PETROBRAS	**TECHNICAL SPECIFICATION**	Nº I-ET-3010.00-1300-850-PEK-001	
	CLIENT PETROBRAS		SHEET 1 of 27
	JOB		
	AREA –		
SUB	TITLE **CONTROL AND MONITORING SYSTEM FOR RISER SUPPORTS**		***PUBLIC***
			SUB/ES/EECE/ECE

REVISION INDEX

REV.	DESCRIPTION AND/OR REVISED SHEETS
0	Original
A	Items included
B	Safety improvements.
C	Revised Hydraulic actuator Top Cone support hydraulic functions. Changes marked

	REV. 0	REV. A	REV. B	REV. C	REV. D	REV. E	REV. F	REV. G	REV. H
DATE	30/12/2020	15/03/2021	08/04/2021	18/06/2021					
DESIGN	ECE	ECE	ECE	ECE					
EXECUTION	Y5UJ	BYE8	Y5UJ	Y5UJ					
CHECK	BYE8	Y5UJ	BYE8	BYE8					
APPROVAL	UR6A	UR6A	UR6A	UR6A					

TABLE OF CONTENTS

1 SUBJECT

This document presents the Technical Specification of control and monitoring system for riser supports (BSDL-SI, TSUDL and Receptacles).

2 ABBREVIATION

BSDL-SI	Diverless Bell Mouth - Standard Interface (Portuguese acronym)
DL	Diverless
FAT	Factory Acceptance Test
FPU	Floating Production Unit
HPU	Hydraulic Power Unit
TSUDL	Unified Diverless Support Tube (Portuguese acronym)
XT	Xmas Trees

3 REFERENCE DOCUMMENTS, CODES AND STANDARDS

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

3.1 International Standards

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

[2] API 17E – Specification for Subsea Umbilicals

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

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

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

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

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

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

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

3.2 Petrobras documents

[10] I-DE-3010.00-1300-279-PEK-003 – 5K HYDRAULIC ACTUATOR ASSEMBLY FOR BSDL

[11] I-ET-3010.00-1300-279-PEK-002 – 5K HYDRAULIC ACTUATOR FOR BSDL / DIVERLESS BELL MOUTH

[12] I-ET-3010.00-1300-279-PPC-350 - DIVERLESS BELL MOUTH STANDARD INTERFACE SUPPLY SPECIFICATION

[13] I-DE-3010.00-1300-279-PEK-003 – Lateral Support Module

[14] I-ET-3010.00-1300-850-PEK-002 - Hullside Umbilical for Riser Systems

[15] I-ET-3000.00-5529-850-PEK-005 – RIGID RISER MONITORING SYSTEM (RRMS) – FPU Scope – HULLSIDE UMBILICAL SOLUTION

[16] ET-3000.00-1500-251-PEK-001 – FIXADORES EM AÇO BAIXA LIGA DE ALTA RESISTÊNCIA PARA APLICAÇÃO SUBMARINA

[17] ET-3000.00-1500-251-PEK-002 - RASTREABILIDADE DE FIXADORES DE ALTA RESISTÊNCIA PARA UTILIZAÇÃO SUBMARINA

[18] ET-3000.00-1500-29B-PMU-001 - FIXADORES DE LIGAS RESISTENTES A CORROSÃO PARA UTILIZAÇÃO EM UMBILICAIS SUBMARINOS

[19] I-DE-3010.00-1300-850-PEK-001 - Riser Supports P&ID

[20] I-ET-3010.00-1519-140-P56-001 - UNIFIED DIVERLESS SUPPORT TUBE (TSUDL)

[21] I-ET-3000.00-1500-823-PEK-001 Qualification of Wet-Mate Electrical Connectors and Accessories

[22] PETROBRAS N-858 Construção, Montagem e Condicionamento de Instrumentação

[23] I-DE-3010.00-1300-279-PEK-004 – LATERAL SUPPORT MODULE - MTL

4 DEFINITIONS

FPU CONTRACTOR	The company contracted by PETROBRAS to construct the FPU
DIVING TEAM	The party responsible for execution of diving-related tasks, to be defined during the bidding phase.
MAY	It is used when alternatives are equally acceptable
RISER SUPPORT	General reference for lower balcony risers support. Comprising BSDL-SI, TSUDL and Receptacle.
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
SUBCONTRACTOR	Company contracted by FPU CONTRACTOR, to supply hydraulic actuator system for BSDL.

5 TECHNICAL CARACTERISTICS

5.1 Design and fabrication

5.1.1 All subsea control components shall be designed in accordance with API 17E and API 17F.

5.1.2 Selection of materials for all subsea structures shall be in accordance with DNVGL-RP-B401:2017 item 5.5, and be designed for the same design life as the riser.

5.1.3 All enclosures and equipment to be placed in hazardous areas shall comply and be certificated according IEC 60079 (latest revision).

5.1.4 All enclosures with a required degree of ingress protection shall comply with IEC 60529 (latest revision).

5.2 Qualification

5.2.1 All subsea equipment shall be qualified in accordance with API 17Q or ISO 13628-6:2006.

5.2.2 FPU CONTRACTOR shall consider SUBCONTRACTORS with experience in subsea hydraulic actuators and subsea monitoring systems.

