established to fulfill this gap. Mixing of many design codes or requirements for different versions of the same code, shall be avoided. The design premises document shall clearly present the selected code for each failure mode.

5.1.6 All data shall be reported in primarily SI units. Customary US units may also be indicated for reference only.

5.2 Design and Fabrication

5.2.1 All subsea control components, shall be designed in accordance with [4] and [5].

5.2.2 Hydraulic cylinder shall be designed according to [1] and [5].

5.2.3 All subsea equipment shall be qualified in accordance with [7] or [18].

5.2.4 Selection of materials for all subsea structures shall be in accordance with [15] item 5.5 and be designed for the same design life as the riser.

5.2.5 All enclosures and equipment to be placed in hazardous areas shall comply and be certificated according to [17].

5.2.6 All enclosures with a required degree of ingress protection shall comply with IEC [16].

5.2.7 Electrical subsea connectors shall be wet-mate connectors designed, as a minimum, with the following requirements:

- Diver-mate solution
- Be housing made with stainless steel (AISI 316L)
- Be suitable for operation in the foreseen environment
- Have a double barrier solution to protect the electrical connections/pins
- Be able to withstand at least 100 connections/disconnection cycles
- Be qualified according to [5];
- Have a design life at least 25 years.

FPU CONTRACTOR/SELLER shall present evidence for each of the aforementioned requirements.

5.2.8 Optical subsea connectors shall be wet-mate connectors designed, as a minimum, with the following requirements:

- Diver-mate solution
- Be 8 (eight) or more-ways optical fiber cores, with fibers end face angled physical contact (APC)
- Be housing made with stainless steel (AISI 316L)
- Be suitable for operation in the foreseen environment
- Have a double barrier solution to protect the electrical connections/pins

- Be able to withstand at least 100 connections/disconnection cycles
- Be qualified according to [5]
- Have a design life at least 25 years

FPU CONTRACTOR/SELLER shall present evidence for each of the aforementioned requirements. The optical infrastructure of the umbilical may be applicable or not depending on the project design. For more details such as umbilical cross section and other characteristics, consult the MD.

5.2.9 The Hydraulic fluid shall be water-glycol based hydraulic control fluid, with cleanliness class according to Norm ISO 4406 CLASS 17/15/12. (Equivalent to class 6 from the old Norm NAS1638 Cleanliness Requirements used in Hydraulic Systems). The following water-glycol based hydraulic fluids are allowed:

- Castrol Transaqua HT (Compatible with Castrol Transaqua DW)
- MacDermid Oceanic ECF (Compatible with MacDermid HW443 & HW525P)

5.2.10 The design of the hydraulic components and any other component that is in touch with the hydraulic control fluid shall be fully compatible with 5.2.9.

5.2.11 The design shall consider the following requirements, otherwise noted on their specific sections:

- Hydraulic Maximum operation pressure (Design Pressure): 5000 psi
- Hydraulic Test pressure: 5500 psi
- External Environment: Sea Water
- Maximum sea water temperature: 30 °C
- Minimum sea water temperature: 20 °C
- Range of outside water temperature: -20°C to 50°C
- Operational Life: 30 years
- Operational Life: 100 cycles
- Maximum external pressure: 40 m water column

6 BSDL-SI DESIGN REQUIREMENTS

6.1 System Overview

6.1.1 BSDL-SI is a device designed to support flexible line bend stiffener loads and allow diverless pull-in and pull-out operations. Three nominal sizes of BSDL-SI are considered: 32”, for umbilical lines, 46” and/or 48” for flexible production, service, export or gas/water injection lines. Figure 1 shows BSDL-SI with hydraulic actuator system.

6.1.2 The scope of this document covers the BSDL manufacture, hydraulic actuator design, monitoring system and hull side umbilical.

6.1.3 FPU CONTRACTOR/SELLER shall provide a 3D analysis to demonstrate that there is no clashing or interference caused by the supports, bilge plates and shellside plates or any other components in the lower riser balcony. If any clashing is identified along FPU CONTRACTOR/SELLER analysis, a detailed report, including recommended corrections shall be submitted to PETROBRAS for review and approval.

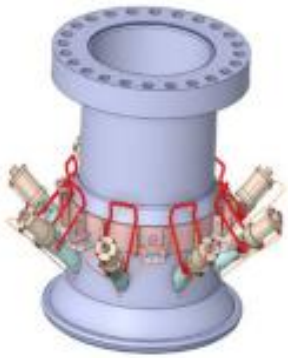


Figure 1: BSDL-SI with Hydraulic Actuator System

6.1.4 The verification of 6.1.3 is critical for the system and its verification shall be carried out in the engineering phase, integrated into the 30% Design Review of the FPSO.

6.2 Latch Bar Mechanism

6.2.1 The latch bar is a sliding component used to lock and secure Cap DL-SI on BSDL-SI for flexible riser connection. A general overview of the latch bar mechanism is illustrated on Figure 2.

Figure 2: Latch Bar Mechanism

6.2.2 The Latch Bar Mechanism shall be designed to support the full range of loads imposed by the flexible risers throughout the design life without replacement. Please see 7.6.

6.2.3 The latch bar mechanism shall be in accordance with the reference Cap DL design as [59].

6.2.4 FPU CONTRACTOR/SELLER shall not machine the latch bars to force the contact with the dummy cap. The shape and angles of the latch bars shall not be changed from the dimensions and tolerances shown in the manufacturing drawings approved by FPU CONTRACTOR/SELLER.

6.2.5 Hydraulic Actuator Assembly for the Latch Bar

6.2.5.1 The hydraulic actuator is responsible primarily for diverless unlocking mechanism of the flexible riser bend stiffener during pull-out operation and functional tests before pull-in operation.

6.2.5.1 The scope of hydraulic actuator assembly is shown in Figure 3. The left figure presents the external view while the right one shows internal parts. Red parts represent the hydraulic actuator components, and the blue parts are part of the latch bar design.

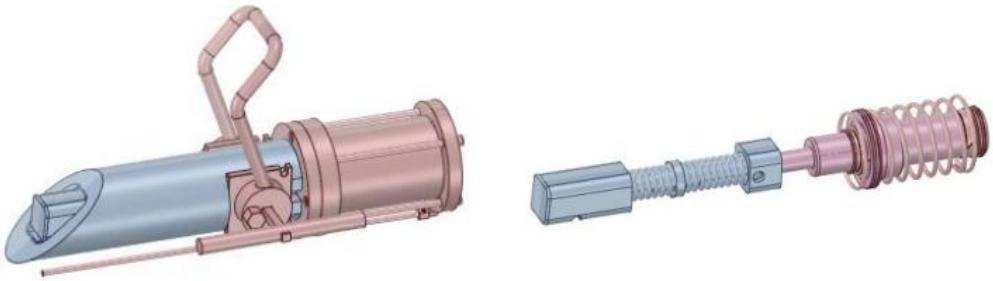


Figure 3: Scope of latch bar (blue) x scope of hydraulic actuation system (red)

6.2.5.1 Drawing ref [59] presents conceptual hydraulic actuator assembly and establishes detailed scope separation between the latch bar and hydraulic actuator.

6.2.5.2 Detailed design for actuators and tubing lines shall be submitted to PETROBRAS approval prior to start of hydraulic system component production. Technical requirements described in the following paragraphs shall be fulfilled as a minimum.

6.2.5.3 As a minimum design documentation shall comprise assembly and component drawings with dimensional and tolerances, stress analysis and material description.

6.2.5.4 Refer to Hydraulic Pressure tests in Annex A:

6.2.5.5 Hydraulic Actuator design shall be compatible with 3 (three) modes of operation, where 1 (one) is for pull-in and 2 (two) are for pull-out operations:

This is the primary mode of operation during pull-in activities and its latching/unlatching function is independent of hydraulic actuation. The latch bar internal components provide all the necessary functionality for pull-in operation. Handler remains at same position while latching bar moves towards inside by compressing the springs as shown in Figure 4. Driving force for the latch bar retraction is done by Cap DL ([59]) upwards movements during pull-in operation.

Return of latching bar is performed by spring force after Cap DL reaches a level with reduced section releasing space for latching.

Actuator design shall have drilled rod to allow free movement of latch mechanism axis as shown in Figure 4 in yellow.

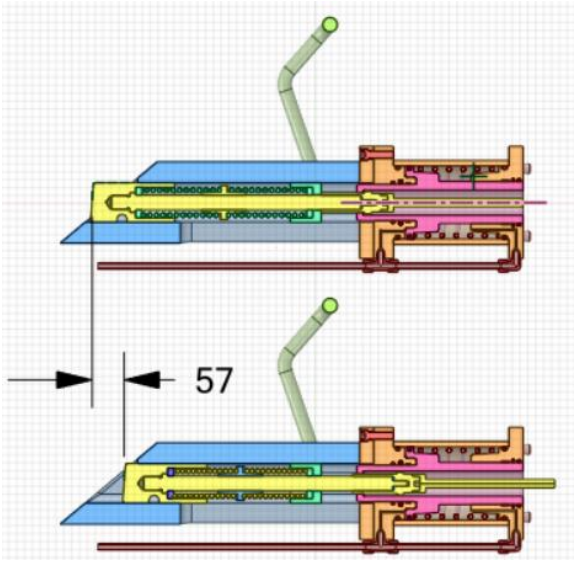


Figure 4: Mechanical Automatic Latching During Pull-in

- Manual Override Mode Diver Operation (Pull-out)

Latch bar retraction may be performed by handler movement operated by diver for pull-out activities. During override the internal components highlighted in yellow Figure 5, Figure 6 and Figure 7 in moves on right direction driven by eccentric/sliding plate mechanism.

Two types of handlers shall be designed to perform override operation:

- In plane detachable handler is used initiate rotation until 45°.
- Lateral detachable handler is used to complete 180°.

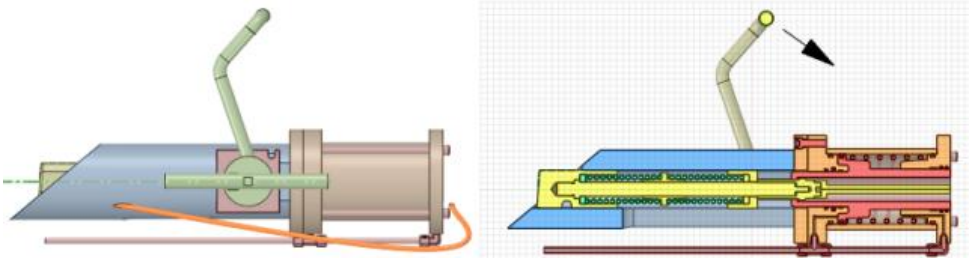


Figure 5: Manual Override Diver Operated for pull out activities

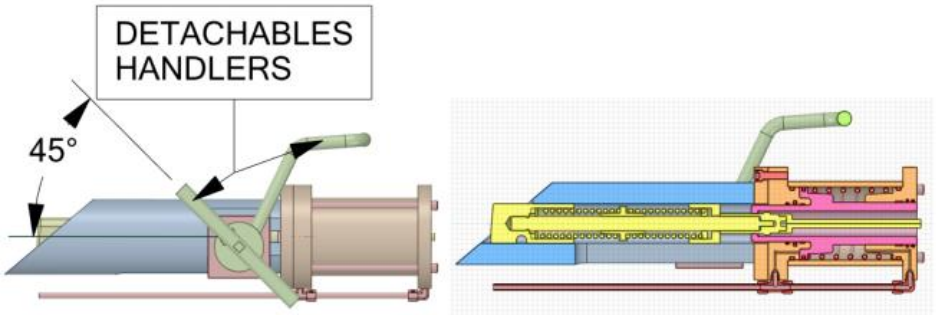


Figure 6: Detachable in plane handler restricted rotation movement

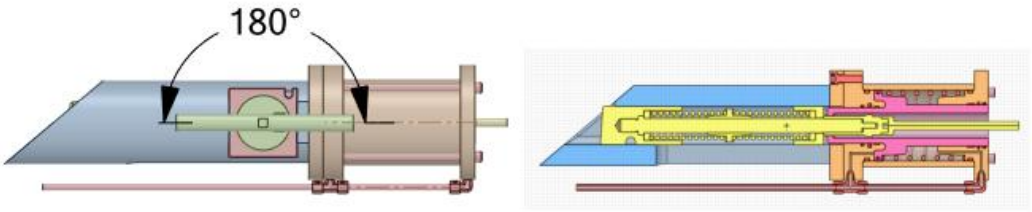


Figure 7: 180° rotation performed by lateral detachable handler

Note that in override mode of operation none of the springs are compressed, since the whole assembly is moved as shown in the previous figure. Internal moving parts are highlighted in yellow.

Hydraulic actuator piston rod and internal cap shall leave enough space for latch bar reaction block stroke, 57 mm, during override operation. [59] shall be consulted for latch bar assembly dimensions to be considered in hydraulic actuator design.

- Hydraulic Remote Control Diverless Operation (Pull-out)

Latch bar single action hydraulic cylinders with spring return shall be designed for regenerative hydraulic circuit. Only one tubing line is used for all cylinders at each latch bar.

During pull-in operation the hydraulic actuator is aligned to HPU atmospheric pressure tanks the only remaining pressure acting over hydraulic actuator is due to 20 m hydrostatic column and its FPSO dynamic effects from lower riser balcony to FPSO deck as shown in Figure 8.

Hydraulic actuator is pressurized by FPSO valves to retract latch bars during pull-out operation an allowing bend stiffener downwards movement (see Figure 8).

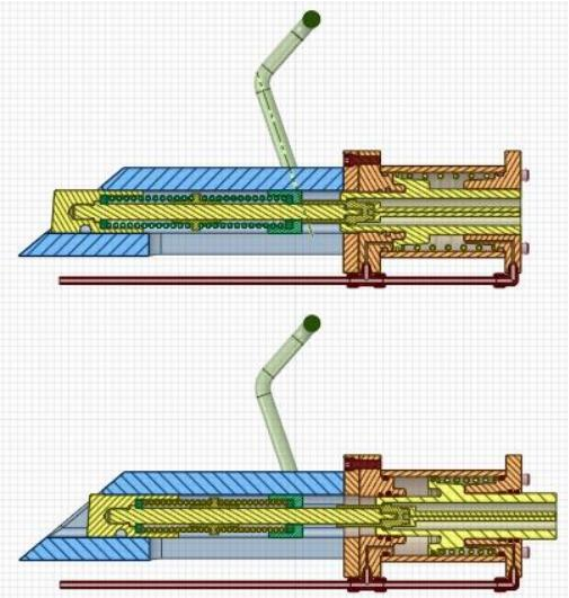


Figure 8: Hydraulic Actuation

6.2.5.6 Actuator Interface and Material Requirements:

6.2.5.6.1 Bolting

Hydraulic actuator shall be hold to round blocks by four ½ inch socket heads bolts. Wedge locking washers shall be used to prevent loosen bolts.

A mounting plate may be used to fix hydraulic actuator in the round block.

Bolt materials, including tie rods, shall comply with [45] if selected low alloy steel if selected corrosion resistant alloy ASTM A453 Gr.660D and electrical connected to the cathodic protection.

6.2.5.6.2 Selection of materials (other than bolting) and cathodic protection and Subsea hydraulic actuator and tubings shall be compatible with sea water environment and a combination of cathodic protection and use of corrosion resistance alloys are required as described in the following paragraphs.

6.2.5.6.3 3 (three) regions of round block and hydraulic actuator shall be considered for cathodic protection:

- Moving parts highlighted in yellow in Figure 9 shall be protected by cathodic protection connected to round block by copper cable shown in Figure 10. Handlers also shall be connected by another copper cable to round block.

- Hydraulic actuator piston rod shall be made as a single part of corrosion resistant alloy due to long time sea water exposure and need to keep sealing dimensions. Also, calcareous deposit under cathodic protection in sea water environment needs to be prevented and its possible harmful effects in rod surface and possible sealing failure. So, hydraulic actuator piston rod shall be insulated from cathodic protection by internal wear rings, insulating internal bush and gaps shown in [59]. Additionally, resistance to biofouling needs to be considered and copper alloys are required to combine sea water and biofouling resistance. Beryllium-copper, UNS 17200 shall be considered for hydraulic actuator rod.

- Stationary parts like actuator tube and caps are connected to round blocks thus are subjected to cathodic protection. Hydraulic actuator tube and caps may use either CRA alloys or low alloy steels with external painting and internal hard coated in sliding surfaces provided that a numerical cathodic protection model (FEA type) using recognized software has been performed to show that regions like gaps between internal cap and rod will not be affected by calcareous deposit.

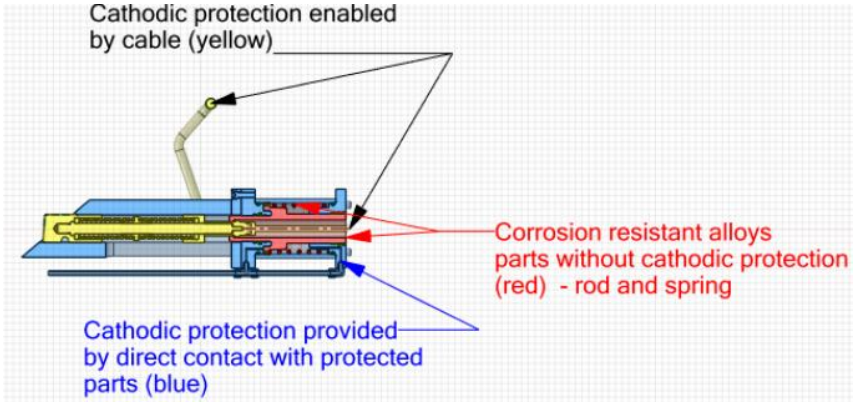


Figure 9: Corrosion Resistance and Cathodic Protection

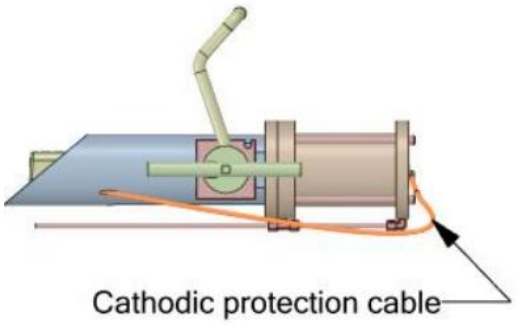


Figure 10: Cathodic Protection Cable

6.2.5.6.4 Hydraulic actuator spring shall be made of alloy 718 with hardness limited to 35 HRC. Any changes in the hydraulic actuator spring materials shall be submitted to PETROBRAS for review and approval.

6.2.5.6.5 Hydraulic actuator length shall be limited to 300 mm or 357 mm considering piston rod end of stroke.

6.2.5.6.6 Fitting sealings type shall comply with ISO 8434-2 (JIC 37) standard when applied at forged blocks or at main equipment components. Fitting sealings type shall comply with Medium Pressure standard as defined in the ref [51] between tubings connections.

6.2.5.6.7 Allowable working pressures shall be calculated according to ASME B31.3.

6.2.5.6.8 Sealings shall be selected considering, at least:

- Hydraulic Fluid requirements on Sections 5.2.9 and 5.2.10.
- External Environment described on 5.2.11
- Minimum and Maximum Temperatures described on 5.2.11
- Sealing components are expected to remain stationary for periods of up to 30 years. It is recommended to consider PTFE-faced seals.
- As a minimum, the sealing and wear rings configuration shall be considered as shown in [59].

6.2.5.6.9 Scope of supply includes procurement, construction, assembly, FAT.

6.2.5.6.10 Hydraulic actuator manufacturing, quality control, storing and shipping shall comply with [2] considering PSL 3.

6.2.5.6.11 Performance requirements level PR2 shall be fulfilled.

6.2.5.7 Manufacturing and quality control databook shall be issued including traceability of materials used. Each hydraulic actuator shall be low stress stamped with serial number linked with tests and materials certificates.

6.2.5.8 Hydraulic line cleanness shall be compatible with the control fluid cleanness requirements described in 5.2.9.

6.2.5.9 Design Data, as described on Figure 11, shall be considered as follows:

- Minimal spring force: 2,5 x rod hydraulic force due to pressure produced as a result of hydrostatic column in umbilical considering 30 m and fluid density
- Stroke equal to 57 mm

- Minimum net rod force at 5000 psi internal pressure at initial stroke: 15 kN net force is calculated considering hydraulic force minus the three-spring force as follows:

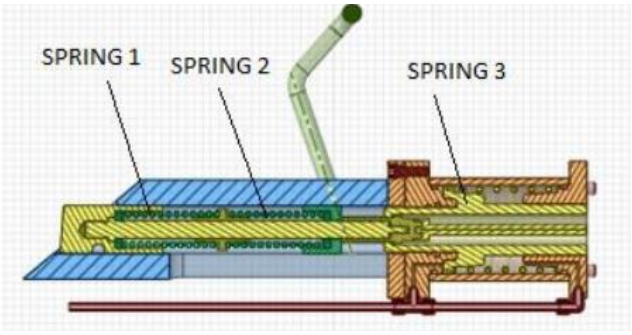


Figure 11: Spring net force calculation

6.2.5.10 The requirements from hydraulic fluid cleanness of 5.2.9 and 5.2.10 shall be fulfilled.

6.2.5.11 Requirements described on section 5.2.11 shall be fullfeed, with exception of the test pressure (described on 6.2.5.9) and operational cycles. Design operational life shall be 30 years and 50 cycles.

7 BSDL-SI MANUFACTURING REQUIREMENTS

7.1 General Requirements

7.1.1 The BSDL-SI fabrication shall be subject to the scrutiny, inspection, verification, qualification, and documentation in accordance with FPU CONTRACTOR/SELLER and industry standards as set in this specification and project documentation.

7.1.2 Pad eyes and other lifting devices used for general handling of the equipment shall be designed in accordance with internationally accepted code (e.g. [33]).

7.1.3 FPU CONTRACTOR/SELLER may manufacture a prototype of the BSDL previous starting the production. This prototype shall include all sensors and actuators. This prototype shall be tested in accordance with this technical specification and, in addition to the current documentation, the acceptance of these tests blocks start of fabrication.

7.2 Materials and Components

7.2.1 FPU CONTRACTOR/SELLER shall provide material certificates of raw materials used in BSDL manufacturing to be included in the databook.

7.2.2 FPU CONTRACTOR/SELLER shall provide water absorption material report for all polymeric components. Those reports shall be included in the databook.

7.2.3 Material Selection

7.2.3.1 All equipment and material manufactured and/or supplied under this technical specification shall be new and following the best engineering fabrication and manufacturing practices. It is preferred to use existing designs or modifications that have already been qualified and accepted. As a minimum requirement, the selected materials shall comply with [1].

7.2.3.2 FPU CONTRACTOR/SELLER shall verify all critical components material described in drawings list [59]. FPU CONTRACTOR/SELLER may suggest a different material for these components; however, it shall be submitted to PETROBRAS review for approval.

7.2.3.3 All materials shall be suitable for the intended service, described within Project Documentation. The selected materials shall be under the relevant applicable codes, standards, and specifications and be able to meet the requirements defined for the Project.

7.2.3.4 The origin of all materials used in the manufacture shall be clearly identified. FPU CONTRACTOR/SELLER shall submit any required material manufacturing process details, tests, examinations, inspections, and acceptance criteria for PETROBRAS review.

7.2.3.5 The selection of materials is a responsibility of FPU CONTRACTOR/SELLER and shall be made under:

- Relevant codes listed in this document and related project specifications
- Results of both the structural and the fatigue analysis
- Maintenance-free requirement during the product life, as per project specifications
- Corrosion Protection

7.2.3.6 Wear losses, including deleterious effects on the surface topography and its consequences on tribo-corrosion, fatigue or corrosion-fatigue life, due to relative movement and contact (e.g. fretting) of the parts according to Section 7.2.4.

7.2.3.7 The compatibility between all materials shall be checked. Materials shall not be affected by corrosion reactions (galvanic, crevice, pitting) and may be required to be welded to other specified metallic pieces where necessary.

7.2.3.8 Inspection criteria shall consider as a minimum the requirements as specified for the FPSO.

7.2.4 Material Selection for Parts and Components under Wear

7.2.4.1 Materials for parts with relative movement must be selected based on tribological considerations referenced on appropriated literature and proven through laboratory wear tests and with conduction of near full-scale (e.g. contact pressure, sliding speed, environment, temperature) to demonstrate the adherence to the specified product life. A technical specification for the mentioned wear tests shall be submitted to PETROBRAS as well as the laboratories where such tests are planned.

7.2.4.2 The fatigue and corrosion-fatigue performance of these parts must also be proven through mechanical-corrosion tests. A technical specification for the mentioned fatigue and corrosion-fatigue tests shall be submitted to PETROBRAS as well as the laboratories where such tests are planned.

7.2.4.3 The hardness of the material and the surface roughness of these parts must be in accordance with the tribological requirements of each pair in contact.

7.2.5 Ferrous Materials

7.2.5.1 Ferrous Materials used to manufacture the BSDL-SI and its parts, including latch bars and springs shall be certified by a classification society.

7.2.6 Thermally Pretreated Steels

7.2.6.1 Parts manufactured with thermally pretreated steels may need treatment after welding and/or machining for ensure that its mechanical properties will remain unaltered. FPU CONTRACTOR/SELLER shall contact the SUBCONTRACTOR that is providing the steel to spcify the appropriate heat treatment.

7.2.7 Studs

7.2.7.1 Studs for BSDL-SI assembly to the I-tube [59] shall comply with [59].

7.2.7.2 The flanges make-up shall be made with a pre-load stress of at least 50% of the stud´s material SMYS, using a hydraulic tensioner for a proper pre-load accuracy.

7.2.8 Spring

7.2.8.1 FPU CONTRACTOR/SELLER shall be attentive to the material defined in spring´s drawing [59].

7.2.8.2 Item [59] presents a preliminary spring design that was obtained by mechanical compression spring theory, and the spring geometric properties may be modified to achieve the design requirements. The values indicated on the table represent the following conditions:

- F1: Latch mechanism pre-load, which corresponds to the “locked” condition presented on [59].
- L1: Corresponding spring length for F1 condition, which may depend on spring free length (L) and geometric/material properties (see Figure 12).
- F2: Spring compression corresponding to the latch bar necessary stroke for Cap DL-SI/Dummy cap automatic connection.
- L2: Corresponding spring length for F2 condition, which may depend on spring free length (L) and geometrical/material properties (see Figure 12).

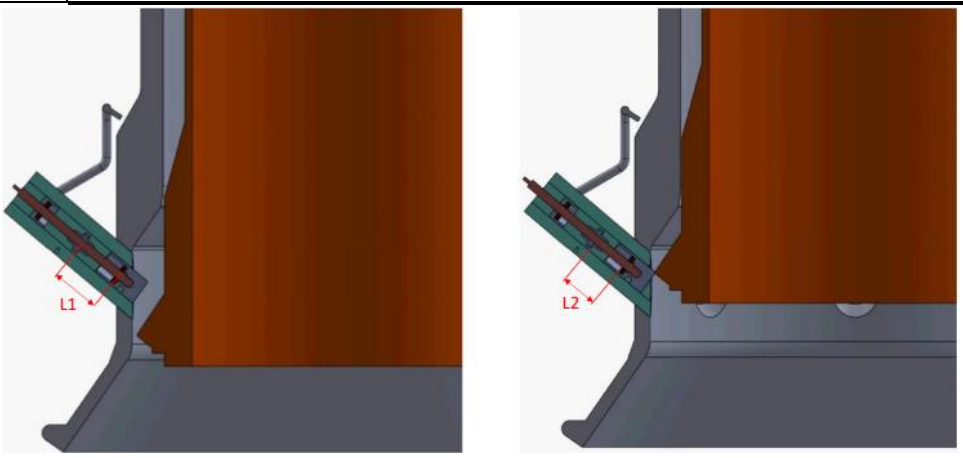


Figure 12: Latch Mechanism spring design conditions (L1 and L2)

7.2.8.3 The spring shall be designed with sufficient pre-load shear any marine growth inside the round block's square hole. This capability is obtained by F1; thus, this condition shall be the main requirement to be achieved.

7.2.8.4 The mechanism return force shall be similar to the original design.

7.2.8.5 Spring stiffness (k) shall be similar to the original design.

7.2.8.6 Please note that the spring stiffness by design may be inferred by k=(F2-F1)/(L2-L1).

7.2.8.7 The F1 and F2 shall be verified by tests, with tolerances as per [32].

7.2.9 Material Testing

7.2.9.1 FPU CONTRACTOR/SELLER shall perform a tensile test to obtain the stress-strain diagram for all the structural metallic materials. Results shall be included in the databook.

7.2.9.2 When using thermally pretreated steel in the manufacturing of latch bars, if the material suffers any manufacturing process that can alter its mechanical properties (such as, but not limited to, cutting with blowtorch), the manufacturer must ensure that the properties of the finished material remain similar to the properties of raw material.

7.2.9.3 FPU CONTRACTOR/SELLER shall manufacture an additional latch bar by batch of steel plate used. This additional latch bar shall be heat-treated along with the latch bars that will be used in the assembly of the BSDL-SI.

7.2.9.4 Destructive testing shall be performed on this additional latch bar to estimate the mechanical properties of the remaining latch bars. The results shall meet the contractual specifications and shall be part of databook.

7.3 Forging

7.3.1 The material shall be selected to have good weldability, strength, and toughness when welded to steel plate (e.g. ASTM A131 EH36). The forgings shall be forged to a near net shape, rough machined, heat treated and final machined. FPU CONTRACTOR/SELLER shall document a written specification complete with chemistry, material properties, toughness, testing, test coupon locations, inspection requirements, and NDE requirements. The forging SUBCONTRACTOR shall provide an MPS detailing the material, forging processing with reduction rations, heat treatment with times and temperature ranges, location of material sampling locations, and inspections. Test material for mechanical tests shall be representative of the production part and be from a portion of the actual forging such as the “cut-out” area or a prolongation. The forging reduction ratio shall not be less than 3.5:1. An alloy such as ASTM A707 L5 having good weldability and high toughness should be selected. Forgings shall be UT inspected after heat treatment and MT inspected after final machining. Consideration shall be given to the effects of weld distortion, to ensure the final profile after completion of all welding is acceptable.

7.3.2 As a minimum forging requirement shall meet Classification Society Rules for hull construction and [28] - SFC 3 with the following modifications and additional information:

- Min. Yield Strength (0.2% Offset): 355 MPa
- Min. Tensile Strength: 455 MPa
- Elongation in 2 in. or 50 mm, min 20%
- Charpy V-Notch Impact test temperature: -40°C
- Charpy V-Notch Minimum Average Absorbed Energy: 50 J (set of 3 samples)
- Charpy V-Notch Minimum Individual Absorbed Energy: 34 J

Note: Charpy V-Notch Impact test temperature exemptions may be proposed by FPU CONTRACTOR/SELLER by submitting to PETROBRAS approval a fracture mechanics assessment based on BS 7910 at the temperature of -20°C and considering the stress levels and the minimum detectable flaw size.

7.4 Welding

7.4.1 All welds shall be in accordance [27].

7.4.2 Personnel qualification of welders shall comply with 12.2.1. Qualification of NDT inspectors shall comply with 12.2.2.

7.4.3 Preparation of the welding technical documentation shall comply with item 5.3 (welding documents) of [57]. Each WPS shall be supported by suitable(s) PQR(s). Each PQR shall have attached on it the following documents, as minimum: base material certificates, consumable certificates, non-destructive testing reports, PWHT reports, laboratory testing reports. Pre-qualified welding procedures provided in [27] and standard procedures specified in AWS D1.1 are not acceptable.

7.4.4 Welding Qualification Procedure shall comply with 12.3.3.

7.4.5 All complete joint penetration welds shall be inspected by means of ultrasonic examination. Ultrasonic testing shall comply with 12.3.4.

7.4.6 All welds and surrounding area of base metal s hall pass through magnetic particle inspection. Partial NDE is not allowed. Magnetic particle shall comply with 12.3.6.

7.4.7 The extent of the Weld NONDESTRUCTIVE TESTS shall 100% ultrasonic test, 100% magnetic particle test and 100% visual inspected.

7.4.8 For full penetration joints welded from one side only, without a backing the nondestructive inspection percentage shall be complemented as follows: Butt joint with full penetration - Longitudinal = 5 % Radiography (full penetration butt joint); Butt joint with full penetration - circular = 5 % Radiography

7.4.9 The selection of welding consumables shall be in accordance with [55]. For processes not covered, the corresponding specification of ASME BPVC Section II Part C or AWS specification and classification shall be followed. Welding consumables shall be provided with its respective batch certificates (ISO 1O204 Type 3.1 or AWS A5.01 Sch J).

7.4.10 Heat treatment for stress relief shall be performed in the BSDL-SI structural body after all welds have been performed and before the inner diameters machining to avoid the structure ovalization and to improve the material fracture toughness.

7.5 Corrosion Protection

7.5.1 General

7.5.2 Corrosion Protection of the BSDL shall be accomplished with a combination of protective coating and cathodic protection.

7.5.3 Although not indicated on all the cable connections on the drawings, all surfaces where the cables shoes assembled shall be free of coating to assure electrical contact.

7.5.4 Coating procedure shall comply with 7.5.6 or coating manufacturer specification. In case of divergence, coating manufacturer specification shall be used, observing the thickness specification for each layer and final thickness.

7.5.5 FPU CONTRACTOR/SELLER shall consider different top coat colors for fixed components (e.g. BSDL main body) and for moving parts (e.g. latch bars) to make a contrast in order to achieve an easier visualization for ROV operation. The selected color scheme shall be submitted and approved by PETROBRAS.

7.5.6 Similar color scheme may be used for BSDL identification, as requested on 10.2.

7.5.7 Cathodic Protection

7.5.7.1 The BSDL-SI cathodic protection is provided by the electrical contact with the main I-tube structure, which is provided by the impressed current (definitive system) from the FPSO. A numerical simulation of the potential distribution shall be performed for BSDL-SI cathodic protection designs to confirm the absence of harmful electrochemical potential in the BSDL-SI components.

7.5.7.2 A temporary cathodic protection system for the BSDL-SI can be achieved by impressed-current or galvanic type and shall operate whenever the hull is in contact with sea water and the definitive system is not in operation. Temporary cathodic protection shall not interfere with tubing and cable routing of the BSDL-SI body.

7.5.7.3 BSDL-SI cathodic protection design report shall be issued considering both definite and temporary phases.

7.5.7.4 All moving parts that are subjected to corrosion and is connected to the BSDL-SI by other means than welding and without a reliable electrical connection shall consider an electric cable for cathodic protection transmission.

7.5.7.5 To assure electrical contact between the BSDL-SI and the I-tube, the flange contact surfaces from both sides shall not be painted.

7.5.7.6 All electrical cables shoes shall have a brazed connection to the cable.

7.5.7.7 Electrical cables shall have a contrasting insulation color to achieve an easier visualization for ROV or diver operations.

7.5.7.8 A green base with yellow strip color scheme may be used as insulation color. FPU CONTRACTOR/SELLER may select another color scheme. Nevertheless, the selected color scheme shall be submitted to PETROBRAS for approval.

7.5.7.9 FPU CONTRACTOR/SELLER shall consider bolt loosening prevention with proven and reliable methods due to dynamic loads imposed by sea waves and current on supports and cable connections.

7.5.7.10 Electrical continuity between all components must be tested after assembly according to [15].

7.5.7.11 Cathodic Protection for specific equipment is described within its respective sections, such as 6.2.5.6.3.

7.5.8 Painting

7.5.8.1 FPU CONTRACTOR/SELLER shall observe that parts whose drawings present the indication “DO NOT PAINT” are not to be either coated or electrically isolated.

7.5.8.2 Painting procedure shall comply with 7.5.10.1 or paint manufacturer specification. In case of divergence, paint manufacture specification shall be used, observing the thickness specification for each layer and final thickness.

7.5.9 Finishing and anti-fouling coating

7.5.9.1 For Surface Preparation

7.5.9.2 All surfaces shall be free of oil, grease and salt contamination before blasting. Abrasive blast clean to Sa 2 ½ ISO 8501 or SSPC-SP10. If oxidation occur between blasting and coating application, the surface shall be re-blasted to the specified visual standard. Surface defects revealed by the blast cleaning process shall be ground or corrected in the appropriate manner.

7.5.9.3 Anchor profile: A sharp, angular surface profile of 50-75 microns (2-3 mils) is recommended.

7.5.9.4 Salt Contamination: Surface salts concentration (e.g. Chloride deposits) shall be less than 70 milligrams/m2 (or 7 micrograms/cm2) prior to coating.

7.5.9.5 All surfaces to be coated shall be clean, dry and free of contamination. Prior to coating application all surfaces shall be assessed and treated in accordance with [34]. Oil or grease shall be removed in accordance with [41] solvent cleaning.

7.5.9.6 For Epoxy Coating

7.5.9.6.1 Apply two coats of High Abrasion Resistant Aluminum Epoxy Coating Cured with Polyamine, with a minimum dry film thickness of 125 microns per coat, using airless spray gun. Interval from one coat to the next shall be at least 7 (seven) hour or at most 14 (fourteen) days.

7.5.9.7 For Sealant Coating

7.5.9.7.1 7 (seven) hours to 14 (fourteen) days after applying second coat of primer, apply one coat of intermediate bi-component coal tar free epoxy, with a minimum dry film thickness of 100 microns, using airless spray gun. Interval from one coat to the next shall be at least 8 (eight) hours.

7.5.9.8 Antifouling Coating

7.5.9.8.1 Apply two coats of copper free, self-polishing copolymer (SPC) antifouling coating, for static condition in maximum current of 3 knots, with a minimum dry film thickness of 125 microns per coat, using airless spray gun.

7.5.10 Final thickness

7.5.10.1 The maximum thickness of the coating after application of finishing and antifouling layers shall not exceed 0.6 mm.

7.5.10.2 Special attention for the tolerances indicated on [59] (ϕA, ϕB and ϕC) as it is a critical dimension for pull-in operation, as it defines the clearance between the BSDL and the CAP DL-SI. If necessary, FPU CONTRACTOR/SELLER can propose to PETROBRAS modifications to the coating scheme to achieve the required inner diameter tolerances.

7.5.10.3 Coating thickness shall be included as a verification on ITP.

7.5.11 Final Coating

7.5.11.1 The BSDL-SI shall be delivered with the coating free of defects.

7.5.11.2 Inspection by Holiday Detector is mandatory.

7.5.11.3 For the FAT, BSDL-SI shall be coated with the last layer applied (antifouling). If any BSDL-SI component is not in its final coating, such fact shall be reported, the tests shall be postponed, and the coating of the parts shall be finished.

7.5.11.4 After the FAT, coating shall be touched up to remove any risks and defects caused by the test. Final thickness shall not exceed that required in 7.5.10.1.

7.5.11.5 If necessary, the coating shall be touched up only in parts that do not require disassembly of the locking mechanisms. If FPU CONTRACTOR/SELLER needs to disassemble the locking mechanisms, the BSDL-SI shall be retested.

7.5.12 Anti-friction coat

7.5.12.1 Apply one coat of PTFE finishing with a minimum dry film thickness of 25 microns in parts of whose drawings specify this type of coating.

7.6 Structural Calculation

7.6.1 General

7.6.1.1 FPU CONTRACTOR/SELLER shall perform a structural assessment (static loads and corrosion-fatigue, including the deleterious effects on thickness and surface topography due to the wear caused by the relative movement of the parts) considering the loads defined [33], [54] and the specific riser configuration defined by the project.

7.6.1.2 If the calculations indicate the need of structural changes, the design modification requirement shall be only implemented after PETROBRAS review and approval.

7.6.1.3 Design methodology and acceptance criteria shall be in accordance with an internal recognized code as [6]. Other design codes or methodologies previously validated by FPU CONTRACTOR/SELLER may be accepted after PETROBRAS approval.

7.6.1.4 FPU CONTRACTOR/SELLER shall consider the design requirements from [33] for static load analysis.

7.6.1.5 FPU CONTRACTOR/SELLER shall consider the design requirements from [30] for fatigue analysis.

7.6.1.6 The calculated life shall exceed the specified design life with Design Fatigue Factor (DFF) of 10, assuming no inspections required during the design life (non-inspectable structure)

7.6.1.7 The structure is to be considered a fatigue sensitive component and designed accordingly. Material toughness, welding procedures, and inspection criteria shall be selected to insure meeting the required fatigue life.

7.6.1.8 All welds that require grinding to meet the required life shall be clearly detailed on SUBCONTRACTOR'S drawings. The root and crown surfaces shall merge smoothly with the adjoining base metal without the undercut exceeding 0.5 mm (0.02 in). Final grinding marks shall be transverse to the weld axis.