6 GENERAL TECHNICAL REQUIREMENTS

6.1 System overview

6.1.1 Riser support is a device designed to support risers in lower balcony of a FPSO. This document specifies Control and Monitoring system for 3 types of riser support:

- BSDL-SI: Diverless Bellmouth – Standard Interface;
- TSUDL: Unified Diverless Support Tube;
- Receptacle.

6.1.2 The components of Control and Monitoring System for Riser Suports shall be connected to topside by a hull side umbilical detailed in ref [15].

6.1.3 CONTRACTOR shall provide a topside structure in order to:

- Route cabling and hydraulic circuits;
- Manage and Supply hydraulic circuits.
- Process and present data related to control and monitoring system.

6.1.4 This document does not specify the mechanical structure of riser supports itself. The technical specification of these supports is referenced in item 3.

6.1.5 In riser positions with TSUDL or Receptacle shall be provided Optical and electrical connectors for RRMS (Rigid Riser Monitoring System) as detailed in Ref [16].

6.2 BSDL-SI

6.2.1 BSDL-SI is a device designed to support flexible line bend stiffener loads and allow diver less pull in operations. Three nominal sizes of BSDL-SI are considered: 32”, for umbilical lines, 46” and 48” for flexible production, service or gas/water injection lines.

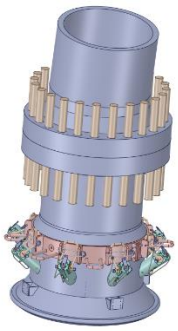

Figure 1 – BSDL-SI

6.2.2 Control and monitoring system for BSDL-SI, comprises:

6.2.2.1 Hydraulic actuation with simple action hydraulic actuators installed on BSDL-SI round blocks, in order to unlatch the locks and release bend stiffener’s adaptor cap at pull-out operations. The number of actuators for each BSDL-SI depends upon its nominal size as ref. [11].

6.2.2.2 Monitoring actuators position with end course sensor in order to identify the complete unlatching of all actuators.

6.2.2.3 Monitoring electrochemical potential of the support structure in order to verify an indication of corrosion process.

6.3 TSUDL

6.3.1 TSUDL is a device designed to support rigid and flexible risers at the lower balcony structure and allow diver less operations (pull-in and pull-out).

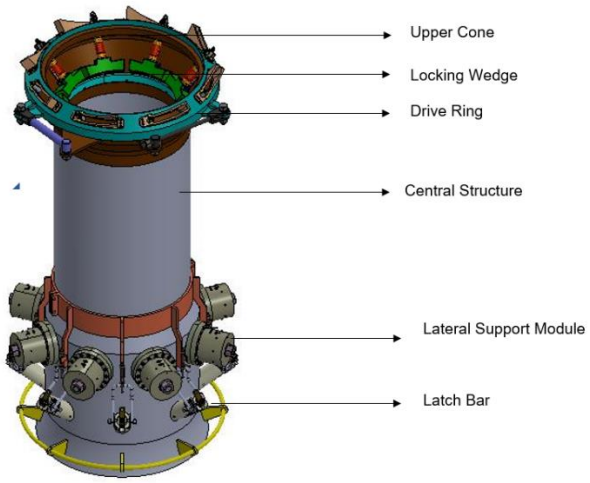

Figure 2 - TSUDL

6.3.2 TSUDL has three main structures as illustrated in Figure 2:

- Top Cone Support: function to hold the rigid riser hang off adaptor;
- Lateral Support Module: function to lock laterally the rigid riser hang off adaptor;
- Adaptor Cap Latch mechanism (when flexible risers is used in TSUDL): function to hold bend stiffener's adaptor cap.

6.3.3 Control and monitoring system for TSUDL, comprises:

- Hydraulic actuators (dual action) to latch/unlatch locking wedges in Top Cone support, in order to allow pull-out operations;
- Hydraulic actuators (dual action) to latch/unlatch lateral support modules;
- Monitoring actuators position with end course sensors to identify the complete latching/unlatching of all locking wedges in Top Cone Support;
- Monitoring actuators position with end course sensors to identify the retracted position of Lateral Support Modules.
- Monitoring electrochemical potential of the support structure in order to verify an indication of corrosion process.

6.4 RECEPTACLE

6.4.1 Receptacle is a conic structure to support top segment of rigid risers (e.g. Flex

joints or Stress Joints)

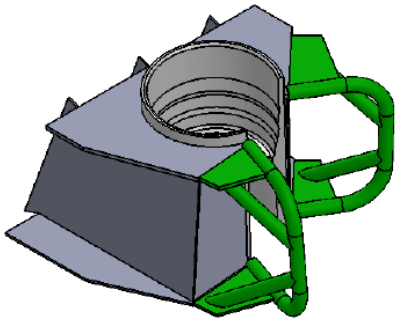

Figure 3 – Receptacle

6.4.2 Although it is a riser support type, there is no automation and control in its operations. So, there no scope for control and monitoring system for this structure.

6.4.3 The above item, do not exclude the need to RRMS connectors as required in 6.1.5 and Ref [16].

7 TECHNICAL REQUIREMENTS FOR BSDL-SI

7.1 System overview

7.1.1 The Figure 4 presents a block diagram of Control and monitoring system related to BSDL-SI.

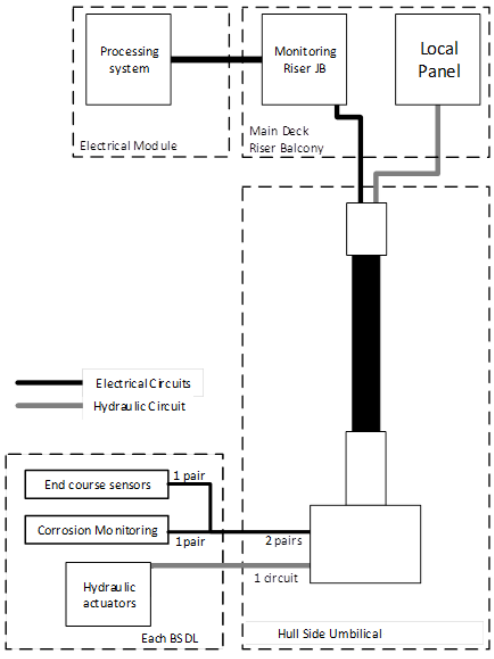

Figure 4 – BSDL-SI Control and Monitoring system

7.1.2 Detailed specification about BSDL-SI and Hydraulic actuator is in ref [11].

7.1.3 The number of BSDL-SI connected to each umbilical shall consider:

- Umbilical optimization;
- Riser Balcony arrangement;
- Hydraulic and Electric connectors available;

7.2 Hydraulic actuator

7.2.1 The hydraulic actuator is responsible primarily for diverless unlocking mechanism of the flexible line bend stiffener during pullout operation.

7.2.2 Techincal requirements for detailed design, testing and fabrication are defined in ref.[11].

7.3 End course detector

7.3.1 FPU CONTRACTOR shall provide end course detector in order to monitor if after the hydraulic actuation, all pistons worked.

7.3.2 This end detectors shall work as an electrical subsea switches connected in series, each one with on resistor in parallel (see Figure 5). Each resistor, shall be dimensioned in order to be possible to determine the final course of each piston individually (using Voltage Dividers).

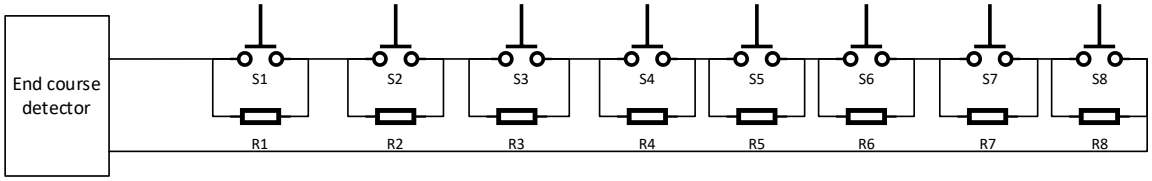

Figure 5 – End Course detector scheme

7.3.3 The End course circuit shall be connected to a topside by one electric pair, available for this purpose. FPU CONTRACTOR shall provide electronics on topside (Monitoring Riser JB) to detect end course data and show in supervisory system at Monitoring Riser Cabinet (see item 10.4).

7.3.4 The position of end course sensors shall be design by FPU CONTRACTOR and submitted to PETROBRAS approval.

7.4 Corrosion Monitoring

7.4.1 FPU CONTRACTOR shall provide an electrochemical potential monitoring solution of the support structure in order to verify an indication of corrosion process.

7.4.2 The electrochemical potential monitoring shall comprises 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.

7.4.3 The corrosion monitoring shall be connected to a topside by one electric pair, available for this purpose. FPU CONTRACTOR shall provide electronics on topside (Monitoring Riser JB) to measure electrochemical potential data and show in supervisory system at Monitoring Riser Cabinet (see item 10.4).

7.4.4 The position of corrosion monitoring installation point shall be design by FPU CONTRACTOR and submitted to PETROBRAS approval.

7.5 Umbilical Interface

7.5.1 Considering that hull side umbilical is a multipurpose structure, some premises shall be adopted to design the interface to BSDL-SI.

7.5.1.1 Each electrical connector of umbilical lower termination shall connect up to 3 BSDL-SI. FPU CONTRACTOR shall use these electrical circuits to connect instrumentation (end course and corrosion monitoring) of each BSDL-SI.

7.5.1.2 Each BSDL-SI shall have one individual hydraulic circuit, connected to one JIC connector of umbilical lower termination.

7.5.2 Hydraulic connection between BSDL-SI and umbilical:

7.5.2.1 The hydraulic circuit between BSDL-SI and umbilical lower termination (plate) shall be made by steel tubing;

7.5.2.2 The tubings and supports shall be made of materials defined at 6.2.8.5.

7.5.2.3 The steel tubing shall have internal diameter of 3/8 inches.

7.5.2.4 The steel tubing shall be properly fixed and routed bellow lower riser balcony. The routing shall prioritize protected areas in order to avoid mechanical damage of tubing.