7.6.2 Finite Element Analysis

7.6.2.1 Finite element analysis shall be used to establish static structural, buckling and fatigue performance of the BSDL-SI.

7.6.2.2 The finite element analysis shall be modeled using contact formulation at least on the interaction between the bell mouth and the adjacent structures: I-tube and CapDL-SI.

7.6.2.3 The contact interaction between the bell mouth and the Cap DL-SI shall be modeled to correctly represent the localized stresses due to these contacts.

7.6.2.4 The contact interaction between the bell mouth and the i-tube shall be modeled, including the studs pre-load with appropriate accuracy to model the prying effect and the consequence on these elements for static and fatigue calculations.

7.6.2.5 Care shall be exercised in the finite element analysis to ensure that appropriate element types, mesh refinement, element aspect ratio/distortion and boundary conditions are used.

7.6.2.6 Applied boundary conditions shall be clearly indicated in model sketches and/or in finite element plots.

7.6.2.7 Mesh sensitivity analysis shall be performed to ensure that accurate results are predicted. Mesh density convergence checks shall be presented in the reports.

7.6.2.8 The sensitivity of the calculation model and the parameters utilized in the model shall be examined.

7.6.2.9 Surfaces of equipment structural elements in contact with salt water and therefore vulnerable to corrosion must be reduced to thickness by 3.75 mm on each face for structural strength calculations.

7.6.2.10 Stress-strain curve with strain hardening shall be considered for non-linear structural calculation.

7.6.3 FEA Methods to Evaluate Protection Against Progressive Collapse

7.6.3.1 Methods for protection against progressive collapse from repeated loading are found on internationally recognized design codes. FPU CONTRACTOR/SELLER shall follow the recommended procedure of the respective selected codes for the verification of the bell mouth.

7.6.3.2 For a FE elastic analysis, the sum of primary plus secondary stresses shall be less than the respective allowable value defined on the selected code. Note that if all requirements for protection against plastic collapse are met in an elastic FE analysis with all stresses categorized as primary then the load is safe regarding progressive collapse. In the context of verification of protection against progressive collapse by means of elastic analysis, it is considered acceptable the use of stress linearization as per [13].

7.6.3.3 However, if elastic-plastic analysis results are used, then an assessment method compatible with such type of analysis shall be employed instead (see [13]).

7.6.4 Slamming Loads

7.6.4.1 Fairlead support structures, mooring balconies, riser balconies, aft hull structures and other attached structures subject to wave slamming load shall be designed and positioned in a way to avoid or minimize the effects of wave slamming. Sufficiently inclined plates at the bottom of each of these structures and/or more transparent concepts shall be employed

7.6.4.2 Structures that are potentially subjected to wave slamming loads shall be analyzed considering the slamming pressure combined with other environmental loads for a period of return of 100 years. Significance of effects on onboard comfort, as well as on stresses in hull and vibration (whipping) in the hull girder are also to be addressed.

7.6.4.3 Slamming loads can be calculated considering CFD software, model tests or by approximations as described on [26].

7.6.4.4 If wave slamming probability of occurrence and associated loads provide a relevant contribution to fatigue damage, fatigue calculations shall include wave slamming loads.

7.6.5 FEA Documentation

7.6.5.1 The analysis report shall be sufficiently detailed to allow for independent verification and approval by a third party, PETROBRAS, FPU CONTRACTOR/SELLER, either based on review of the documentation, or using independent analyses (sensible data may be provided under a non-disclosure agreement and provision). The documentation shall include at least description of:

- Purpose of the analysis
- Failure Criteria
- Geometry model and reference to drawings used to create the model
- Analysis approach
- Application of safety factors
- Mesh convergence study results

- Boundary conditions
- Element types
- Element mesh
- Material models and properties
- Loads and load sequence
- Analysis results
- Sensitivity analysis
- Discussion of results
- Conclusions
- Any performed verification

7.6.5.2 The third-party activities are FPU CONTRACTOR/SELLER responsibility.

7.6.5.3 The final version of the document specified hereinabove shall be approved by FPU CONTRACTOR/SELLER and PETROBRAS before the start of the BSDL-SI manufacturing.

8 HULL SIDE UMBILICAL

8.1 System Overview

8.1.1 The hydraulic/electrical components of the BSDL-SI system shall be connected to the topside by a hullside umbilical. It is FPU CONTRACTOR/SELLER responsibility to provide the umbilicals and make all the connections on the system.

8.1.2 Umbilical Outer Sheat material shall be either Polyurethane or HDPE (High Density Polyethylene).

8.1.3 The construction materials to be used in the umbilical and its functional components, hoses, electrical cables and optical fibers and terminations, shall withstand all types of degradation arising from the exposure of these components to marine environment or atmosphere. This includes, but not limited to the following components:

- Seawater, microorganisms and marine life, considering the functional components and their terminations, when sea water penetrates through the interstices between umbilical components. It should also be considered that the materials that make up the functional components shall not suffer degradation due to the phenomenon of hydrolysis.
- Ultra-violet radiation, as the ends of the functional components will be exposed to sunlight during transport, storage and operation of the umbilical.
- High temperatures resulting from sun exposure during the transport, storage and operation of the umbilical.
- Specified hydraulic fluid.

8.1.4 The number of umbilical's armor wire layers shall guarantee the robustness of the design and lifetime operation. It is FPU CONTRACTOR/SELLER responsibility to provide an analysis to demonstrate that the proposed number of layers fulfil the requirements. As a minimum, the number of armor wire layers shall be equal to 2 (two).

8.1.5 Some umbilical characteristics will depend upon the project. Information such as umbilical cross section, number of hydraulic lines, number of electrical conductors, number of fiber optics cores will be fully available in the specific MD.

8.1.6 A general diagram of the Hull Side umbilical infrastructure is illustrated on Figure 13.

8.1.7 FPU CONTRACTOR/SELLER shall foresee all handling/installation at dry dock accessories like slings, shackles, etc.

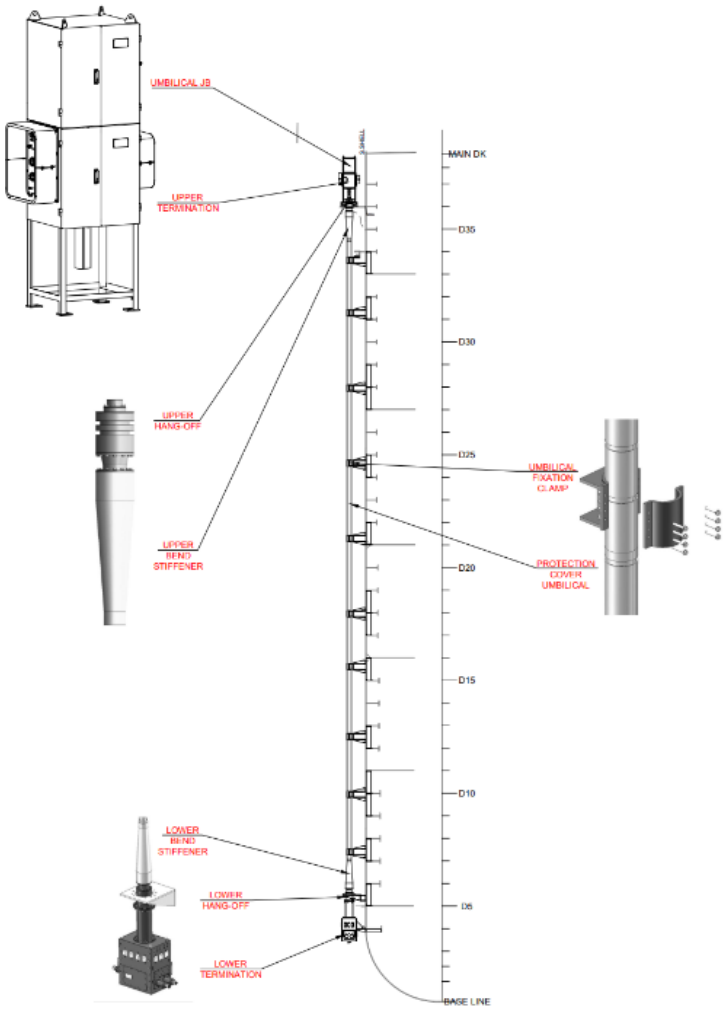


Figure 13: Hullside Umbilical basic infrastructure

8.1.8 The umbilical lines shall be supplied with all accessories to protect both ends (for example, armor pots, bend stiffener) and for handling and fixation at riser balconies.

8.2 Mechanical Infrastructure

8.2.1 All top umbilical ends shall be supplied with pull-in heads designed to handle umbilical lines installation at dry dock.

8.2.2 Both ends of the lines at upper and lower riser balconies supports shall be fixed by a bipartite hang off structures as demonstrated on Figure 14.

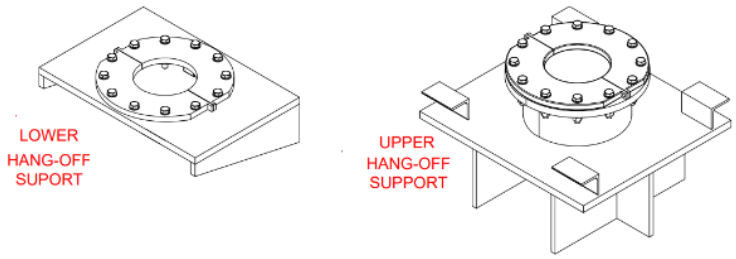


Figure 14: Upper and Lower Hang off structures

8.2.3 Upper hang off shall be designed to allow different levels of umbilical fixation. As demonstrated on Figure 15, these levels permit proper fixation of the umbilical at the FPU with minimum length adjustments.

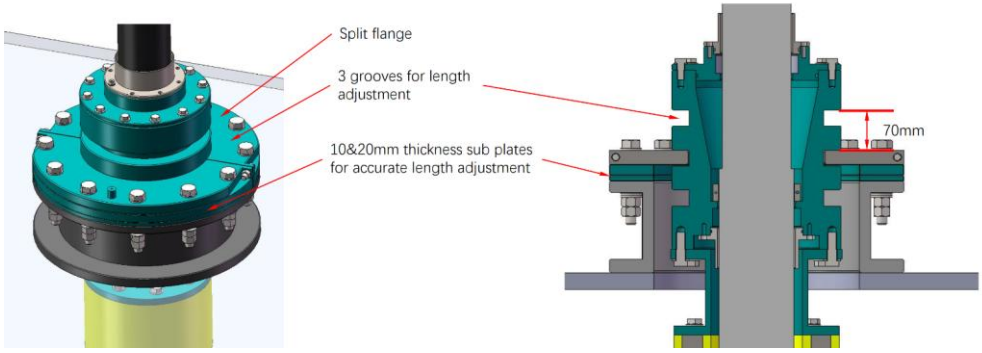


Figure 15: Hang off design with length adjustment

8.2.4 The umbilical lines shall be terminated in plates at both sides. Each plate shall have connectors (Medium pressure standard tube fitting as [51]) to connect each pigtails thermoplastic hoses in a steel tubing.

8.2.5 In terminations, FPU CONTRACTOR/SELLER shall observe:

- Thermoplastic hoses need a minimum 400 mm of straight section after terminal connector.
- Thermoplastic hoses need a minimum bend radius of 150 mm.
- Cathodic protection to hydraulic, electrical and optical connectors (if applicable).
- Steel tubing routing at lower and upper balcony.
- All pigtails (hydraulic, optical and electrical) shall be housed internally of umbilical termination to protect from UV radiation and mechanical impacts.

8.2.6 The umbilical body shall be fixed along the hull side of FPU by welded fixing/clamps supports at double plates. The fixing/clamps supports quantities, mechanical details and welded locations shall be submitted to PETROBRAS for review and approval. A general fixation scheme is shown on Figure 16.

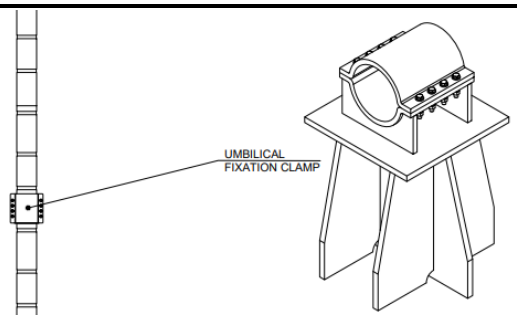


Figure 16: Clamps design for hull side umbilical fixation

8.2.7 Regarding fasteners for umbilical fixation, FPU CONTRACTOR/SELLER shall follow requirements on ref [45].

8.2.8 Umbilical and its supports design shall consider, at least, hydrodynamic loads (waves and current) acting on umbilical length over hull side.

8.2.9 The number of clamps shall be consistent with the stress analysis described in 8.2.6. A minimum number of 10 umbilical clamps supports over hull side shall be considered, unless clearly demonstrated by previous analyses.

8.2.10 Umbilical supports shall be calculated to withstand the most stringent loads combination due to pipe, wave, currents, and hull movement. Hydrodynamic loads (wave and current) acting over the support shall be included in the stress analysis.

8.2.11 The installation positions for umbilical lines hydraulic actuation system shall not use any riser slot in balcony reserved to subsea riser arrangement, as illustrated on Figure 17 and Figure 18

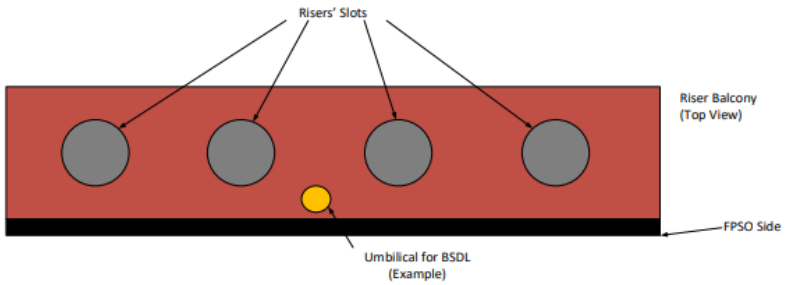


Figure 17: Umbilical Position

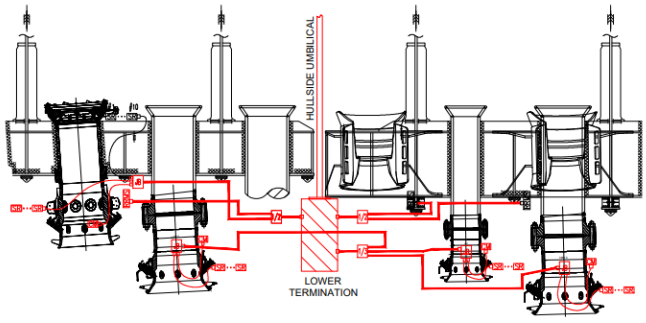


Figure 18: Hull Side umbilical position and routing

8.2.12 . The upper termination shall observe the following requirements:

- FPU CONTRACTOR/SELLER shall provide medium pressure standard tube fitting connector to connect each pigtails thermoplastic hoses in a steel tubing (for local panel interface).
- FPU CONTRACTOR/SELLER shall guarantee that any thermoplastic hose will not be exposed to solar UV light to avoid upper balcony pigtails degradation.
- Electrical and optical cables shall interface to Riser Junction Box. FPU CONTRACTOR/SELLER shall provide this connection (by spare length or jumpers).
- The upper umbilical termination shall be fixed in upper riser balcony area with free access to terminal plate to allow future maintenance.

8.2.13 Upper Umbilical Termination body material shall be AISI 316L.

8.2.14 Upper Umbilical Termination shall be supplied with 4 adjustable legs to guarantee that any of the umbilical pigtails (i.e. optic, electric and hydraulic pigtails) not be exposed to solar UV light to avoid upper balcony pigtail degradation.

8.2.15 Upper Umbilical Termination shall be installed after hullside umbilical erection during dry dock phase.

8.2.16 Umbilical JB shall be installed bolted over the Umbilical Upper Termination.

8.2.17 The set of (Umbilical JB & Upper Umbilical Termination) shall be installed bolted over the umbilical hang off with the maximum height of 2 meters where is dismiss the use of safety harness for high work for any operator during offshore activities. Figure 19 illustrates this requirement.

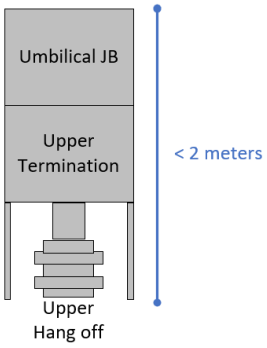


Figure 19: Umbilical JB and Upper termination installation requirements

8.2.18 . The lower umbilical termination shall be fixed in lower riser balcony area, with terminal plate sided to below area as shown on Figure 18 and Figure 20.

8.2.19 Lower Termination body shall be designed with the same metallic material from the hull structure.

8.2.20 Lower Umbilical Termination body shall be supplied with anodes for protection.

8.2.21 Lower Umbilical Termination shall be provided by FPU CONTRACTOR/SELLER with medium pressure standard tube fitting connector to connect each hydraulic thermoplastic hoses with a steel subsea tubing.

8.2.22 Lower Umbilical Termination shall be provided by FPU CONTRACTOR/SELLER with electrical and optical cables (if applicable, see MD for details) to interface with Riser Monitoring JB, as shown in Figure 20. FPU CONTRACTOR/SELLER shall provide this connection (by spare length or jumpers).

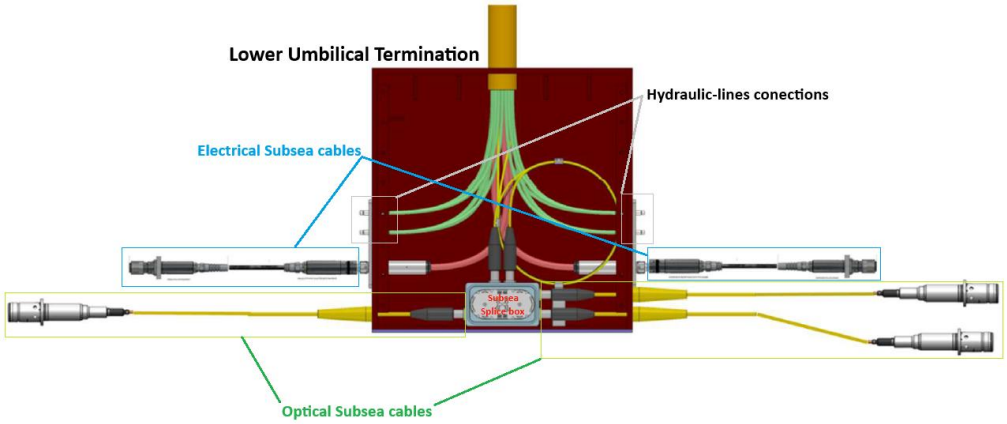


Figure 20: Schematic drawing for the Lower Umbilical Termination

8.2.23 FPU CONTRACTOR/SELLER shall provide a routing analysis and a 3D model demonstrating all the connections between each umbilical lower termination and electrical/hydraulic components. There shall be no clashing and no interference with any other structure in the lower balcony. This analysis shall be submitted to PETROBRAS review and approval before operations in the dry dock.

8.3 Hydraulic Infrastructure

8.3.1 The hydraulic infrastructure of the umbilical will be responsible for providing hydraulic force to actuate the pistons along pull-in and pull-out activities for the system lifetime.

8.3.2 Hydraulic Control: Thermoplastic hoses (DWP = 7500 psi)

8.3.3 Thermoplastic hose shall be designed and qualified following the requirements on [49].

8.3.4 All thermoplastic hoses shall be supplied from umbilical factory filled with the same hydraulic fluid planned to be used on PUPS (in accordance with 5.2.9) and plugged with hydraulic hose caps at both ends.

8.3.5 All thermoplastic hoses shall be flushed to guarantee supply of water glycol based hydraulic fluid in accordance with 5.2.9 and ensure no air bubbles are inside.

8.3.6 All hydraulic pigtails not used shall be filled with the hydraulic fluid and closed with caps at both ends.

8.3.7 FPU CONTRACTOR/SELLER shall guarantee that any thermoplastic hose shall not be exposed to solar UV light to avoid upper balcony pigtails degradation.

8.3.8 At Lower Umbilical Termination, it shall be terminated the hydraulic pigtails with a medium pressure standard ([51]) for interface with lower balcony tubings.

8.3.9 All hydraulic pigtails shall have individual identification. Identification may be done by numbers, letters and/or insulation color. Identification shall withstand handling and installation of hydraulic lines and umbilical system.