7.5.2.5 FPU CONTRACTOR shall provide properly hydraulic connection between steel tubing and umbilical lower termination (plate), considering the environment and the life cycle.

8 TECHNICAL REQUIREMENTS FOR TSUDL

8.1 System overview

8.1.1 The Figure 6 presents a block diagram of Control and monitoring system related to TSUDL.

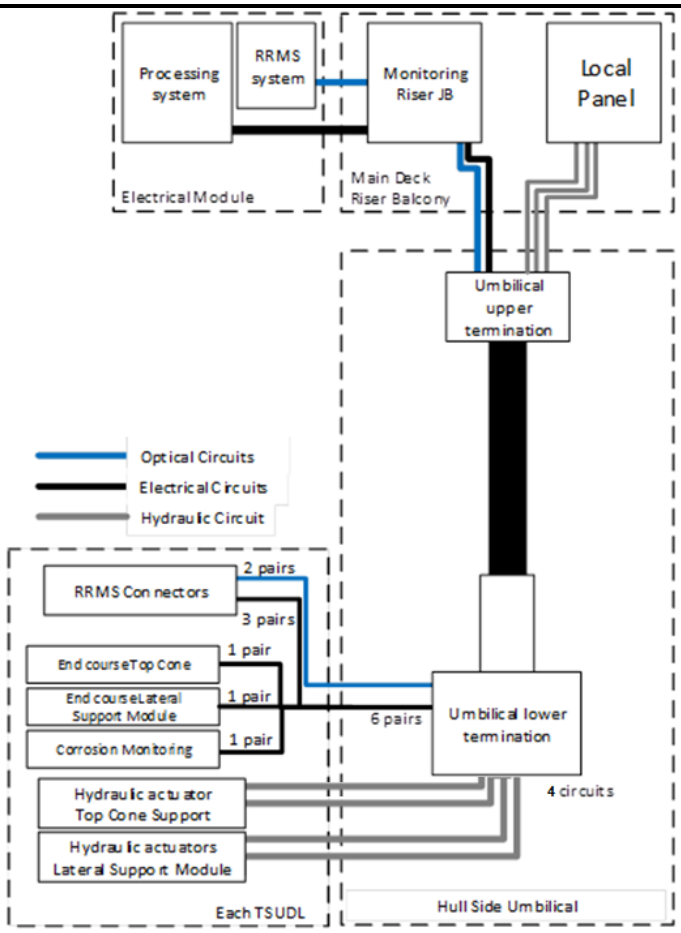

Figure 6 – TSUDL Control and Monitoring system

8.1.2 Detailed specification about TSUDL is in ref [20].

8.1.3 The number of TSUDL connected to each umbilical shall consider:

- Umbilical optimization;
- Riser Balcony arrangement;
- Hydraulic and Electric connectors available;

8.1.4 The hydraulic circuits between the TSUDL and HPU for subsea can be divided in three segments, detailed as follows:

- Connection between TSUDL and Umbilical (see item 8.8);
- Umbilical (See ref [14]);
- Local Panel and HPU interface (See item 10.1 and 10.2).

8.2 Hydraulic Actuator for Top Cone Support

8.2.1 The hydraulic actuator for Top Cone Support is responsible primarily for diverless latch/unlatch mechanism (locking wedges and drive ring) that support rigid riser hang-off during pullin/pullout operation.

8.2.2 Technical requirements for detailed design, testing and fabrication is defined in ref. [20]

8.2.3 Tubings and fittings shall be made of one of this options:

- Super austenitic stainless steel, shall comply with DNV RP B401.
- S32750 with hardness limited to 35 HRC and tubing design shall comply with DNVGL-RP-F112 (ed.2018).
- Design operational life: 30 years and 50 cycles.

8.3 End-course for hang-off

8.3.1 FPU CONTRACTOR shall provide end course detectors in order to monitor the complete course of locking wedges stages:

8.3.1.1 For “released” stage a minimum of two detectors installed in drive ring;

8.3.1.2 For “locked” stage, shall be provided one detector for each locking wedge.

8.3.2 This end detectors shall work as an electrical switch connected in series, each one with on resistor in parallel (see Figure 7). Each resistor shall be dimensioned in order to be possible to determine the final course of each piston individually.

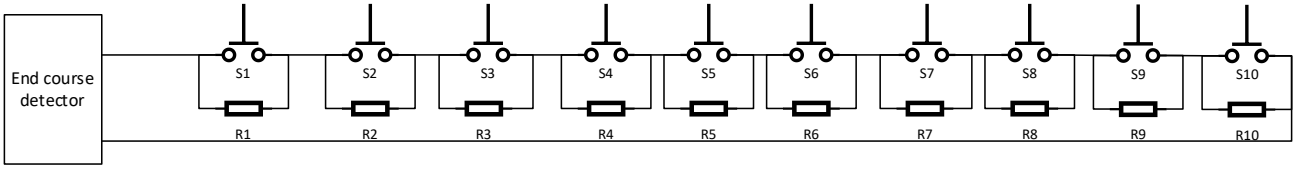

Figure 7 – End Course detector scheme

8.3.3 If needed, FPU CONTRACTOR, may use two circuits in order to accommodate all sensors.

8.3.4 The End course data shall be connected to a topside by umbilical electric pairs, available for this purpose. FPU CONTRACTOR shall provide electronics on topside (Monitoring Riser JB) to detect end course data and show in supervisory system at Monitoring Riser Cabinet (see item 10.4).

8.3.5 The position of end course sensors (“released” and “locked” stages) shall be design by FPU CONTRACTOR and submitted to Petrobras approval.

8.4 Hydraulic Actuator for Lateral Support Module

8.4.1 The hydraulic actuator for Lateral Support Modules is responsible primarily for diverless latch/unlatch mechanisms to lock laterally the hang off adaptor from rigid riser in order to avoid fatigue damage of the top cone support from FPU and riser movements.

8.4.2 Technical requirements for detailed design, testing and fabrication of Lateral Support Module are defined in ref. [20].

8.5 End-course for Lateral Support Module

8.5.1 FPU CONTRACTOR shall provide end course detector in order to monitor if after the hydraulic actuation, all pistons are in the final “release state”.

8.5.2 This end detectors shall work as an electrical subsea switches connected in series, each one with on resistor in parallel (see Figure 8). Each resistor, shall be dimensioned in order to be possible to determine the final course of each piston

individually (using Voltage Dividers).

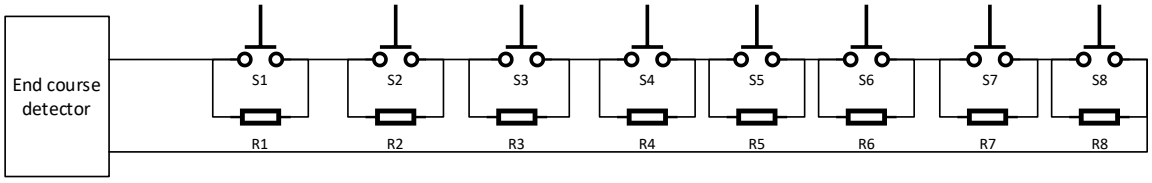

Figure 8 – End Course detector scheme

8.5.3 The End course circuit shall be connected to a topside by one electric pair, available for this purpose. FPU CONTRACTOR shall provide electronics on topside (Monitoring Riser JB) to detect end course data and show in supervisory system at Monitoring Riser Cabinet (see item 10.4).

8.5.4 The position of end course sensors shall be design by FPU CONTRACTOR and submitted to PETROBRAS approval.

8.6 Corrosion monitoring

8.6.1 FPU CONTRACTOR shall provide an electrochemical potential monitoring solution of the support structure in order to verify an indication of corrosion process.

8.6.2 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.

8.6.3 The corrosion monitoring shall be connected to a topside by one electric pair, available for this purpose. FPU CONTRACTOR shall provide electronics on topside (Monitoring Riser JB) to measure electrochemical potential data and show in supervisory system at Monitoring Riser Cabinet (see item 10.4).

8.6.4 The position of corrosion monitoring installation point shall be design by FPU CONTRACTOR and submitted to PETROBRAS approval.

8.7 Umbilical interface

8.7.1 Considering that hull side umbilical is a multipurpose structure, some premises shall be adopted to design the interface to TSUDL.

8.7.1.1 Each electrical connector of umbilical lower termination shall connect one TSUDL:

- 3 electrical pairs shall be dedicated to connect instrumentation (end course and corrosion monitoring);
- 3 electrical pairs shall be dedicated to connect to RRMS connector (for Riser Monitoring System).

8.7.1.2 Each optical connector of umbilical termination shall connect one TSUDL. The optical connection related to RRMS system.

8.7.1.3 Each TSDUL shall have 3 individual hydraulic circuits connected to hull side umbilical, connected JIC connectors of umbilical lower termination, distributed as follows:

- 2 Hydraulic circuit to Top Cone Support;
- 2 Hydraulic circuit to Lateral Support Module

8.7.2 Hydraulic Connection between TSUDL and umbilical

8.7.2.1 The hydraulic circuits between TSUDL and umbilical lower termination (plate) shall be made by steel tubing;

8.7.2.2 Tubing supports shall be provided at a maximum distance of 15 L/D (L – distance between supports and D – external tubing diameter).

8.7.2.3 The tubings and supports shall be made of materials defined at 8.2.4.

8.7.2.4 The steel tubing shall have internal diameter of ½ inch.

8.7.2.5 The steel tubing shall be properly fixed and routed bellow lower riser balcony. The routing shall prioritize protected areas in order to avoid mechanical damage of tubing.

8.7.2.6 FPU CONTRACTOR shall provide properly hydraulic connection between steel tubing and umbilical lower termination (plate), considering the environment and the life cycle.