8.3.10 FPU CONTRACTOR/SELLER shall evaluate in their detailed design to have at least one hydraulic spare at lower umbilical termination structure for each hull side umbilical line.

8.4 Electrical Infrastructure

8.4.1 The electrical infrastructure of the umbilical shall be responsible for providing the communication between the sensors installed for the RSMS with the topside supervisory system.

8.4.2 Low Voltage Electrical Conductors: 2.5 mm^2 0.6/1.0(1.2) kV.

8.4.3 Low voltage electrical cable shall be designed and qualified following the requirements on [50].

8.4.4 All electric cables construction materials shall be selected considering environmental resistance for the specified umbilical system service life. Environmental conditions include, at least, sea water, marine growth, UV radiation, and hydrogen generated in electric cables and/or umbilical armoring and/or umbilical cathodic protection.

8.4.5 The electric cables design shall minimize gap and voids between layers to reduce air and gas accumulation in electrical cable.

8.4.6 Fillers, if used, shall be polymeric material.

8.4.7 Electrical cables shall have at least two barriers to protect conductors against seawater. The electric cable outer sheath shall not be considered as a barrier.

8.4.8 The conductors shall have a longitudinal water blocking material (within strands) to minimize water migration in case of conductors flooding.

8.4.9 At lower umbilical termination, it shall be terminated with electrical wet-mate connectors in accordance with 5.2.7.

8.4.10 FPU CONTRACTOR/SELLER shall evaluate in their detailed design to have at least one electrical spare connector at lower umbilical termination structure for each hull side umbilical line.

8.4.11 Conductors shall have individual identification. Identification may be done by numbers, letters and/or insulation color. Identification shall withstand handling and installation of electrical cables and umbilical system.

8.4.12 Subsea electrical cables at lower riser balcony shall be installed at trays attached with mechanical clamps. The distance between each clamp shall be measured between 200 to 300 mm. Mechanical clamps shall be designed considering the cathodic protection from the hull.

8.4.13 At lower riser balcony a solution shall be designed to accommodate cable overlength. An example of the solution is shown on Figure 21.

Figure 21: Cable overlength solution example at lower riser balcony

8.4.14 At the transition from cable tray to the support, extra protection shall be included for all cabling. As an example (Figure 22), a heavy-duty spiral wrap shall be used.

Figure 22: Extra Protection for electrical cables

8.5 Optical Infrastructure

8.5.1 The optical infrastructure of the umbilical may be applicable or not depending on the project design. For more details such as umbilical cross section and other characteristics, consult the MD.

9 HYDRAULIC SYSTEM

9.1 System Overview

9.1.1 The hydraulic system shall be responsible for providing hydraulic force to move the actuators when commanded, allowing pull-in and pull-out diverless activities.

9.1.2 The system is composed by the topside, lower balcony and umbilical infrastructure.

9.1.3 Hydraulic System shall be filled with water glycol-based fluid in accordance with 5.2.9. FPSO CONTRACTOR/SELLER shall inquire PETROBRAS about what will be the fluid predicted for this project before any filling operations.

9.1.4 System design and material selection shall fulfil the requirements described 5.2.10.

9.1.5 PETROBRAS highlights the necessity to meet the assembly and spacing requirements for tubing and its supports, especially those set out in 9.3, as being critical for the operation of the system.

9.2 Topside Infrastructure

9.2.1 Topside infrastructure is composed by the equipment that provides hydraulic force and controlling mechanisms for the correct operation of the actuators.

9.2.2 The design for each component is fully described on Sections 11.1, 11.4 and 11.5.

9.3 Lower Balcony Hydraulic Infrastructure

9.3.1 The hydraulic circuits between the support and umbilical lower termination (plate) shall be made by steel tubing.

9.3.2 Subsea tubing supports at lower riser balcony shall be installed at trays with distance L between each support measuring between 200 to 300 mm.

9.3.3 Subsea tubings, fittings and supports be made of one of these options:

• Super austenitic stainless steel (SS alloy with 6% molybdenum) and shall comply with [29].

• S32750 with hardness limited to 35 HRC and tubing design shall comply with DNVGL-RP-F112 (ed.2018).

9.3.4 Steel tubing shall have a minimum external diameter of 1/2 inch.

9.3.5 Subsea tubings shall be electrically connected to the Hull cathodic protection system.

9.3.6 The steel tubing shall be properly fixed and routed below lower riser balcony. The routing shall prioritize protected areas to avoid mechanical damage of the tubing.

9.3.7 FPU CONTRACTOR/SELLER shall provide a routing analysis and a 3D model demonstrating all the connections as described on Section 8.2.13.

9.3.8 Design of the Lower riser balcony shall consider ROV access and Diver operations in case of maintenance.

9.3.9 FPU CONTRACTOR/SELLER shall provide proper hydraulic connection between the steel tubing and umbilical lower termination (plate), considering the environment and lifecycle.

9.3.10 Tubing design shall consider proper flexibility for components that presents displacement (for example, top cone hydraulic actuator). Flexible hoses will not be acceptable as part of the solution.

9.4 Umbilical Infrastructure

9.4.1 Umbilical infrastructure will connect the topside and lower riser balcony equipment.

9.4.2 Umbilical mechanical, electrical/optical and hydraulic characteristics are fully described on Section 8.

10 MONITORING SYSTEM

10.1 System Overview

10.1.1 FPU CONTRACTOR/SELLER shall provide a Monitoring System comprising all the sensors for monitoring the BSDL-SI main parameters, such as: hydraulic actuators, the electrochemical process and the correct attachment of the bend stiffener adaptor cap.

10.1.2 Each quad cable of Hull side Umbilical shall be dedicated to one BSDL-SI. Four conductors' way shall be designed in a CANBUS topology to gather all the BSDL-SI information.

10.1.3 All conductors related to each umbilical/local panel shall be terminated in an appropriated junction box with SAK connectors.

10.1.4 . The Figure 23 presents a block diagram of control and monitoring system related to a single BSDL-SI.

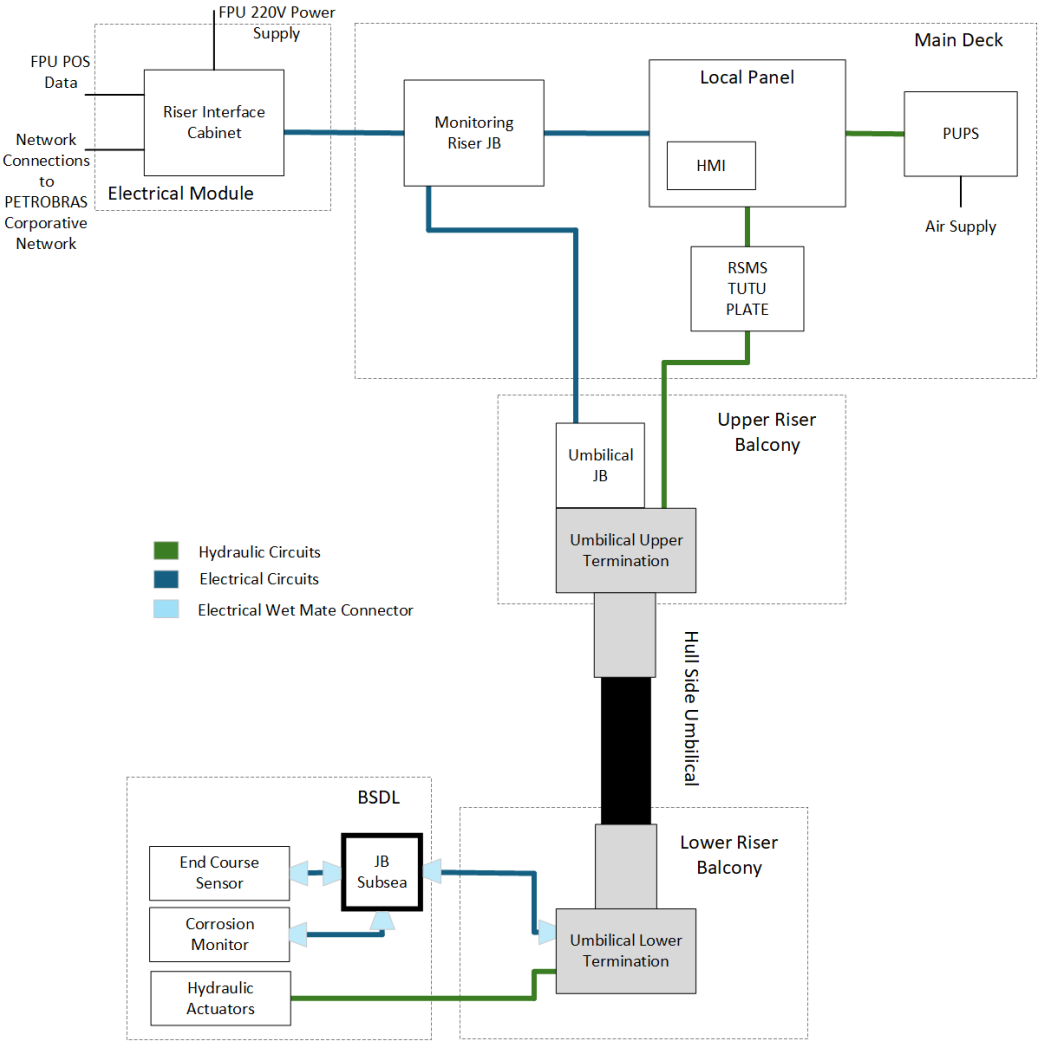


Figure 23: BSDL Control and Monitoring System for a Single Support

10.1.5 The interface between the monitoring components and the subsea cabling connect to the Hullside Umbilical shall be done by electrical wet-mate connectors with the requirements described on 5.2.7.

10.1.6 Each sensor shall be a self-contained unit, composed by all the necessary electronics embedded for signal conditioning and topside communication.

10.1.7 Sensor location shall not interfere with ROV maneuverability. FPU CONTRACTOR/SELLER shall design and submit to PETROBRAS for approval each sensor location followed by an analysis to demonstrate that each sensor does not impact ROV activities.

10.1.8 A 3D analysis containing all sensor location shall be provided to PETROBRAS. This analysis shall guarantee that no interference neither structural clashing between the sensors and BSDL-SI structure.

10.1.9 FPU CONTRACTOR/SELLER shall provide all electronics inside the Monitoring riser JBs and Local Panels for each sensor and show it displayed on the HMI screen inside the corresponding Local Panels and Riser interface cabinet.

10.2 End Course Detector

10.2.1 FPU CONTRACTOR/SELLER shall provide an end course detector, as illustrated on Figure 24, to monitor if, after the hydraulic actuation, all pistons moved to their expected position.

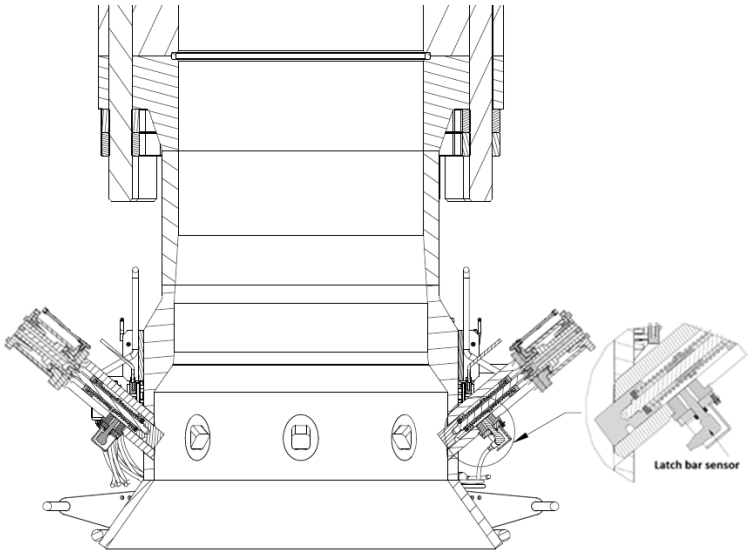


Figure 24: End Course Detector scheme at BSDL Latch Structure

10.2.2 The end course detectors work principle shall be based on a subsea inductive ultrasonic proximity sensor.

10.2.3 Sensor solution shall follow the design principles of 10.1.6.

10.2.4 Sensor installation location shall not compromise BSDL-SI structure and its main functionalities. It shall also comply with 10.1.7.

10.3 Corrosion Monitoring

10.3.1 FPU CONTRACTOR/SELLER shall provide an electrochemical potential monitoring solution of the support structure to verify an indication of corrosion process, as illustrated at Figure 25.

10.3.2 The electrochemical potential monitoring shall comprise one conductor connected to the support structure and other conductor connected to a Zinc reference electrode. Both connection points shall be close but not electrically connected. Both connection points shall be designed for easy access, maintenance and visualization by divers. The Zinc reference electrode shall be dimensioned for 25 years design life.

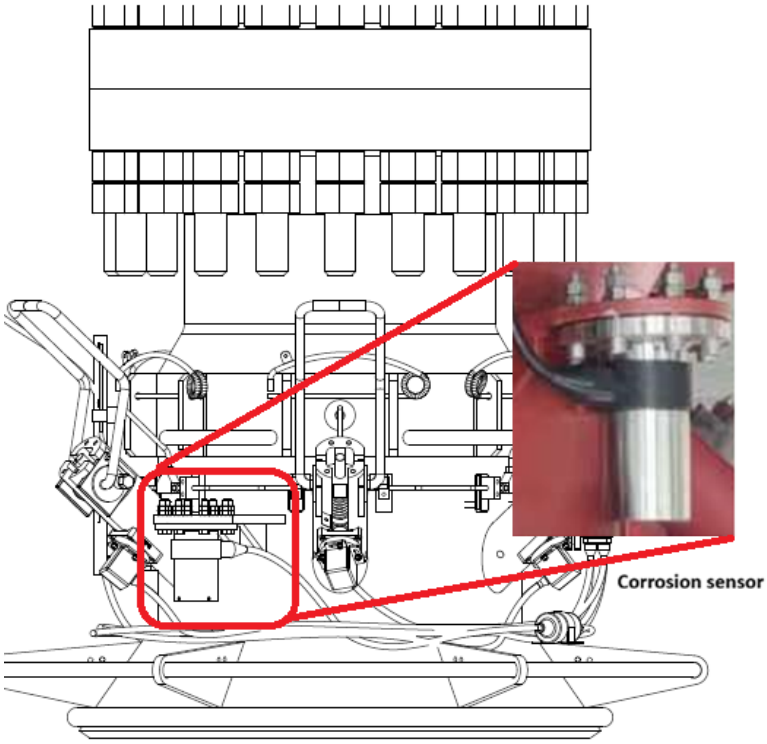


Figure 25: Schematic drawing of the Corrosion sensor

10.3.3 The electrochemical potential solution shall follow 10.1.6. Figure 26 illustrates a general concept design of the sensor and its embedded electronic circuits.

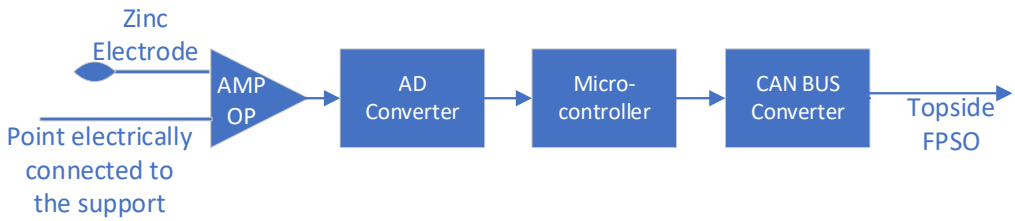


Figure 26: General Schematic of the Embedded Sensor Solution

10.3.4 The solution shall be calibrated to address both overprotection and general corrosion of the system. Calibration shall be within the range -50mV to 250 mV, which are the limits for overprotection and general corrosion, respectively.

10.3.5 Sensor installation location shall not compromise BSDL-SI structure and its main functionalities. It shall also comply with 10.1.7.

10.4 Subsea Junction Box (aka CAN HUB)

10.4.1 A Subsea Junction box shall be provided for each instrumented support as shown on Figure 23.

10.4.2 Subsea JB shall be responsible for gathering all the information from the sensors and transmit them via CANBUS to the lower riser balcony termination infrastructure.

10.4.3 Subsea JB shall fulfill the requirements for subsea units described on 5.2.1, 5.2.3 and 5.2.4

10.4.4 Subsea JB is part of the Lower Balcony Infrastructure, and its design shall comply with 8.2.23.

10.5 Lower Balcony Infrastructure

10.5.1 Lower Riser Balcony Infrastructure shall be in accordance with Section 8 and in specific project MD.

10.6 Umbilical Infrastructure.

10.6.1 Umbilical Infrastructure shall be in accordance with Section 8 and in specific project MD.

11 TOPSIDE REQUIREMENTS

11.1 RSMS TUTU Plates

11.1.1 FPU CONTRACTOR/SELLER shall provide 1 (one) RSMS TUTU plate and 1 (one) umbilical JB for each hullside located in the upper balcony.

11.1.2 TUTU plate shall have 1 (one) manual operated valve and 1 (one) pressure indicator for each hydraulic control line. The RSMS TUTU plate shall be connected in the topside with corresponding Local Panel.

11.1.3 FPU CONTRACTOR/SELLER shall provide a seal tag for each hydraulic circuit at RSMS TUTU plate to certificate the correct assembly (avoiding switching hydraulic lines during construction and assembly or operational phase). Each change during FPU construction and assembly shall be registered.

11.2 Umbilical Junction Boxes

11.2.1 Umbilical JBs, as illustrated on Figure 27, shall comply with the requirements on 8.2.16 and 8.2.17.

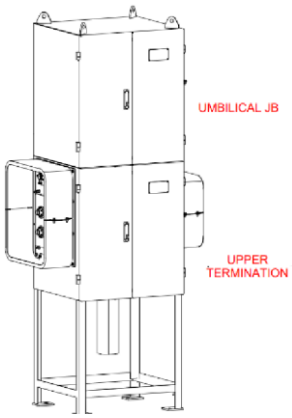


Figure 27: Umbilical JB and Upper Termination Design

11.2.2 Umbilical JB shall aggregate all optical fibers at splice trays (if applicable, see MD for details) and electrical conductors at SAK terminals from umbilical pigtails. The Umbilical JB shall be connected in the topside with the corresponding Monitoring Riser JB.

11.2.3 Umbilical JB shall be sealed against dust and powerful water jets (protection degree IP-66).

11.2.4 Umbilical JB shall be in accordance with its corresponding area classification.

11.2.1 Umbilical JB and cable glands specification/installation shall be in accordance with its corresponding area classification.

11.3 Monitoring Riser Junction Boxes

11.3.1 FPU CONTRACTOR/SELLER shall provide 1 (one) junction box (aka monitoring riser JB) for each hull side umbilical, and it shall be installed in the main deck at a level without green water issue.

11.3.2 Monitoring Riser JB comprises the main functions.

- Collect/process BSDL-SI monitoring system electrical signals
- Collect Local Panel monitoring system electrical signals
- Transmit data to SCADA Master Station (at Riser Interface Cabinet)

11.3.3 Monitoring Riser JB shall be designed with a RTU automation solution. This RTU shall collect/process all analog signals and transmit using TCP-IP standard protocol to the SCADA Master Station at Riser Interface Cabinet).

11.3.4 RTU shall process/digitalize the following main variables:

- BSDL-SI locking module end stroke signals.
- BSDL-SI structure corrosion monitoring indication.
- Local Panels pressure transmitters.

11.3.5 Monitoring Riser JB shall be installed in places with easy access, in maximum height of 2 meters and where is dismiss the use of safety harness for high work.

11.3.6 Monitoring Riser JB shall be sealed against dust and powerful water jets (protection degree IP-66).

11.3.7 Monitoring Riser JB and cable glands specification/installation shall be in accordance with its corresponding area classification.

11.4 Local Panel

11.4.1 FPU CONTRACTOR/SELLER shall provide 1 (one) Local Panel for each Hull Side Umbilical.

11.4.2 Local Panels main functions comprise:

- Terminate the hydraulic connections of each Hull side Umbilical.
- Provide Hydraulic Interface (hydraulic connector and control valve) to PUPS.
- House HMI of monitoring system interface.

11.4.3 For each hydraulic circuit, FPU CONTRACTOR/SELLER shall provide inside Local Panel 1 (one) manual valve to interface with PUPS hydraulic headers.

11.4.4 The hydraulic circuit between Umbilical Upper Termination and Local Panel shall be made by steel tubing and follow the requirements on [46].

11.4.5 The hydraulic supply for Riser Support control system shall be provided by PUPS system, that will be placed close and connected to all local panels for the pull-in and pull-out operations.

11.4.6 The Local Panel shall be installed in the main deck. The place shall consider the access and supply for PUPS hydraulic headers and for any maintenance of the internal components during FPU life.

11.4.7 FPU CONTRACTOR/SELLER shall provide hydraulic jumpers to connect PUPS to the hydraulic headers.

11.4.8 Hydraulic circuits routed in the same umbilical can share the same local panel, with individual circuits for each BSDL-SI. FPU CONTRACTOR/SELLER shall guarantee the unmistakable correspondence solution between umbilical termination and Local Panel Outlets.

11.4.9 Local Panel arrangement shall organize control valves the hydraulic outlets with clear identification, avoiding connection misunderstanding.

11.4.10 The design of Local Panel shall include pressure transmitters for hydraulic supply. Each hydraulic actuation lines shall be monitored and have its data logged/showed in the supervisory system (see Figure 23).

11.4.11 Local Panels shall be supplied inside a closed cabinet to protect its internal items. It shall have front and rear access for any internal component maintenance during operational life.

11.4.12 Local Panel shall have an HMI as described in 11.7.22.2.

11.4.13 Each Local Panel shall have an internal solenoid valve aligned to each hydraulic supply header from PUPS Unit. This activation shall use electrical switches (ON/OFF) able to be locked to avoid activation by mistake. The control logic of the solenoid actuation shall be controlled by the SCADA system inside the Riser Interface Cabinet, allowing only one local panel to be energized at a time.

11.4.14 The design of Local Panel shall include a signal indicator of each solenoid activation.

11.4.15 The design of Local Panel shall include pressure indicators to verify pressure in the hydraulic headers and at all hydraulic outlets of the BSDL-SI.

11.4.16 Manual isolation valves shall be installed before each directional valve for BSDL-SI actuation.

11.4.17 FPU CONTRACTOR/SELLER shall supply a physical hydraulic jumper that guarantees uncoupling from BSDL-SI hydraulic circuit, avoiding actuation of unwanted support by mistake.

11.4.18 Local Panels' final design shall be defined according to specific MD from the project, depending on its scope

11.5 Portable Umbilical Pressurization System (PUPS)

11.5.1 PUPS is a topside portable device to allow the FPU CONTRACTOR/SELLER to safety pressurize control line of hull side umbilical.

11.5.2 FPU CONTRACTOR/SELLER shall provide two PUPS units (main and redundant) according to [52]. They shall be located in the same deck level from the Local Panel.

11.5.3 PUPS operation location shall be with easy access for operator and with all air supply facilities required to operate.

11.5.4 PUPS shall be designed in accordance with its corresponding are classification where it will operate.

11.5.5 FPU CONTRACTOR/SELLER shall provide the hydraulic supply headers for all local panels according to [52].

11.5.6 PUPS shall be filled with water glycol-based fluid in accordance with 5.2.9. FPU CONTRACTOR/SELLER shall inquire PETROBRAS about what will be the fluid predicted for this project before any filling operations.

11.5.7 PUPS design shall be fully compatible to 5.2.10.

11.6 Riser Interface Cabinet

11.6.1 The Riser Interface Cabinet is a multipurpose cabinet that can be shared among different types of monitoring systems, for example, RSMS (Riser Supports Monitoring System), RRMS (Rigid Riser Monitoring System) and MODA (Brazilian acronym for Flexible Riser Monitoring System). For detailed information of which systems are applicable to the project, FPU CONTRACTOR/SELLER shall consult the specific MD.

11.6.2 Riser Interface Cabinet, including all components/equipment to be installed and respective connections are FPU CONTRACTOR/SELLER responsibility.

11.6.3 Detailed Riser Interface Cabinet design information can be found in the specific MD.

11.7 Supervisory and Data Server

11.7.1 Supervisory system shall observe a topology of Figure 28.

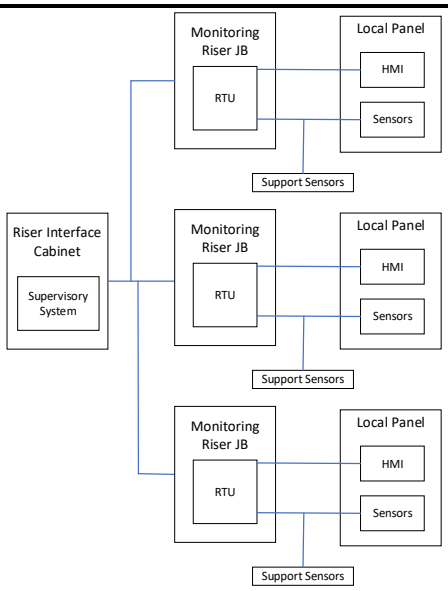


Figure 28: Supervisory System Topology

11.7.2 A supervisory system shall communicate with the RTU and act as an interface to human operators and external systems of the monitoring system.

11.7.3 The use of a well-established integrated supervisory solution able to provide all required functionalities is strongly advised.

11.7.4 Dedicated supervisory screens shall report the value of every monitored variable as they are acquired along with the status of communication channels and each monitoring unit, including Local Panels, RTU and Cabinet housekeeping data.

11.7.5 FPU CONTRACTOR/ SELLER shall design supervisory to receive data from all risers supports position in FPU.

11.7.6 Riser Support Supervisory System shall be connected to FPU automation network and shall have a server installed in Riser Interface Cabinet to allow manage all system and register data log of all sensors.

11.7.7 RSMS Processing Equipment shall be installed in the Riser Interface Cabinet.

11.7.8 Riser Supervisory System shall not be part of the FPU cause and effect matrix, i.e. shall not be used to trigger emergency shutdown.

11.7.9 In the case of power loss, the main processing equipment shall be able to restart automatically without the need for operator intervention.

11.7.10 Riser Supervisory System shall be capable to configure alarms (Low low/ low/ high/high high) for each parameter. FPU CONTRACTOR/SELLER shall present to PETROBRAS recommendations of the alarm limits and discuss with PETROBRAS before implementing them to the software. Alarms limits shall be possible to be changed during operation.

11.7.11 The FPU position provided by on-board GPS and AHRS (Attitude and Heading Reference system) shall be retrieved by the supervisory system from the POS system (Positioning and Navigation System for Floating Production Unit (FPU)).

11.7.12 Supervisory system shall be able to receive a customized input of FPU Positioning System.

11.7.13 The GPS UTC time provided by the FPU Positioning System shall be used as reference for the timestamps of all acquired data.

11.7.14 Data shall be continuously retrieved from the instrumentation installed on risers. The sampling period shall be 1 second and a timeout event shall be understood as the unsuccessful retrieval of 3 consecutive samples.

11.7.15 A database system for storage of generated data points shall be included in a OPC server.

11.7.16 The database shall operate on a circular buffer pattern, whereby older records shall gradually be overwritten by newer samples once the database reaches its capacity. Storage space shall be provided as a dedicated RAID 1 array, sized for at least 24 months of logging at the highest possible data sampling rate.

11.7.17 Data shall be provided to external systems and users via standardized OPC UA (Unified Architecture) interfaces as follows:

- OPC UA Data Access (DA) for real-time data.
- OPC UA Historical Access (HA) for historical data

11.7.18 Real time data shall be made available for external access through a standardized OPC UA Data Access Interface.

11.7.19 Historical data stored on the local database shall be accessible through an OPC UA Historical Access Interface.

11.7.20 Alarms shall be made available for external clients through an OPC UA Alarms & Conditions Interface.

11.7.21 The provided interfaces shall be ready for use by external systems from PETROBRAS corporate network which are allowed through FPU network firewalls.

11.7.22 Local Panel HMI

11.7.22.1 FPU CONTRACTOR/SELLER shall provide a supervisory system to allow operator in local panel to check the status of each sensor installed in the BSDL-SI and manage the entire system and to data log at Riser Interface Cabinet.

11.7.22.2 FPU CONTRACTOR/SELLER shall provide an HMI Integrated to Local Panel to check all supports related to respective panel. The supervisory screen shall show graphically all supports and the data sensors related to each one.

12 INSPECTION, TEST, INSTALLATION AND COMMISSIONING REQUIREMENTS

12.1 Quality Control

12.1.1 FPU CONTRACTOR/SELLER shall have quality control system, ensuring compliance with PETROBRAS requirements.

12.1.2 Each element of the Work shall be executed in accordance with quality management systems that comply with the requirements of FPU CONTRACTOR/SELLER and PETROBRAS project requirements.

12.1.3 SUBCONTRACTOR shall refer to the document “Project Quality Management Plan”.

12.1.4 FPU CONTRACTOR/SELLER shall produce for PETROBRAS review and approval a project quality plan and a project quality control plan:

- *Project Quality Plan: Detail the organization, responsibilities, activities, and an index of referenced and applicable procedures to complete the work, including that of FPU CONTRACTOR/ SELLER*
- *Project Quality Control Plan (ITP): Detail quality control plan and control monitoring to be employed during mobilization, acquisition and reporting phases.*

12.2 Personnel Qualification

12.2.1 Personnel qualification of welders, NDT and dimensional inspectors shall comply with [57].

12.2.2 Qualification of NDE Inspectors shall be according to [27], [19] and [57].

12.3 Procedure Qualification

12.3.1 FPU CONTRACTOR/SELLER shall qualify the following procedure for non-destructive testing before the beginning of activities: Ultrasonic Testing; Liquid Penetrant Testing; Magnetic Particles Testing; Visual Testing.

12.3.2 Procedures presented on 12.3 shall be qualified according to corresponding standards and certified by a level 3 inspector, with qualification and certification established on 12.2.

12.3.3 Welding procedures shall be qualified and certified before the beginning of activities according to the following specifications:

- For activities rendered in Brazil by a level 2 welding inspector, qualified and certified in the main standard applicable. Qualification and certification shall be by the Brazilian System of Welding Personnel Qualification and Certification-FBTS, according to [57] or;
- Welding activities rendered abroad by qualified and certified welding inspectors, shall be also in the main applicable standard by independent international entities that meet requirements in [38].

12.3.4 Ultrasonic testing of welds shall conform [27] and [57].

12.3.5 The acceptance criteria for ultrasonic inspection and testing of complete joint penetration welds shall be [19] Level A.

12.3.6 Magnetic Particle testing shall conform to [19].

12.3.7 The acceptance criteria for magnetic inspection shall be [19]. Local grinding of the weld to enhance interpretation of examination results shall be carried out as determined necessary by FPU CONTRACTOR/SELLER.

12.3.8 Welding Procedure Qualification (WPS) shall meet, at least, Classification Society Rules for hull construction with the following modifications and additional information:

- Min. Yield Strength (0.2 % Offset): 355 MPa
- Min. Tensile Strength: 455 MPa
- Elongation in 2 in. or 50 mm, min 20%

- Charpy V-Notch Impact test temperature: -20 °C
- Charpy V-Notch Minimum Average Absorbed Energy: 50 J (set of 3 samples)
- Charpy V-Notch Minimum Individual Absorbed Energy: 34 J
- The maximum hardness in the HAZ and weld metal is 325 HV10 for C-Mn and low alloy steels.

12.4 Manufacturing Inspection

12.4.1 General

12.4.1.1 FPU CONTRACTOR/SELLER shall maintain a fabrication inspector during manufacturing process of the bell mouth.

12.4.1.2 All inspections records and results shall be included in the databook.

12.4.1.3 Inspections shall be performed in accordance with specific procedures and shall include at least the activities listed herein.

12.4.1.4 FPU CONTRACTOR/SELLER shall keep available for inspectors the ITP, procedures, technical standards and other documents necessary to perform the inspection and interpretation results.

12.4.1.5 All non-conformities records shall be part of the databook.

12.4.1.6 All BSDL-SI mechanical components shall be visual and dimensional inspected and as a result from the inspection shall be reported and included on the databook.

12.4.2 Inspection and Test Plan – ITP

12.4.2.1 FPU CONTRACTOR/SELLER shall define the extent of his participation in the monitoring of inspections and factory tests through an Inspection and Test Plan – ITP to be prepared and submitted by FPU CONTRACTOR/SELLER.

12.4.2.2 FPU CONTRACTOR/SELLER shall send the ITP for PETROBRAS review and approval respecting the contractual terms.

12.4.2.3 The ITP is a document within the FPU CONTRACTOR/SELLER's Quality Plan that follows the standards set by quality management standards, which shall contain at least:

- A description of activities of the manufacturing process, including those carried out in SUBCONTRACTORS, indicating the types and extent of exams, tests or checks to be performed during the manufacturing process.
- Identification of intervention type that will be performed by FPU CONTRACTOR/SELLER's personnel and by FPU CONTRACTOR/SELLER inspection representative throughout the manufacturing cycle (document verification, monitoring point, observation point and hold point).

- Indication of procedures, technical specifications and standards for each activity.
- Acceptance criteria for all features and quality requirements of each activity, including activities carried out at SUBCONTRACTOR facilities.
- Identification and preparation of quality records, citing the record type applicable to each activity.

12.4.3 Preparation and Cutting

12.4.3.1 Verify if parts to be cut are identified in accordance with Section 13.3.

12.4.3.2 Verify if materials certificates correspond to the specified ones in the drawings.

12.4.3.3 Verify if parts dimensions are in accordance with drawings.

12.4.4 Pre-Assembly

12.4.4.1 Verify if traceability of the parts is in accordance with Section 13.3.

12.4.5 Nondestructive Tests

12.4.5.1 All procedures and personnel used in NDT shall be qualified and certified in accordance with 12.2 and 12.3.

12.4.5.2 Visual inspection – All welds shall be inspected in 100% (both sides) of their extension to check aspect and continuity.

12.4.5.3 Liquid penetrant inspection – All welds shall be inspected in 100% of their extension.

12.4.5.4 Magnetic particle inspection – Shall be performed in union welds: cylindrical body vs conical structure, cylindrical body vs round block and cylindrical body vs flange.

12.4.5.5 Ultrasonic inspection – Shall be performed in 100% of the welded joints performed by full penetration and in 100% of the plate used to manufacture the latch bars, before cutting them.

12.4.5.6 Surface finishing of all latch bars shall be in accordance with the drawings. The tests records shall be part of the databook.

12.4.5.7 Hardness shall be verified on all latch bars and shall be 32HC maximum. The tests records shall be part of databook.

12.4.6 Tensile and Impact Tests

12.4.6.1 An additional latch bar shall be supplied to prepare 2 (two) samples for tensile tests and 2 (two) samples for the impact test. For sample dimensions see Figure 29 and [20].

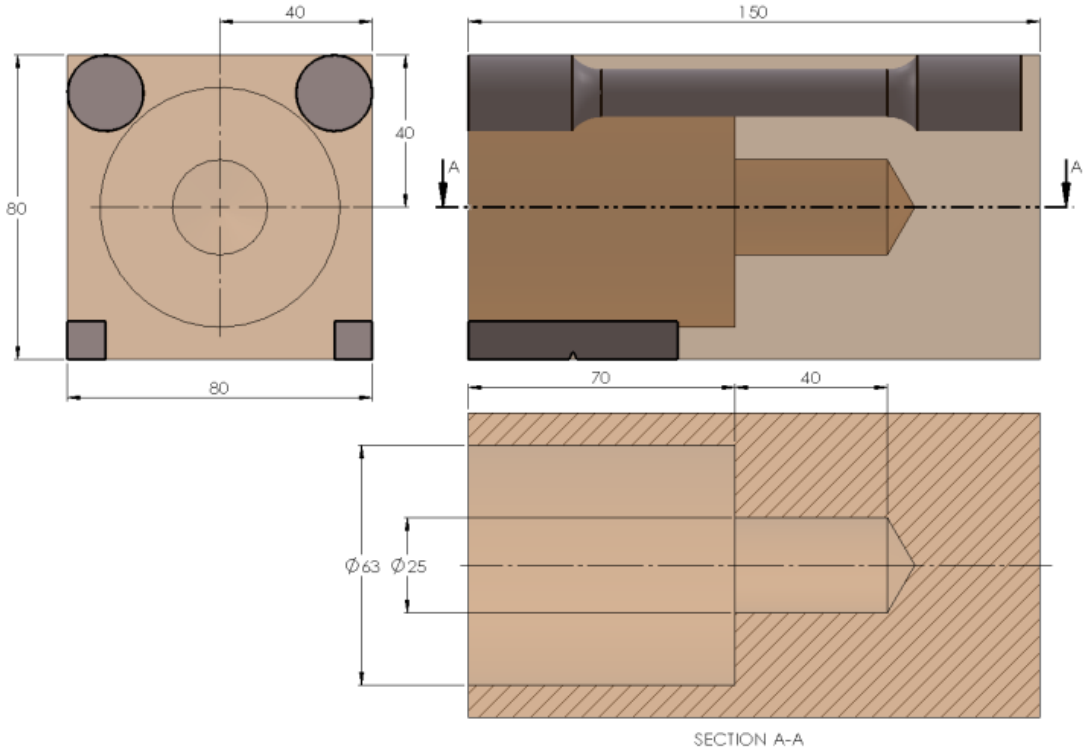


Figure 29: Position for extraction of tensile and impact test samples

12.4.6.2 The samples shall be extracted after latch bars heat-treatment.

12.4.6.3 A Test Inspection and Certification Society (TIC-Society) shall certify the tests results.

12.4.6.4 The results shall be included in the databook

12.4.6.5 For the tensile tests, the yield strength, tensile strength, stretching and area reduction shall be obtained by tensile test. The yield strength shall be 500 (five hundred) MPa minimum.

12.4.6.6 For the impact tests, Charpy tests shall be performed at -10 °C. The result shall be 27 (twenty-seven) Joules minimum.

12.4.7 Dimensional

12.4.7.1 Verify if dimensions are in accordance with the drawings.

12.4.7.2 PETROBRAS highlights that the correct pre-assembly of the moving parts (as presented in [59]) is critical for the mechanism performance.

12.4.7.3 FPU CONTRACTOR/SELLER may consider to manufacturing a template to achieve the required distance prior to assembly the moving parts on the round block.

12.4.7.4 The bellmouth inner diameters shall be measured at least in the vertical P1 to P4 positions, as shown in Figure 30.

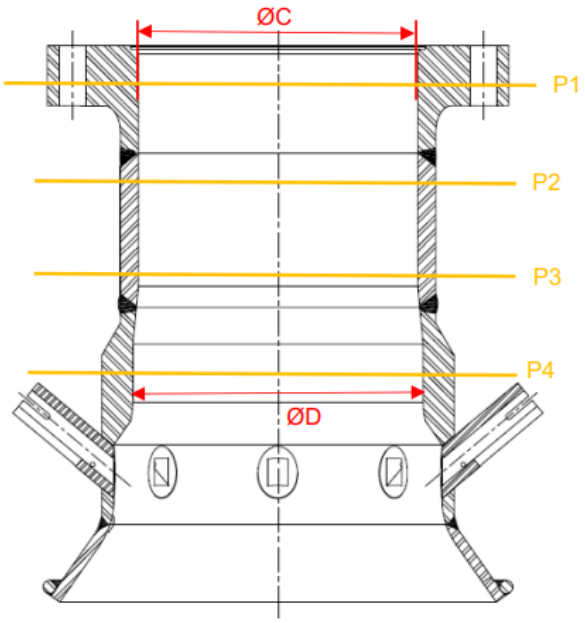


Figure 30: Vertical positions for internal diameters measurements

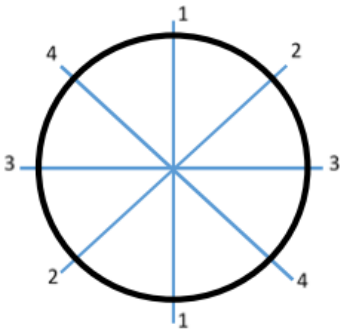


Figure 31: Angular positions for internal diameter C measurements

12.4.7.5 At least, in each vertical position, four measurements of the inner diameters shall be made, with angles of 45 degrees between them as shown in Figure 31.

12.4.7.6 In addition to inner diameters, the respective thicknesses in vertical positions P2 and P3 shall be measured.

12.4.7.7 In total, at least 32 measurements of inner diameters and 16 measurements of thicknesses must be made (8 in each vertical position P2 and P3).