9 TECHNICAL REQUIREMENTS FOR RECEPTACLE

9.1 System overview

9.1.1 The Figure 9 presents a block diagram of Control and monitoring system related to Receptacle.

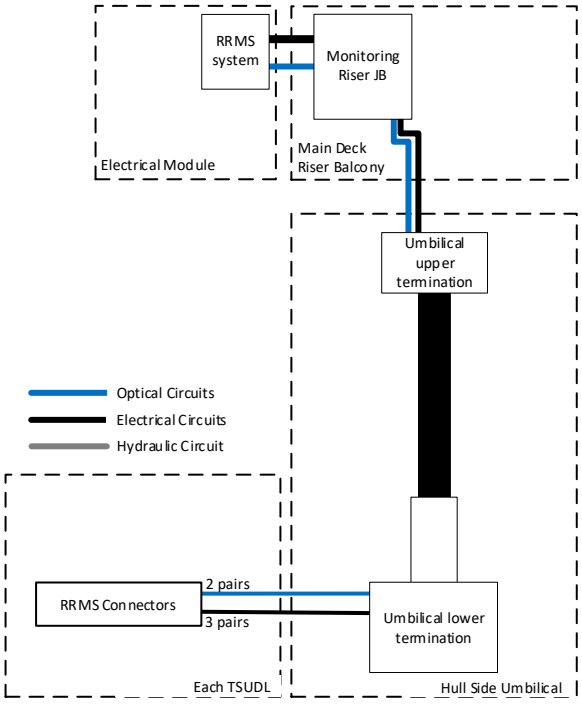

Figure 9 – Receptacle Control and Monitoring system

9.1.2 The number of Receptacles connected to each umbilical shall consider:

- Umbilical optimization;
- Riser Balcony arrangement;
- Optical and Electric connectors available;

9.2 Umbilical interface

9.2.1 Considering that hull side umbilical is a multipurpose structure, some premises shall be adopted to design the interface to Receptacles.

9.2.1.1 Each electrical connector of umbilical lower termination shall connect one Receptacle with 3 electrical pairs dedicated to connect to RRMS electrical wet mate connector (for Riser Monitoring System).

9.2.1.2 Each optical wet mate connector of umbilical termination shall connect each receptacle related to RRMS system.

10 TECHNICAL REQUIREMENTS FOR TOPSIDE

10.1 Upper balcony infrastructure

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

10.1.2 TUTU plate shall have 1 (one) manual operated valve and 1 (one) pressure indicator for each hydraulic control line. The TUTU plate shall be connected in the topside with the corresponding Local panel. See ref.[19].

10.1.3 FPU CONTRACTOR shall provide a seal tag for each hydraulic circuit at TUTU plate in order to certificate the correct assembly (avoid switching hydraulic lines during Construction and Assembly or operational phase). Each change during FPU Construction and Assembly shall be registered.

10.1.4 Umbilical JB shall aggregate all optical fibers (at splice trays) and electrical conductors (at SAK terminals) from umbilical pigtails. The Umbilical JB shall be connected in the topside with the corresponding Monitoring Riser JB.

10.2 Monitoring Riser JB

10.2.1 FPU CONTRACTOR shall provide one JB (named Monitoring Riser JB) for each hullside umbilical located in the main deck.

10.2.2 Monitoring Riser JB comprises the following main functions:

- Arrange RRMS optical and electrical signals;
- Collect/process TSUDL Monitoring System electrical signals;
- Collect/process BSDL-SI Monitoring System electrical signals;
- Collect Local Panels Monitoring System electrical signals including activation hydraulic supply header;
- Activate/deactivate subsea HPU hydraulic supply header.

10.2.3 To arrange RRMS signals, this JB shall aggregate optical fibers (at splice trays) and electrical conductors (at SAK terminals).

10.2.4 For the other functions, this JB shall be designed with a RTU automation solution. This RTU shall collect/process all analog signals and transmit using a TCP-IP standard protocol to the SCADA Master Station (at Monitoring Riser Cabinet).

10.2.5 RTU shall process/digitalize the following main variables:

- TSUDL top cone support and side locking module end courses signals;
- TSUDL structure corrosion monitoring indication;
- BSDL-SI locking module end courses signals;
- BSDL-SI structure corrosion monitoring indication;
- Local Panels pressure transmitters.

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

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

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

10.3 Local Panel

10.3.1 CONTRACTOR shall provide one Local Panel for each Hullside umbilical.

10.3.2 Local Panel comprises the following main functions:

- Manually operate TSUDL/BSDL-SI hydraulic actuation systems
- Monitor hydraulic lines from actuation systems
- Activate hydraulic supply header from subsea HPU.

10.3.3 The hydraulic circuit between Umbilical Upper Termination and Local Panel, as well as, between Local Panel and HPU shall be made by steel tubing;

10.3.4 The steel tubing shall be made of stainless steel S31600 with requirements established in ISO 15156-3:2009.

10.3.5 The steel tubing shall have internal diameter of 3/8 inches.

10.3.6 FPU CONTRACTOR shall provide a local panel close to upper umbilical termination at main deck. This panel shall contain the directional control valves and connections for BSDL-SI / TSUDL connected to respective umbilical.

10.3.7 The hydraulic circuits routed in the same umbilical can share the same local panel, with individual circuits for each BSDL-SI / TSUDL. FPU CONTRACTOR shall guarantee the unmistakable correspondence solution between direction valves and respective hydraulic actuator for each BSDL-SI / TSUDL.