12.4.8 Equipment weight Verification

12.4.8.1 Verify the weight of each individual bell mouth. The measure shall be registered on the databook.

12.5 Factory Acceptance Test (FAT)

12.5.1 All BSDL-SI shall be tested individually to verify their mechanical functioning.

12.5.2 For the Monitoring Systems, all circuits (i.e. hydraulic, optical and electrical) shall be tested individually. After confirmation of their individual functionality, tests shall be performed with its corresponding system (RSMS) completely integrated.

12.5.3 All BSDL-SI shall be completely assembled, i.e. all instrumentation (sensors), cathodic protection cables, hydraulic cylinder and auxiliary equipment shall be assembled before FAT starts. BSDL's FAT shall include all sensor components to be accepted.

12.5.4 All components of BSDL made of copper-based alloys shall be inspected to check electrical insulation. This electrical insulation procedure shall be subjected for Petrobras' approval before execution of the tests.

12.5.4.1 For copper-based actuator parts, insulation testing shall be performed by measuring the electrical potential of the parts submerged in saline water, following the requirements described in Annex B:.

12.5.5 All components of BSDL made of steel shall be inspected to check for electrical continuity to central structure to assure cathodic protection. This electrical continuity procedure shall be subjected for Petrobras approval before execution of the tests.

12.5.6 All tests for the BSDL-SI are FPU CONTRACTOR/SELLER responsibility.

12.5.7 A member of Quality Control Department of FPU CONTRACTOR/SELLER shall witness all tests and is responsible for registering the tests results and filling out the TRS. This member is also responsible for report any deviation that occurred during the tests.

12.5.8 FAT procedure shall be submitted to PETROBRAS for review and approval.

12.5.9 Flexible Riser's pull-in and pull-out simulation tests shall be performed with a Dummy Cap manufactured in accordance with drawings supplied by PETROBRAS.

12.5.10 Dummy Caps to be used in factory acceptance test is defined on [59]. Only one Dummy Cap may be manufactured for each diameter of the Bellmouth.

12.5.11 A contractor representative shall witness all tests. This representative will be responsible for approving or rejecting the FAT.

12.5.12 PETROBRAS reserves the right to send a representative to monitor the tests. This representative will not have the responsibility of approving or rejecting the tests.

12.5.13 An independent third-party representative shall witness and approve all tests.

12.5.14 A third-party service is contractor and/or supplier responsibility.

12.5.15 For BSDL-SI components manufactured in Brazil, the contractor shall notify PETROBRAS, at least 10 calendar days in advance or as defined in the terms of the contract, the date when the BSDL-SI will be available for FAT.

12.5.16 For BSDL-SI components manufactured abroad, the contractor shall inform PETROBRAS at least 30 calendar days in advance or as defined in the terms of the contract the date when the equipment will be available to be tested.

12.5.17 During all testing, the BSDL-SI components and its parts shall be transported on pallets and is not acceptable to transport them in direct contact with the fork of the forklift.

12.5.18 Tests performed with the BSDL-SI components inverted (upside down) are not acceptable.

12.5.19 Tests shall be performed by lifting the Dummy Cap into a fasten and secured bell mouth on test stand. It is not allowed to perform the tests with the Dummy Cap fixed and moving the bell mouth.

12.5.20 . A load cell shall be installed between the lifting cable and the Dummy Cap to measure the load required to overcome the force exerted by the springs. This measurement shall be reported in the TRS and sent to PETROBRAS for information.

12.5.21 All images in this document are for information only and their purpose is to help one understand tests steps and acceptance criteria.

12.5.22 Photographic records of all tests shall be included in FAT reports.

12.5.23 FPU CONTRACTOR/SELLER shall evaluate and correct any unsafety conditions on all testing procedures.

12.5.24 FAT procedure shall observe the requirements in Annex B:

12.5.25 FAT shall be performed using the same hydraulic control fluid planned to be used on PUPS and in accordance with 5.2.9.

12.5.26 FPU CONTRACTOR/SELLER shall comply with PUPS system requirements [52] predicted for TAP-1.

12.5.27 FPU CONTRACTOR/SELLER shall comply with Section 11.7 within HMI system requirements during TAP-1. Verification of the sensors functionality shall be clearly demonstrated by means of exercising each single reading, including transition stages where applicable.

12.6 Commissioning Requirements

12.6.1 The requirements presented in this section shall be met regarding commissioning activities. Planning of installation and commissioning activities shall be developed and submitted for PETROBRAS approval.

12.6.2 Commissioning is understood, in this context, as the process of placing the system (or parts thereof related to a particular monitored structure) in a fully functional state, without any pending issues.

12.6.3 All equipment shall be tested onshore and pass the FAT (Section 12.5) and any other FPU CONTRACTOR/SELLER approved procedures.

12.6.4 After installation at FPSO, during the commissioning of hydraulic actuator system, the FPU CONTRACTOR/SELLER shall perform integrated tests to certificated that:

- All system is correctly installed and operational.
- Each local panel is activating the correct BSDL-SI.
- All hydraulic actuators are operational (visual check).

- All sensors from sections 10.2 to 10.3 are operational
- There is no leak and no bubbles at hydraulic circuit.

12.6.5 The tests from item 12.6.4 shall be done in dry dock, to perform possible corrections and shall use the same hydraulic fluid planned to be used on PUPS and in accordance with 5.2.9.

12.6.6 FPU CONTRACTOR/SELLER shall inform, during commissioning activities, all administrator passwords needed to operate and manage all equipment.

12.6.7 All components of BSDL made of copper-based alloys shall be inspected to confirm electrical insulation, performing at dry dock with the components emerged and installed at lower balcony. This electrical insulation procedure shall be subjected for Petrobras approval before execution of the commissioning activities.

12.7 Recommendations for BSDL-SI and FPSO Integration

12.7.1 General

12.7.1.1 FPU CONTRACTOR/SELLER shall define the bell mouth preservation recommendations (e.g. UV exposure restriction, packing condition, or any other issue) in order to assure any quality loss due inappropriate storage on shipyard.

12.7.1.2 For an appropriate preservation recommendation, FPU CONTRACTOR/SELLER shall consider the main FPSO schedule milestones related to the bell mouth integration.

12.7.1.3 The milestones shall include, but not limited to, the expected time between the FAT and bell mouth integration with the riser balcony and the end of dry dock condition.

12.7.1.4 In principle, no coating touch-up is allowed during the dry dock phase.

12.7.1.5 This disallowance is due to the importance of the DFT tolerances for the bell mouth compatibility with the Cap DL-SI, particularly on the bell mouth inner diameters.

12.7.1.6 If by any eventuality it is considered that a bell mouth coating must be repaired, FPU CONTRACTOR/SELLER shall submit the repair procedure for PETROBRAS review and approval.

12.7.1.7 The bell mouth shall be assembled on I-tubes with a hydraulic tensioner with the required pre-load required on 7.2.7.2 that shall be validated by structural calculation requirements on 7.6.2.3.

12.7.1.8 The cable connections integrity (cathodic protection transmission for moving parts) shall be verified after the bell mouth assembly on the riser balcony and before the end of dry dock. If necessary, these connections shall be repaired by FPU CONTRACTOR/SELLER.

12.7.1.9 FPU CONTRACTOR/SELLER shall issue a Handling Procedure to PETROBRAS, including the requirements for moving and installing the BSDL-SI, indicating information such as existing eyebolts, static loads, accelerations and movements involved, lifting balancer, use of steel cables and/or straps and/or transport skid, safety measures, etc. This item is critical for the BSDL-SI operation.

12.7.1.10 FPU CONTRACTOR shall issue an Assembly and Installation Procedure to PETROBRAS, including the requirements for construction, assembly and installation of the BSDL-SI, indicating information such as step-by-step assembly with instructions and sequence, checks to be made (alignment/leveling), details of the hydraulic connections and their integration with other systems of the unit, tests, list of tools (including special ones) and materials required for assembly and commissioning, etc., in order to facilitate understanding. This item is critical for the BSDL-SI operation.

12.7.1.11 FPU CONTRACTOR/SELLER shall provide the BSDL-SI Top Load Analysis for PETROBRAS review and approval until the end of 30% FPU design review.

12.7.2 FPSO Dimensional Gauge Test

12.7.2.1 The dimensional gauge should be used in shipyard to verify the main BSDL-SI's dimensions and flange make-up misalignment after its integration to the FPSO riser balcony and the subsequent compatibility with the CAP DL-SI that will be provided by the RISER CONTRACTOR.

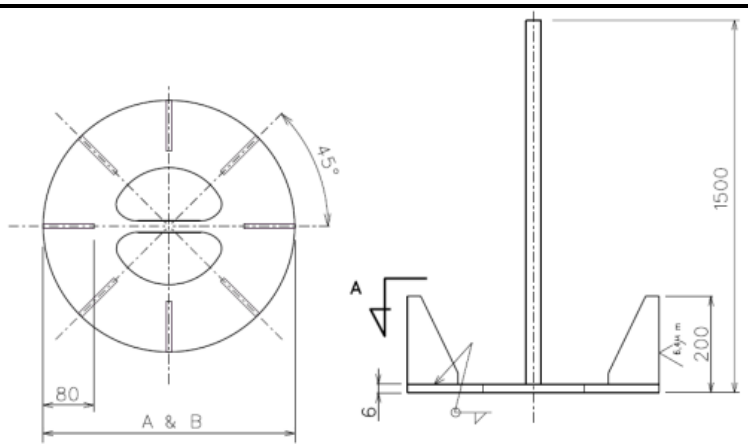
12.7.2.2 The dimensional gauge should be used to assure that no unexpected event occurred to the BSDL-SI between the FAT and the FPSO integration (e.g. disallowed coating touch up or damage during BSDL-SI's shipment).

12.7.2.3 The dimensional gauge may be produced with a lightweight material (e.g. aluminum) for a better handling.

12.7.2.4 PETROBRAS reserves the right to require the use of the dimensional gauge on shipyard whenever it considers to be necessary.

12.7.2.5 Figure 32 shows a preliminary design for the dimensional gauge which can be used to inspect the respective inner diameters shown in Figure 33.

12.7.2.6 Information: The dimensional gauge diameters do not correspond to neither Cap DL-SI [59] nor Dummy Cap [59]. These dimensions also assure the compatibility with the bend stiffener design from previous FPU CONTRACTOR/SELLER designs, whose further details are not necessary for BSDL-SI supply.



BSDL-SI model	ØA	ØB
32”	675,5/675,0 mm	711,5/711,0 mm
46”	1025,5/1025,0 mm	1061,5/1061,0 mm
48”	1075,5/1075,0 mm	1111,5/1111,0 mm

Figure 32: Dimensional gauge preliminary design

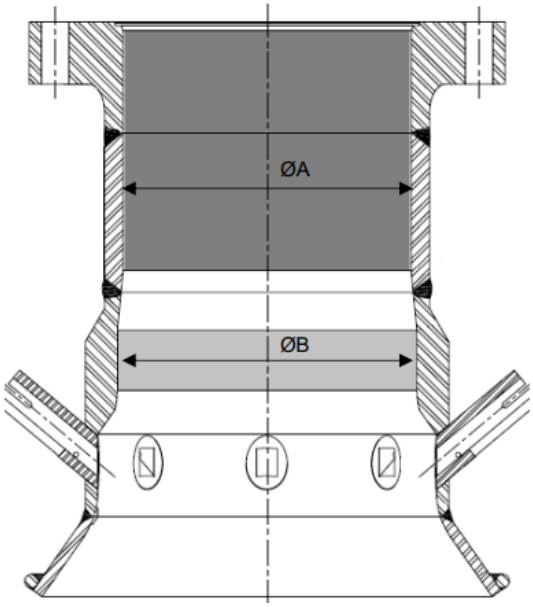


Figure 33: BSDL-SI 's inner diameter to be inspected with the Dimensional Gauge

13 IDENTIFICATION, PROTECTION, TRACEABILITY AND PACKING

13.1 Protection and Packing

13.1.1 BSDL-SI shall be delivered packed to ensure the integrity of the parts, in special of the locking devices mechanism.

13.1.2 The packing shall avoid the ingress of any debris in the round block mechanism.

13.2 Identification

13.2.1 All BSDL-SI shall be identified according to their numbering of riser-slot position on balcony arrangement. Marking shall be performed in 3 (three) points (top and sides of support), in an indelible form (linear weld bead) and painted in contrasting color. Characters shall be visible and identifiable by divers and by ROV. The choice of the positions of these markings shall be submitted to PETROBRAS approval.

13.2.2 Each sector shall be marked on two different locations: external cylindrical surface and bellmouth cone.

13.2.3 The minimum paint height shall be equal to 200 mm (two hundred millimeters).

13.3 Traceability

13.3.1 Codification and traceability procedures shall be in accordance with item 7.5.3 of [36] in addition the following requirements:

- Alphanumeric codes for traceability shall be punctured in materials using low stress punches.
- Each equipment shall receive a unique codification in order to allow tracing back its respective inspection and tests reports.

14 MODIFICATIONS AND ADJUSTMENTS

14.1.1 FPU CONTRACTOR/SELLER may implement small changes in the BSDL-SI design to make it appropriate to its manufacturing process or to correct small non-conformities. In this case, FPU CONTRACTOR/SELLER shall submit a written document to PETROBRAS describing the problem and proposed solutions.

14.1.2 Changes mentioned in 14 will only be implemented after FPU CONTRACTOR/SELLER and PETROBRAS approval.

14.1.3 A Design Review event, with representatives from FPU CONTRACTOR/SELLER and PETROBRAS shall be held before the start of the BSDL-SI manufacturing.

14.1.4 To avoid major changes on the detailed design performed by FPU CONTRACTOR/SELLER at a later stage, it is highly recommended for the FPU CONTRACTOR/SELLER to schedule preliminary meetings with PETROBRAS before design review.

15 DOCUMENTATION REQUIREMENTS

15.1 General

15.1.1 FPU CONTRACTOR/SELLER shall furnish all data generated during the design cycle of the BSDL-SI, including the results of the numerical analyses that will be carried out to fulfill the design requirements, the hull structural requirements defined on FPSO documentation. In case of any conflict identified, PETROBRAS shall be consulted. This documentation shall be comprised of written reports in accordance with FPU CONTRACTOR/SELLER standards, and the electronic input and output files of the finite element analysis.

15.1.2 Design Methodology reports and analysis results reports shall be submitted by FPU CONTRACTOR/SELLER and approved by PETROBRAS before start of fabrication. Design revision cycles, including proprietary documents, when necessary, can be requested by PETROBRAS under FPU CONTRACTOR/SELLER premises.

15.1.3 FPU CONTRACTOR/SELLER shall demonstrate the adequacy and the reliability of the BDSL-SI by proven methods of design. The conservatism of calculation methodology employed shall also be clearly demonstrated, and no question of the adequacy of the project-specific service conditions shall remain.

15.1.4 Commercial local analysis package accepted are Abaqus and Ansys.

15.1.5 All materials intended for the fabrication of BSDL components shall undergo Positive Material Identification (PMI) prior to manufacturing.

15.2 Bidding Documentation

15.2.1 FPU CONTRACTOR/SELLER shall inform conflicting data present in PETROBRAS drawings during Basic Design Endorsement period. If any problem is identified during manufacturing phase the solution taken by FPU CONTRACTOR/SELLER shall follow Article 12 of the agreement.

15.2.2 FPU CONTRACTOR/SELLER shall present the chosen SUBCONTRACTOR portfolio, which must include details about engineering and design staff experience and resources, construction and quality test capabilities as well as company experience in similar projects.

15.2.3 FPU CONTRACTOR/SELLER shall present the outline design and manufacturing plan, from raw material supply up to the hull integration.

15.2.4 FPU CONTRACTOR/SELLER will be responsible to comply with all PETROBRAS requirements.

15.3 Manufacturing and Test Documentation

15.3.1 The points described in this section comprises the requirements for manufacturing and tests phases. For a list of expected minimum documentation, please see Annex C:.

15.3.2 Any other document may be requested by PETROBRAS at any time, depending on the project evolution.

15.3.3 QA/QC procedures (e.g. ITP, NDT, FAT, traceability, nonconformance, document control) shall be submitted to PETROBRAS for review prior to the start of design and production work

15.3.4 Design Basis and Methodology (DBM) shall be submitted to PETROBRAS for review before starting of design and production work, as a minimum, including the following:

- Design Parameters
- Design methodology including FEA tools to be used as agreed by PETROBRAS
- Proposed material specifications
- Chemical composition and mechanical properties of steel components (yield strength, tensile strength, percent elongation, area reduction, and other required properties)
- Component material lists and descriptions, including any “in-house” material specifications, which shall be made available at FPU CONTRACTOR/ SELLER facilities

- List of Design Drawing
- Design calculations and reports for each element

15.3.5 . The QA/QC, DBM and MPS shall be written specifically for the PURCHASE ORDER and shall be approved by PETROBRAS prior to commencement of manufacturing operations.

15.3.6 FPU CONTRACTOR/SELLER shall notify PETROBRAS of any changes in these practices for PETROBRAS review/approval prior to implementation.

15.3.7 Design calculations and reports shall be issued to PETROBRAS for review prior to the manufacturing.

15.3.8 Nonconformity reports shall be issued to PETROBRAS within the contractual deadline. All nonconformity reports, including concession requests, shall be submitted to PETROBRAS for review.

15.3.9 Prior to start of manufacture, FPU CONTRACTOR/SELLER shall generate a General Assembly drawing of the BSDL-SI. This drawing and any other auxiliary drawing of individual parts or subassemblies shall be submitted to PETROBRAS for review. Subsequent revisions to drawings shall also be issued to PETROBRAS for review, as they are prepared.

15.4 Installation, Operation and Maintenance Manual

15.4.1 This section comprises the general requirements to elaborate the Installation, Operation and Maintenance Manual.

15.4.2 Manuals shall be submitted in English and Portugues languages.

15.4.3 The document shall be self-contained, i.e. shall provide all the necessary steps to correctly install, operate and maintain the support.

15.4.4 The manual shall include a specific section with step-by-step information on how to identify the actuator position on the HMI and how to actuate each of them following the process for riser installation/deinstallation.

15.4.5 Manuals are part of FPU CONTRACTOR/SELLER deliverables. For a list of expected minimum documentation, please see Annex C:

15.5 Databook

15.5.1 For BSDL-SI manufactured in Brazil, the databook shall be emitted in Portuguese language, unless otherwise requested. For BSDL-SI manufactured abroad, the databook must be emitted in English language.

15.5.2 FPU CONTRACTOR/SELLER shall issue a databook of the products, to allow traceability of all parts, containing at least the following items:

- Certificate of conformity with time of guarantee according to RM (including elements of fixation).
- Certificate of raw materials and tests according to this specification and project standard.
- Stress-strain curves for all structural metallic materials.
- Records of heat treatment and tests according to this specification and project standards.

- Records of Non-Destructive Examinations according to this specification and project standards.
- Measured weight of each manufacture bell mouth.
- Records of FAT according to this specification and project standards.
- Qualifications of the welding process and welders according to this specification and project standards.
- Records of dimensional inspection according to this specification and project standards.
- Inspection and Test Plan (ITP) approved by Costumer.
- Identification and inclusion of all reports issued by FPU CONTRACTOR/SELLER inspection, concerning the released products.
- Identification and inclusion of non-conformities of the manufacturing process/ SUBCONTRACOTR and corrective actions taken concerning the released products.
- Drawings of set containing traceability of all critical components of the project, reported in the ITP.

16 SCOPE OF WORK

16.1 FPU CONTRACTOR/SELLER Responsibilities

16.1.1 . FPU CONTRACTOR/SELLER shall furnish all labor, consumables, tools, equipment, and materials other than those explicitly identified as supplied by FPU CONTRACTOR/SELLER required to manufacture, test and deliver. FPU CONTRACTOR/SELLER shall perform all required operations for design, manufacture, inspection, testing and handling.

16.1.2 Nothing contained in this Specification or omitted from it shall be construed as relieving FPU CONTRACTOR/SELLER of the obligation to supply the BSDL-SI in accordance with the functional requirements outlined herein, said to be capable of functioning properly in a riser system for the entire design period specified by PETROBRAS for the project, without need for replacement of any of its parts.

16.1.3 FPU CONTRACTOR/SELLER shall develop a written Manufacturing Plan/Procedure, including a Quality Control/ Quality Assurance Plan (QAP), which shall be submitted to PETROBRAS for review prior to commencement of material procurement and manufacturing.

16.1.4 A pre-production meeting shall be held between PARTIES representatives, plus any third-party inspection personnel involved. The purpose of the meeting is to ensure that all parties involved fully understand job requirements and resolve any outstanding issues before the beginning of the manufacturing start.

16.1.5 PETROBRAS furnished Drawings and Specifications shall be checked by FPU CONTRACTOR/SELLER immediately upon receipt, and FPU CONTRACTOR/SELLER shall promptly notify PETROBRAS of any discrepancies therein.

16.1.6 For any requirement in question by FPU CONTRACTOR/SELLER, it shall be FPU CONTRACTOR/SELLER’s responsibility to:

- Obtain clarification from PETROBRAS, which shall be final and binding
- Review and resolve conflicts with PETROBRAS prior to initiation or continuation of Work

16.1.7 FPU CONTRACTOR/SELLER shall allow PETROBRAS and third-party representatives, under FPU CONTRACTOR/SELLER premises, reasonable access to all areas concerned with Design, manufacture, inspection, and testing during all times while Work is being performed for the Project.

16.1.8 FPU CONTRACTOR/SELLER shall provide all reasonable facilities to PETROBRAS'S inspectors, without extra charge, to satisfy the inspector that product is being manufactured in accordance with PETROBRAS' specifications. Such facilities shall include, but not limited to, office equipment and telecommunication equipment. All inspection shall be made at the place of manufacture prior to shipment. If any inspection or testing reveals details not in accordance with PETROBRAS' Specification, then FPU CONTRACTOR/SELLER may demonstrate to PETROBRAS that the product still satisfies the design requirement. If FPU CONTRACTOR/SELLER is unable to prove this to PETROBRAS'S satisfaction, then the manufacturing and/or testing procedure shall be repeated until compliance is demonstrated. All such remedial Work shall be performed at FPU CONTRACTOR/SELLER's cost.

16.1.9 Equipment used for the manufacture shall be of proven Design and in good operating condition.

16.1.10 Methods employed shall be in accordance with prudent engineering, fabrication and construction practice.

16.1.11 All costs, including taxes are to FPU CONTRACTOR/SELLER account in undertaking the responsibilities.

16.1.12 Deviations from this Specification are not permitted. All proposed changes or modifications to this Specification shall be submitted in writing for PETROBRAS approval. Procurement, Fabrication and Procedures Approved changes shall be incorporated into a revised, approved Project (purchase) specification. Disclaimers are not permitted.

17 SUBCONTRACTOR REQUIREMENTS

17.1.1 FPU CONTRACTOR/SELLER shall choose SUBCONTRACTOR(S) with experience (track record) with PETROBRAS' previous projects or with proved experience (track record) in:

- Subsea systems.
- Umbilical systems.
- Hydraulic systems.
- Instrumentation/automation systems.

17.1.2 FPU CONTRACTOR/SELLER shall provide an INTEGRATOR that shall be responsible for all SUBCONTRACTORS interfaces and technical support during design, supply, tests, commissioning (dry dock TAP-1 & topside integration TAP-2 phases) and offshore operations.

17.1.3 During the executive design FPU CONTRACTOR/SELLER shall submit to PETROBRAS approval a Technical Proposal including the evidence of attending items requested.

ANNEX A: HYDRAULIC PRESSURE TESTS

A.1 Integrity Test

The purpose of this test is to verify the assembly of the actuator cylinder-piston. According to API 6A (21st edition), item 14.16.4.1, this test must be performed with the entire actuator assembly mounted on the valve.

FPU CONTRATOR/SELLER shall follow the steps below:

1) Pressure monitoring equipment and device must be isolated from the pressure source.
2) It must be ensured that the external surfaces of the system parts are dry.
3) Integrity pressure (1.5x operating pressure, i.e. 1.5 * 5000 psi = 7500 psi) must be applied to the system. After reaching and stabilizing the pressure, FPU CONTRACTOR/SELLER must wait for at least 3 minutes.
4) The applied pressure must be reduced to 0 (zero).
5) Integrity pressure (1.5x operating pressure, i.e. 1.5 * 5000 psi = 7500 psi) must be applied to the system again. After the pressure is reached and stabilized, FPU CONTRACTOR/SELLER must wait for at least 3 minutes.

Note: If any part of the system cannot be submitted to this test, it shall be submitted to PETROBRAS approval.

A.2 Actuator Sealing Test

According to item 14.16.4.2 (a) of API 6A, this test basically consists of a sealing test at low (20%) and high pressure (100%). This test can be performed with the entire actuator system coupled.

FPU CONTRATOR/SELLER shall follow the steps below:

1) Pressure monitoring equipment and device must be isolated from the pressure source.
2) It must be ensured that the external surfaces of the system parts are dry.
3) A pressure of up to 20% operating pressure, i.e., up to 20% * 5000 psi = 1000 psi, must be applied for at least 3 minutes after reaching and stabilizing the set pressure.
4) A pressure of at least 100% operating pressure must be applied, i.e., 5000 psi or more for at least 3 minutes after reaching and stabilizing the set pressure.

Acceptance Criteria: There must be no leaks in the system at any of the stages.

Note: Pressure, start time and end time of steps 3 and 4 must be recorded.

A.3 Operational Test

As the nominal actuation pressure is 5000 psi, the actuator must be capable to function with a maximum of 4500 psi. Then, in this case, it will have 10% of operating pressure, or 10% * 5000 psi = 500 psi of clearance to accommodate any increases in friction that may arise over time.

FPU CONTRATOR/SELLER shall follow the steps below:

1) Pressure monitoring equipment and device must be isolated from the pressure source.
2) It must be ensured that the external surfaces of the system parts are dry.
3) A pressure of up to 90% operating pressure must be applied (up to 90% * 5000 psi = 4500 psi) and the actuator must reach the fully open position.
4) Step 3 must be repeated at least 3 times.

Note: It is important that the entire actuation, opening and return pressure curve be mapped.

ANNEX B: FAT PROCEDURE

1. FAT Infrastructure

1.1. FPU CONTRACTOR/SELLER shall provide the entire infrastructure necessary to perform the tests.

1.2. FPU CONTRACTOR/SELLER shall supply inspection devices as go no-go gauges for testing and shall be presented to PETROBRAS approval to be used as acceptance criteria.

1.3. The infrastructure necessary to perform the test shall contain, at least the following items:

- One Dummy Cap for each set of bell mouths of same diameter that will be tested. The Dummy Cap diameter must be compatible with the bell mouth that will be tested.
- One HMI device and power supply with cabling to energize and acquire all BSDL-SI sensor readings.
- One wire rope with suitable mechanical resistance to lift up Dummy Cap and BSDL-SI.
- Shackles, with suitable mechanical resistance to lift up Dummy Cap and BSDL-SI.
- Load Cell to measure the force needed to overcome the springs.
- Synthetic cables (ropes) for guiding the Dummy Cap during pull in activities.
- A lifting device, which can be a crane, an overhead crane, etc., capable of suspending the Dummy Cap with a speed between 2 and 4 m/min.
- A test stand containing a fastening device specifically designed to secure the bell mouth so the cylindrical body is plumb. The lower conical part of the bell mouth shall be at an appropriate distance from the floor so the Dummy Cap can be positioned below it and the handling mechanisms of the latch bars can be operated manually.
- A walkway and a guardrail shall be available for secure access to mechanism of the latch bars.
- A four-wire sensing micro-ohmmeter with suitable resolution for measuring values around 0.1Ω.
- One Hydraulic Power Unit (HPU) capable to provide hydraulic power that meets the specifications for hydraulic actuation tests.
- Houses and connectors to bring hydraulic power from HPU to hydraulic circuits.
- A device to measure the force necessary to actuate the ROV override mechanism.
- A feeler gauge set suitable for measuring clearances of 0.5 mm and 2 mm.

1.4. An example of the test stand with appropriate walkway is presented on Figure 34.

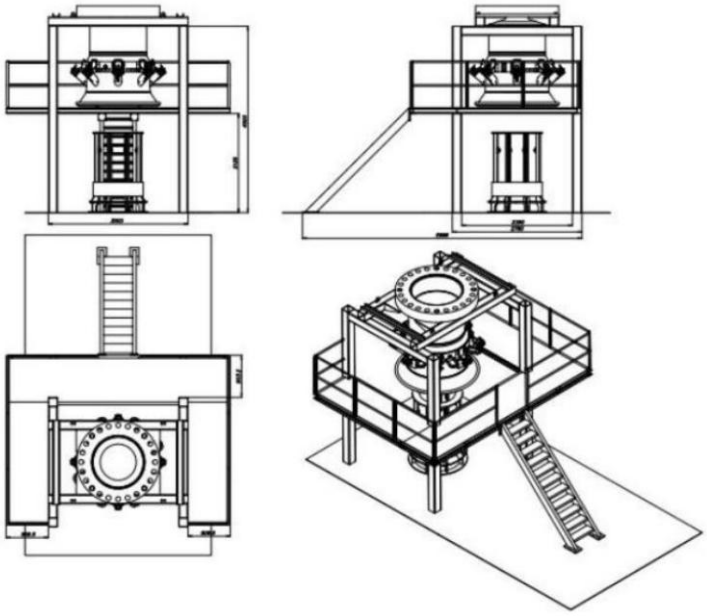


Figure 34: Test Stand Example

2. FAT Results

2.1. FAT results shall be reported in the Test Report Sheet (TRS). A TRS model is provided and instructions on how to fill it out is provided.

2.2. Supplier quality control member and the contractor representative shall issue one report by BSDL-SI components tested stating one of two results: accepted or rejected.

2.3. The BSDL-SI components with status “send to repair” shall be repaired and retested. It will only be considered “accepted” after correction of all non-conformities and after passing through all tests.

2.4. Any repair made in the BSDL-SI components invalidates all tests performed until that moment.

2.5. The BSDL-SI rejected components shall be discarded and a new BSDL-SI component with the same characteristics shall be manufactured.

2.6. In this case, the new BSDL-SI component shall receive a new serial number.

2.7. The TRSs rejected and discarded BSDL-SI components shall be included in the databook set of approved ones.

2.8. In case of any BSDL-SI components performance problems, FPU CONTRACTOR/SELLER shall contact PETROBRAS, and it reserves the right to send a representative to assist in the evaluation of non-conformities.

3. BSDL-SI internal diameters verification

3.1. This verification aims to evaluate the BSDL-SI internal diameters, through a drift pipe testing.

3.2. The Dummy Cap upper and lower rings diameters are slightly bigger than the Cap DL-SI ones, and are used as templates as shown in Figure 35.

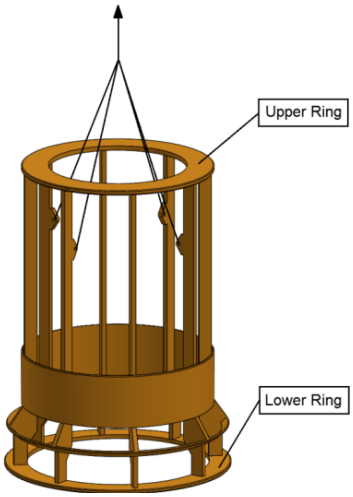


Figure 35: Dummy Cap - Template for the BSDL-SI tests

3.3. The upper ring verifies the BSDL-SI internal main interface surface compatibility with the Cap DL-SI that will be furnished by the RISER CONTRACTOR.

3.4. The lower ring verifies the concentricity of the BSDL-SI larger internal diameter with its main internal surface. This verification guarantees the correct position of the round blocks and so of the latch bars, on the BSDL-SI main structure.

3.5. This verification shall be made during the test with the Dummy Cap. If during any test described below, the upper and/or the lower rings don´t fit in the BSDL-SI, this one is reproved.

4. Electrical Continuity Test.

4.1. The objective of electrical continuity test is to ensure that all BSDL-SI moving parts are electrically connected to the BSDL-SI main structure, with exception of all components of BSDL-SI made of copper-based alloys that shall be isolated from BSDL cathodic protection.

4.2. Supplier shall submit an Electrical continuity test procedure with clear indication of the parts to be measured.

4.3. Measurements shall be made using a calibrated DC multimeter. Calibration due date shall be part of final report.

4.4. Acceptance criteria for the electrical continuity tests shall be below 1Ω and in accordance with [15] and BSDL detail design. In case the criteria is not satisfied, FPU CONTRACTOR/SELLER shall present technical justification for PETROBRAS approval. The deviation shall be evaluated, the test shall be decommissioned and the TSUDL shall be sent to repair. Register in the TRS. Then restart the tests.

4.5. In the event that PETROBRAS is not the Contractor, Contractor shall submit the Electrical Continuity Test Procedure and Acceptance Criteria to PETROBRAS for information purpose only.

4.6. Results of Electrical Continuity Test shall be recorded in TRS.

5. Electrical Insulation Tests

5.1. All components of BSDL made of copper-based alloys shall be inspected to check electrical insulation. This electrical insulation procedure shall be subjected for Petrobras approval before execution of the tests.

5.1.1. For copper-based actuator parts, insulation testing shall be performed by measuring the electrical potential of the parts submerged in saline water, following the requirements:

- It shall be submerged in saline water;
- Carbon steel parts shall be connected to the anode;
- Insulation shall be assessed using electrical potential, compared to the electrical potential of a submerged copper part not connected to any anode.

6. Flexible Riser Pull-in and Pull-out Simulation FAT procedure minimum requirements, sequence and acceptance criteria

6.1. Latch Bars Set Test

6.1.1. The objective of this test is to verify if latch bars set are fully functional and if each latch bar is properly aligned to BSDL-SI inner surface.

6.1.2. Handler Performance Test Sequence:

a) Actuate each latch bar set handler to “lower” position (Figure 36a), so latch bars move to “retracted” position (Figure 37a).

b) Insert latch bar locking tools in round blocks (Figure 38) to lock latch bars in “retracted” position.

c) Actuate 3 (three) times each handler, from “lower” to “upper” position and back (Figure 36). **Acceptance Criteria Ra1**, item A6.5.1.

d) Return handler to “lower” position and remove LBLTs from round blocks to release latch bars.

e) Actuate 3 (three) times each latch bar from “retracted” to “extended” position (Figure 37) using respective handler. **Acceptance Criteria Ra2**, item A6.5.2. Verify if the end course latch bar sensors indication flag from “retracted” to “extended” position is working properly. **Acceptance Criteria Sa1**, item A6.5.16.

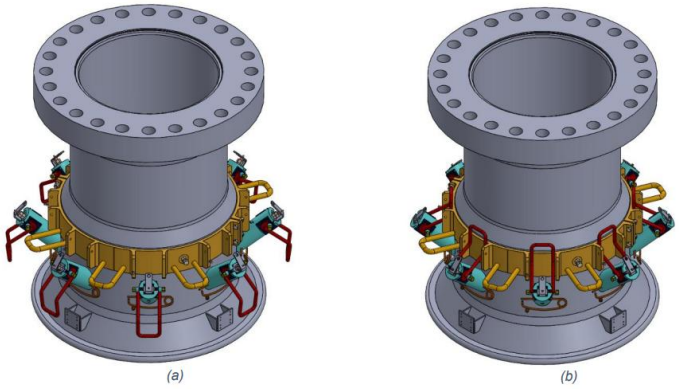


Figure 36: Handles: (a) Lower Position and (b) Upper position

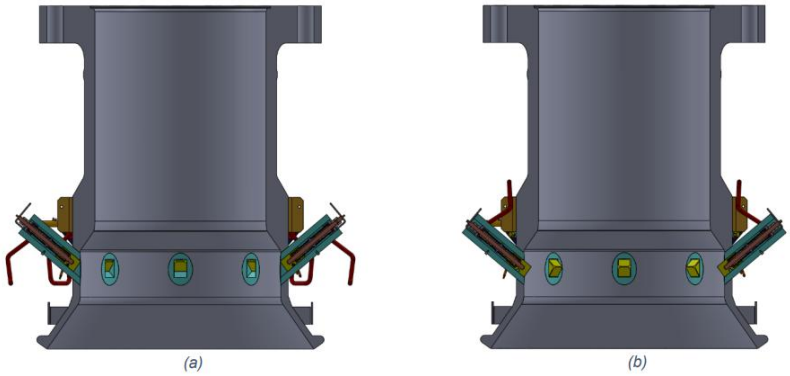


Figure 37: Latch Bars: (a) Retracted and (b) Extended

Figure 38: Latch bar locking tool inserted in the round block to lock the latch bar

6.1.3. Latch Bars Alignment Test Sequence

f) Actuate each latch bar set handler to “lower” position (Figure 36a) so the latch bars move to “retracted” position (Figure 37a). **Acceptance Criteria Ra3**, item A6.5.3.

g) Actuate each latch bar set handler to “upper” position (Figure 36b) so the latch bars move to “extended” position (Figure 37b). **Acceptance Criteria Ra4**, item A6.5.4.

6.2. Pull-in and Pull-out Simulation tests

6.2.1. The objective of this test is to verify latch bars set performance and alignment and how the Dummy Cap rests on latch bars. This is done by observing the automatic and simultaneous expansion of the latch bars, after the passage of Dummy Cap through BSDL-SI and by measuring the clearance between them and Dummy Cap and checking the readings from the end-course sensors.

6.2.2. Pull-in Test Sequence

a) Pull up Dummy Cap into BSDL-SI at a speed of 4 m/min (four meters per minute)

b) Observe the coupling of Dummy Cap into BSDL-SI and latch bars simultaneous and automatic locking (**Acceptance Criteria Ra5**, item A6.5.5). Check end-course latch bars sensors (**Acceptance Criteria Sa2**, item A6.5.17) readings.

c) Record load cell measured value in TRS if applicable.

d) Spool out lifting device cable so Dummy Cap is freely seated on latch bars. Check how Dummy Cap is seated on latch bars, the expansion of latch bars and measure the clearance between each of them and Dummy Cap with a feeler gauge (**Acceptance Criteria Ra6**, item A6.5.6).

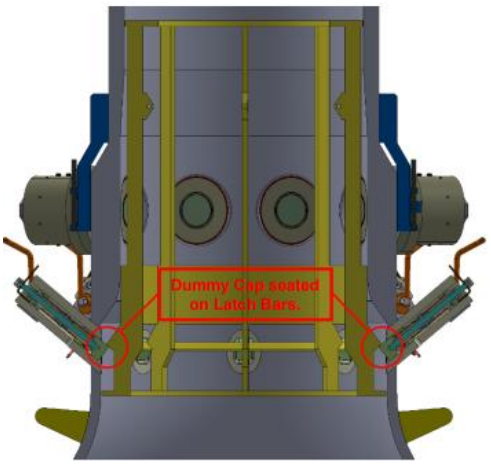


Figure 39: Dummy Cap seated on the latch bars

6.2.3. Pull-out Test Sequence

a) Spool the lifting device cable until Dummy Cap is no longer seated on latch bars.

b) Individually actuate the handler to move latch bars to “retracted” position (Figure 36a) allowing Dummy Cap to be lowered to the floor (**Acceptance Criteria Ra7,** item A6.5.7). Check end-course latch bars sensors (**Acceptance Criteria Sa3**, item A6.5.18) readings.

c) Lower the Dummy Cap until it rests on the floor (**Acceptance Criteria Ra8,** item A6.5.8).

d) Individually actuate each handler to move the latch bars to the “extended” position (Figure 36b) (**Acceptance Criteria Ra9**, item A6.5.9). Check end-course latch bars sensors (**Acceptance Criteria Sa4**, item 6.5.19) readings.

6.3. Hydraulic Actuator Integration Tests

6.3.1. The objective of this test is to verify if hydraulic actuators are fully functional when actuated by its hydraulic circuit and if each latch bar is properly aligned to BSDL-SI inner surface.

6.3.2. Preparation sequence for hydraulic actuator integration tests is the same as previous tests.

6.3.3. Test Sequence:

a) Pressurize hydraulic fluid into a cylinder chamber so latch bars move to “retracted” position (Figure 37a).

b) Check the minimum pressure needed to start moving latch bars (**Acceptance Criteria Ra10,** item A6.5.10). Check the end-course latch bars sensors (**Acceptance Criteria Sa5**, item 6.5.20).

c) Measure the gaps between each latch bar and BSDL-SI inner surface (**Acceptance Criteria Ra11,** item A6.5.11).

d) Align the hydraulic actuator circuit to HPU atmospheric pressure tanks so latch bars move to “extended” position (Figure 37b) due spring return force. Check the end-course latch bars sensors (**Acceptance Criteria Sa6**, item 6.5.21) readings.

e) Measure the gaps between each latch bar and BSDL-SI inner surface (**Acceptance Criteria Ra12**, item A6.5.12).

f) Repeat steps a through e 3 (three) times

6.4. Pull-in and Pull-out Simulation Tests with Hydraulic Actuation

6.4.1. The objective of this test is to verify if hydraulic actuators are fully functional when actuated by its hydraulic circuit and if each latch bar is properly aligned to BSDL-SI inner surface.