10.3.8 Each local panel shall be connected to HPU FOR SUBSEA SYSTEMS by SPCS RACK from direct hydraulic XTs with two hydraulic circuits (hydraulic supply and return lines). All local panels for BSDL-SI / TSUDL Hydraulic Actuation systems shall be connected in the same hydraulic circuit of HPU as Ref [19].

10.3.9 The Hydraulic Circuit in the Local Panel shall have a jumper in order to segment the circuit, and that will be connected in pull-in/pull-out operations of BSDL-SI/TSUDL only. This jumper shall be inserted in design in order to avoid activation by mistake. To connect this jumper FPU CONTRACTOR shall provide fast connectors. For top cone hydraulic actuation, the design shall foresee a differentiated outlet connection (poka yoka concept), in order to avoid wrong assembly.

10.3.10 Each Local Panel shall be able to activate the solenoid hydraulic header supply for BSDL-SI / TSUDL Hydraulic Actuation system (from SPCS Rack from Subsea HPU). This activation shall use electrical switches (ON / OFF) able to be locked in order to avoid activation by mistake.

10.3.11 The design of Local Panel shall include a local signal indicator of solenoid activation and data logged / show in supervisory system at Monitoring Riser Cabinet (see item 10.4).

10.3.12 The design of Local Panel shall include pressure indicators to verify locally the pressure in hydraulic supply header and at all hydraulic outlets to BSDL-SI/TSDUL and pressure transmitters to data log / show in supervisory system at Monitoring Riser Cabinet (see item 10.4).

10.3.13 The TSUDL/BSDL directional control valves, manual valves, pressure relief valves and pressure indicators shall be organized in blocks and shall have individual identification. Identification may be numbers with letters and submitted for PETROBRAS approval according to topside project's tagging standard.

10.3.14 The pressure relief valves shall be dimensioned in order to avoid accidentally hydraulic actuation of the mechanisms when the corresponding riser structure shall be docked at the support, for BSDL-SI: flexible riser bend stiffener structure and for TSUDL: rigid riser flexible joint structure.

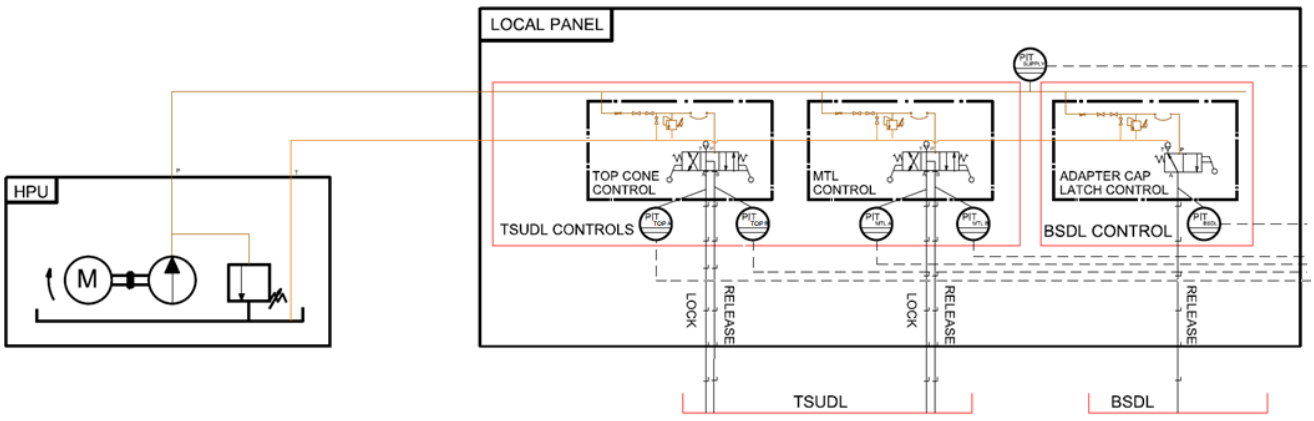

Figure 10 – Local panel example diagram from Riser supports P&ID ref.[19]

10.4 Hydraulic Circuit

10.4.1 The diagram of Hydraulic Circuit shall observe the drawing in ref. [19].

10.4.2 All hydraulic lines and components shall be compatible with the following hydraulic control fluids standardized by PETROBRAS: MacDermid HW443, HW525P and Castrol Transaqua DW.

10.4.3 FPU CONTRACTOR shall provide a compatibility analysis for the hydraulic control fluid adopted in HPU design with all materials used that shall contact with such fluid.

10.4.4 All hydraulic lines shall be supplied filled with the hydraulic fluid defined by the HPU project (MacDermid HW443; MacDermid HW525P or Castrol Transaque DW).

10.4.5 All hydraulic lines shall be flushed in order to guarantee supply of 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) and ensure no air bubbles inside.

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

10.5 Monitoring Riser Cabinet

10.5.1 Monitoring Riser Cabinet shall be the RRMS Interface riser cabinet from ref [15].

10.5.2 Monitoring Riser Cabinet shall be responsible to organize all RRMS electrical (power supply/sensors signals) and optical (FBG sensors signals) cabling.