6.4.2. The pull-in and pull-out simulation tests with hydraulic actuation may be performed during pull-in and pull-out simulation tests (A6.2) at FPU CONTRACTOR/SELLER choice.

6.4.3. Preparation sequence for hydraulic actuator integration tests is the same as previous tests.

6.4.4. Pull-in test sequence is the same as A6.2.2.

6.4.5. Pull-out test sequence:

a) Spool in the lifting device cable until Dummy Cap is no longer seated on latch bars.

b) Pressurize hydraulic fluid into cylinder chamber so latch bars move to “retracted” position (Figure 37a) allowing Dummy Cap to be lowered to the floor (**Acceptance Criteria Ra13,** item A6.5.13). Check end course latch bars sensors (**Acceptance Criteria Sa3**, item 6.5.18).

c) Lower the Dummy Cap until it rests on the floor (**Acceptance Criteria Ra14,** item A6.5.14).

d) Align the hydraulic actuator circuit to HPU atmospheric pressure tanks so latch bars move to “extended” position (Figure 37b) due to spring return force (**Acceptance Criteria Ra15**, item A6.5.15). Check end course latch bars sensors (**Acceptance Criteria Sa4**, item 6.5.19).

6.5. Acceptance Criteria

6.5.1. Ra1

I. Handler performance: the only expected effort to be done by operator in to perform this test is the one necessary to overcome the spring elastic strength. The reference strength necessary to actuate each handler is 3 kgf. If the operator can move each handler smoothly and softly, then this step is approved, and one shall proceed to the next step. Register in the TRS. Otherwise, the deviation shall be evaluated, the test shall be decommissioned and BSDL-SI shall be sent to repair. Register in the TRS. Then restart the tests.

6.5.2. Ra2

I. Visual inspection: Observe if Latch Bars freely move from “retracted” position to “extended” one and back. If they do, then this step is approved, and one shall proceed to II criteria. Register in the TRS. Otherwise, the deviation shall be evaluated, the test shall be decommissioned, and BSDL-SI shall be sent to repair. Register in the TRS then restart the test.

II. Handler and Latch Bar set performance: the only expected effort to be done by operator to perform this test is the one necessary to overcome the handler and Latch Bar Set Inertia. If operator is able to move each Latch Bar smoothly and softly from “retracted” position to “extended” one and back, using only respective handler, then this step is approved, and one shall proceed to the next step. Register in the TRS. Otherwise, the deviation shall be evaluated, the test shall be decommissioned and BSDL-SI shall be sent to repair Register in the TRS. Then restart the tests.

6.5.3. Ra3

I. All Latch Bars shall be in “retracted” position (Figure 37a) and upper aligned to the BSDL-SI inner surface (Figure 40). If the gaps between each Latch Bar and the BSDL-SI inner surface are less than or equal to 3 mm, then this step is approved, and one shall proceed to the next step. Register in the TRS. Photographic record required. Otherwise, the deviation shall be evaluated, the test shall be decommissioned and BSDL-SI shall be sent to repair Register in the TRS. Then restart the tests.

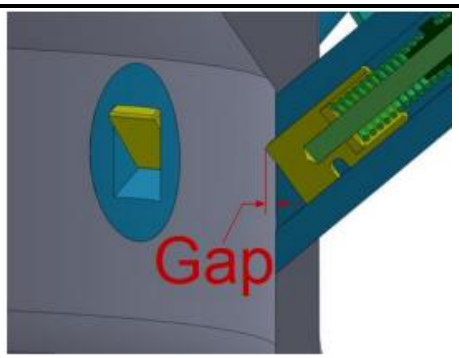


Figure 40: Upper Alignment between latch bar and BSDL-SI inner surface

6.5.4. Ra4

I. All Latch Bars shall be in “extended” position (Figure 37b) and lower aligned with the BSDL-SI inner surface (Figure 41). If gaps, presented between each latch bar and the BSDL-SI inner surface, are less than or equal to 5 mm, then this step is approved, and one shall proceed to the next step. Register in the TRS. Photographic record required.

II. In case of any latch bar is on a cantilever position (Figure 42), the deviation shall be evaluated, the test shall be decommissioned and BSDL-SI shall be sent to repair. Register in the TRS. Then restart the tests.

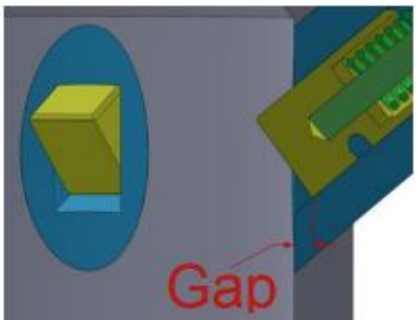


Figure 41: Lower Alignment between latch bar and BSDL-SI inner surface

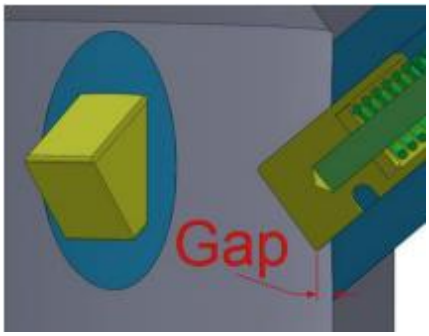


Figure 42: Latch bar on cantilever position

6.5.5. Ra5

I. Latch Bars shall automatically and simultaneously expand after the passage of the Dummy Cap. The verification shall be made through the thud of the latch bars expanding. The thud of the latch bars locking shall be a single and “dry” sound, in unison. If this condition is met, then this step is approved, and one shall proceed to the next step. Register in the TRS.

II. Delays/advances sonorously perceived indicate that some latch bar is locking later/earlier than expected. If the sound is neither single and “dry” nor in unison, the deviation shall be evaluated, the test shall be decommissioned and BSDL-SI shall be sent to repair. Register in the TRS. Then restart the test.

III. If any latch bar does not expand at all, then the deviation shall be evaluated, the test shall be decommissioned and BSDL-SI shall be sent to repair. Register in the TRS. Then restart the tests.

6.5.6. Ra6

I. Dummy Cap is seated on all latch bars and all of them are evenly expanded (Figure 39) or gaps between Dummy Cap and Latch Bars (Figure 43) are less than or equal to 2 mm. This step is approved, and one shall proceed to the next step. Register in the TRS. Photographic record required.

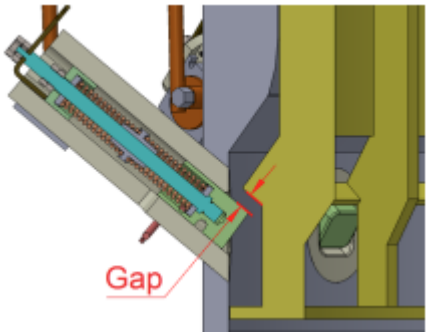


Figure 43: Gap between locking wedge and Dummy Cap

II. Dummy Cap is seated on Latch Bars in the following sequence: “One yes one no”. Check if the gap between Dummy Cap and 2 or more Latch Bars (not properly seated) is greater than 2 mm. If so, the deviation shall be evaluated, the test shall be decommissioned and BSDL-SI shall be sent to repair. Register in the TRS. Then restart the tests. If not, this step is approved. Register in the TRS.

III. Dummy Cap is not seated on two adjacent Latch Bars. Check if the gap between Dummy Cap and 1 of the Latch Bars is greater than 2 mm. If so, the deviation shall be evaluated, the test shall be decommissioned and BSDL-SI shall be sent to repair. Register in the TRS. Then restart the tests. If not, this step is approved. Register in the TRS.

IV. In the event of a combination of II and III deviations above mentioned, the test shall be decommissioned and BSDL-SI shall be sent to repair, regardless the gap between Dummy Cap and Latch Bars. Register in the TRS. Then the tests must be restarted.

6.5.7. Ra7

I. Visual Inspection: Observe if Latch Bars freely move from “extended” position to “retracted” one. If they do, then this step is approved, and one shall proceed to II criteria. Register in the TRS. Otherwise, the deviation shall be evaluated, the test shall be decommissioned and BSDL-SI shall be sent to repair. Register in the TRS. Then restart the tests.

II. Handler and Latch Bar set performance: the only expected effort to be done by operator to perform this test is the one necessary to overcome the handler and Latch Bar set inertia. If operator can move each Latch Bar smoothly and softly from “extended” position to “retracted” one, using only the respective handler, then this step is approved, and one shall proceed to the next step. Register in the TRS. Otherwise, the deviation shall be evaluated, the test shall be decommissioned and BSDL-SI shall be sent to repair. Register in the TRS. Then restart the tests.

6.5.8. Ra8

I. Dummy Cap shall descend freely through the Central Structure and then rest on the floor. If it does so, the step is approved. Register in the TRS. Otherwise, the deviation shall be evaluated, the test shall be decommissioned and BSDL-SI shall be sent to repair. Register in the TRS. Then restart the tests.

6.5.9. Ra9

I. See Ra4

6.5.10. Ra10

I. The minimum pressure necessary to start moving latch bars shall be greater than or equal to 10 bars. If so, this step is approved, and one shall proceed to the next step. Register in the TRS. Record minimum pressure value necessary to move latch bars. Otherwise, the deviation shall be evaluated, the test shall be decommissioned and BSDL-SI shall be sent to repair. Register in the TRS. Then restart the tests. Photographic record required.

6.5.11. Ra11

I. See Ra3

6.5.12. Ra12

I. See Ra4

6.5.13. Ra13

I. Visual Inspection: Observe if latch bars freely move from “extended” position to “retracted” one. If they do, then this step is approved. Register in the TRS. Otherwise, the deviation shall be evaluated, the test shall be decommissioned and BSDL-SI shall be sent to repair. Register in the TRS. Then restart the tests.

6.5.14. Ra14

I. See Ra8

6.5.15. Ra15

I. See Ra4

6.5.16. Sa1

I. Sensor’s indication: Observe if end-course signal latch bar indication flag changes value from “extended” position and “retracted” position are according to the flag indications. If they do, then this step is approved. Register in the TRS. Otherwise, the deviation shall be evaluated, the test shall be stopped and decommissioned and BSDL-SI shall be sent to repair. Register in the TRS. Then restart the tests.

6.5.17. Sa2

I. Sensor’s indication: Observe the register of all end-course signal latch bar indication flag changes value from “extended” to “retracted” to “extended” position one, i.e., it shall be observed a gate signal for all sensors from the Dummy Cap locking operation. If they do, then this step is approved. Register in the TRS. Otherwise, the deviation shall be evaluated, the test shall be stopped and decommissioned and BSDL-SI shall be sent to repair. Register in the TRS. Then restart the tests.

6.5.18. Sa3

I. Sensor’s indication: Observe if end-course signal latch bar indication flag changes value from the transition of “extended” position to “retracted” one. If they do, then this step is approved. Register in the TRS. Otherwise, the deviation shall be evaluated, the test shall be stopped and decommissioned and BSDL-SI shall be sent to repair. Register in the TRS. Then restart the tests.

6.5.19. Sa4

I. Sensor’s indication: Observe if end-course signal latch bar indication flag changes value from the transition of “retracted” position to “extended” one. If they do, then this step is approved. Register in the TRS. Otherwise, the deviation shall be evaluated, the test shall be stopped and decommissioned and BSDL-SI shall be sent to repair. Register in the TRS. Then restart the tests.

6.5.20. Sa5

I. Sensor's indication: Observe if all the end-course signal latch bar indications flag changes value from the transition of "extended" to "retracted" position one after hydraulic pressurization. If they do, then this step is approved. Register in the TRS. Otherwise, the deviation shall be evaluated, the test shall be stopped and decommissioned and BSDL-SI shall be sent to repair. Register in the TRS. Then restart the tests.

6.5.21. Sa6

I. Sensor´s indication: Observe if all end-course signal latch bar indications flag changes value from the transition of "retracted" to "extended" position one due to all springs return forces. If they do, then this step is approved. Register in the TRS. Otherwise, the deviation shall be evaluated, the test shall be stopped and decommissioned and BSDL-SI shall be sent to repair. Register in the TRS. Then restart the tests.

7. Test Record Sheet – TRS

7.1. General

7.1.1. The FAT procedure shall include a document to record the results of each step of the tests, named Test Record Sheet – TRS.

7.1.2. All sheets of all tests shall be filled out using pen.

7.1.3. TRS of BSDL-SI rejected and sent for scrapping shall be stored along with the databook sets of approved ones.

7.2. Minimum Content:

- Date – Date of the test
- Supplier – Manufacturer of the BSDL-SI
- Sheet – Indication of page number and total number of pages
- Rep. Num. – Report number defined according to supplier's methodology
- ND – BSDL-SI nominal diameter
- SN – BSDL-SI serial number
- FPU – Production unit where the BSDL-SI will be installed
- Report – Field to be filled in with any information regarding the current step
- AP/SR/RE – Indication of approved, send to repair and reproved
- RaX – Flexible riser mechanical tests
- SaX – Flexible riser sensor tests
- Responsible – Name and signature of the responsible for releasing the BSDL-SI
- Result – Result of the tests, Approved or Rejected

7.3. Fields AP, SR and RE

7.3.1. The AP, SR and RE fields shall be marked with an X or checked in accordance with one of the three situations shown below.

7.3.2. Approved (AP)

7.3.2.1. The BSDL-SI is released to the next test. This option will be marked alone if the test passes with no indication of repairs.

7.3.3. Send to Repair (SR)

7.3.3.1. There was a deviation during the test and the BSDL-SI must be repaired and retested.

7.3.3.2. The deviation occurred shall be reported as well as the description of what shall be done to repair the bell mouth. After repairing the BSDL-SI shall be submitted to test again from the beginning.

7.3.3.3. In case of repairing the bell mouth, besides the SR field, the AP or RE field may be marked after the second test, depending on the result of this test. That is, if both AP and SR fields are marked, it means that BSDL-SI was tested and failed, it was sent to repair, tested again and later approved. Similarly, if SR and RE are marked, it means that the BSDL-SI was tested and failed, it was sent to repair, tested again, and failed once more, indicating that it shall be discarded.

7.3.4. Reproved (RE)

7.3.4.1. The BSDL-SI shall be discarded. This option will be marked alone if the rejection indicates discard without repairs.

7.3.4.2. The new BSDL-SI manufactured to replace the rejected one shall receive a new serial number.

ANNEX C: LIST OF MINIMUM DOCUMENTATION

1. This Annex contains a list of minimum documentation to be provided as part of the BSDL-SI design.
2. These lists summarize the main content of each expected document.
3. First column of the tables contains PETROBRAS recommended document type according to standard N1710.
4. Last column of the tables contains the expected documents to be provided per phase of the project.
5. General Arrangement Drawing shall provide as-built document.
6. All drawings of BSDL components shall include internal parts design and the details of isolation mechanism for CuBe alloys.
7. All 3D models of the TSUDL, in CAD (Computer-Aided Design) or CAE (Computer-Aided Engineering) format, shall be included in the documentation list for Petrobras' approval.

CMS = Control and Monitoring System SMD = Support Manufacture Design

Table 1: CMS Minimum Documentation List

Type	Document Title	Phase
LD	Vendor Document List (VDL)	Pre-Project
LD	Final Documentation Folder	Pre-Project
CR	Project Main Schedule	Pre-Project
DB	Data Book	Pre-Project
FD	Data Sheet	Detailing
LI	Spare Part List	Detailing
LI	Equipment & Special Tool & Hazardous Equipment List	Detailing
LI	Supplier / Sub-Supplier Equipment List	Detailing
MD	Design Basis	Detailing
DE	General Arrangement Drawing	Detailing
RL	Hullside Umbilical Calculation Report	Detailing
DE	Umbilical Erection and Installation Drawing Hullside Umbilical for Riser Supports	Detailing
DE	Piping And Instrument Diagram (P&ID)	Detailing
DE	Single Line Electrical Diagrams	Detailing
DE	Electrical Termination Wiring Drawing	Detailing
DE	System Topology	Detailing
RL	Network Topology and HMI	Detailing
DE	Instrument / Electrical Logic Diagram	Detailing
DE	Loop Diagrams	Detailing
RL	VDU Screen Display Graphics	Detailing
ET	WPS and PQR Hullside Umbilical for Riser Supports	Detailing
DE	Welding Map Hullside Umbilical for Riser Supports	Detailing
LI	I/O List	Detailing

RL	Lower Riser Balcony Clashing and Interference Analysis	Detailing
ET	Inspection & Test Plan	Implementation
PR	Factory Acceptance Test Procedure	Implementation
RL	Factory Acceptance Test Report	Implementation
PR	Chemical Cleaning and Flushing Procedure	Implementation
PR	Hydrostatic Test Procedure	Implementation
PR	NDT Procedure Hullside Umbilical for Riser Supports	Implementation
PR	Painting Procedure Hullside Umbilical for Riser Supports	Implementation
CE	NDT Operator Qualification Hullside Umbilical for Riser Supports	Implementation
RL	NDT Report Hullside Umbilical for Riser Supports	Implementation
PR	Site Integration Test Procedure	Implementation
RL	Site Integration Test Report	Implementation
CE	Instrument Test/Calibration Certificate	Implementation
MA	Installation and Operation Manual (English)	Implementation
MA	Installation and Operation Manual (Portuguese)	Implementation
MA	Preservation and Maintenance Manual	Implementation
RL	Life Cycle Support Statement	Implementation
RL	RSMS Login/Password Document	Implementation
ET	Training Program	Implementation

Table 2: SMD Minimum Documentation List

Tipo	Título	Phase
LD	Vendor Document List (VDL)	Pre-Project
LD	Final Documentation Folder	Pre-Project
CR	Project Production Schedule	Pre-Project
DB	Data Book	Pre-Project
LI	Spare Parts List	Pre-Project
MD	Design Basis and Methodology	Pre-Project
RL	Riser Balcony Interference Report	Pre-Project
DE	General and Structure Drawing	Detailing
DE	ISO Drawing	Detailing
DE	Piping And Instrument Diagram (P&ID)	Detailing
DE	Typical Electrical Wiring Diagram	Detailing
DE	Interface and Connection Schedule	Detailing
RL	Dimensional Report	Detailing
MC	Calculation Report	Detailing
MC	Hydraulic Actuator Calculation Report	Detailing
DE	Dummy Cap Drawing	Detailing
DE	Cap Drawing	Detailing
DE	Hydraulic Actuator Assembly & Structure Drawing	Detailing
ET	Project Quality Plan	Detailing
ET	HSE Plan	Detailing
DE	Welding and NDT Map	Detailing
ET	Weld Procedure Specifications(WPS)	Detailing

RL	Welder Performance Qualification	Detailing
RL	NDT Operator List and Certificate	Detailing
CE	Calibration Certificate	Implementation
ET	Inspection & Test Plan	Implementation
PR	Chemical Cleaning and Flushing Procedure	Implementation
PR	FAT Procedure	Implementation
RL	FAT Report	Implementation
MA	Installation Operation and Maintenance Manual (English)	Implementation
MA	Installation Operation and Maintenance Manual (Portuguese)	Implementation
MA	Preservation and Maintenance Manual (Procedure)	Implementation
PR	Hydraulic Actuator FAT Procedure	Implementation
RL	Hydraulic Actuator FAT Report	Implementation
PR	Wearing Test Procedure	Implementation
RL	Wearing Test Report	Implementation
RL	Requests for Deviations	Implementation
CE	Material Test Certificate	Implementation
RL	Asbestos-Free Declaration	Implementation
PR	Hydrostatic Test Procedures	Implementation
PR	Surface Painting Procedure	Implementation
PR	Packing and Shipping Procedure	Implementation
PR	NDT Procedure	Implementation
PR	UT Procedure	Implementation
PR	MT Procedure	Implementation
PR	Heat Treatment Procedure	Implementation
RL	NDT Report	Implementation
RL	Material Traceablity Record	Implementation
RL	Surface Treatment Inspection Record	Implementation
RL	Welding Traceability Records	Implementation
RL	UT Report	Implementation
RL	MT Report	Implementation
RL	Heat Treatment Record	Implementation
LI	Shipping and Packaging List	Implementation
PR	BSDL-SI Handling Procedure	Implementation
RL	NDT Report	Implementation