10.5.3 Monitoring Riser Cabinet shall be responsible to concentrate the Riser Supports Monitoring System (RSMS) main processing equipment (as a SCADA Master Station) and power supply for Riser JBs RTUs and sensors from topside (Local panels) and subsea (BSDL-SI / TSUDL).

10.5.4 The main processing system shall have a three-layered architecture:

- The Data Collection System (DCS) shall be responsible for collecting data from all RSMS RTUs from riser balcony.
- The data server shall concentrate all functionalities related to data storage (SQL, OPC, etc), working as data repository.
- The Supervisory shall act as a supervisory system, serve data to external clients, process acquired data, issue alarms and log access data.

10.5.5 All components in item 10.4.2 shall run in a same physical server, running as independent virtual machines.

10.5.6 CONTRACTOR shall provide a physical server with the minimum requirement as follow:

- Processor: 2x Intel Xeon-G 5220 18-Core (2.20GHz 24.75MB L3 Cache) or superior;
- RAM memory: RAM: 32GB DDR4-2933 or superior;
- 2 hard disk drives (SSD) of at least 1TB each in RAID-1 mode;
- Support to RAID technology (Implemented by disk controller);
- Remote management by dedicated LAN card, able to:
  - Turn on/off equipment
  - Remote diagnosis;
  - KVM;

- Support SNMP and RSYSLOG;

- Redundant power supply;
- Power Supply, Hard Disks and fans hot-swap type;
- Windows Server Standard (one of the last two versions at least);
- Support to VMWare ESXi (the last two versions at least);

10.5.7 RSMS shall not be part of the FPU cause and effect matrix (i.e. shall not be used to trigger emergency shutdowns).

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

10.5.9 CONTRACTOR shall inform, during the commissioning, all administrator passwords needed to operate and manage all equipment.

10.6 SUPERVISORY AND DATA SERVER

10.6.1 A Supervisory and Data Server shall communicate with the RTU System and act as an interface to human operators and external systems of the monitoring system. The Supervisory and Data Server shall be based on Microsoft Windows.

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

10.6.3 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 the Local Panels, RTU and Cabinet housekeeping data.

10.6.4 CONTRACTOR shall design supervisory to receive data from all riser supports position in FPU

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

10.6.6 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.

10.6.7 The supervisory shall allow for the querying and plotting of historical data for user-selectable intervals. Users shall be able to export data sets to files compatible with Microsoft Excel 2003 or newer.

10.6.8 Two categories of password protected user accounts shall be implemented, common and privileged. Access to all functionalities of the supervisory shall be restricted exclusively to authenticated users belonging to one of these categories.

10.6.9 Configuration duties, including the management of the various monitoring units and also of the user accounts themselves, shall be restricted to privileged users. All view-only functionalities shall be available to all authenticated users.

10.6.10 The supervisory shall keep a log of all accesses, both local and remote, for a minimum of 12 months.

10.6.11 The supervisory system shall provide Web Interface (HTTP) access to all screens from within PETROBRAS corporate network. Authenticated users shall be given access to all functionalities just as they are available locally.

10.6.12 The Web Interface shall be fully compatible with the latest versions of the Internet Explorer, Mozilla Firefox and Google Chrome browsers, without the aid of any plugins.

10.6.13 At least 20 concurrent accesses to the supervisory shall be supported by the Web Interface.

10.6.14 The standard Microsoft Windows remote desktop solution shall also be provided to allow remote access to the system from onshore facilities.

10.6.15 The supervisory system shall generate, display and log alarms for monitored variables.

10.6.16 Each alarm shall be issued with a descriptive message that allows an operator to clearly identify the condition and its source (i.e. the structure, data tag and/or components involved).

10.6.17 The supervisory shall provide the infrastructure to manage and configure alarm limits and to enable/disable each alarm individually. An alarm shall remain active until it is explicitly acknowledged by an operator.

10.6.18 "Range"-type alarms shall be implemented with configurable LL/L/H/HH limits for the monitored variable value.

10.6.19 All alarms should include some form of hysteresis mechanism in order to avoid excessive alarm generation when the monitored value is near alarm thresholds.

10.6.20 Alarms shall also be issued for monitoring system failure conditions (housekeeping), including loss of communications to any component and detection of faulty sensors.

10.6.21 Alarms shall be classified in the following severity levels:

- **High:**
  - LL/HH (low-low/high-high) range alarms.
  - "Red" offset diagram alarms.
  - Loss or degradation of monitoring system functionality, or conditions which may imminently lead to that. Example: loss of communications with a component/sensor (timeout).
- **Medium:**
  - L/H (low/high) range alarms.
  - "Yellow" offset diagram alarms.
  - Conditions which do not cause degradation of monitoring system functionality but may lead to that if unchecked.
- **Low:**
  - Notifications of changes in system operating modes.
  - Any other implementer-defined conditions which do not present an immediate thread to integrity.

10.6.22 Detailed design of the alarm system shall be submitted for PETROBRAS approval prior to implementation.

10.6.23 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.
- OPC UA Alarms & Conditions (AC) for alarms.

10.6.24 Detailed design of the alarm system shall be submitted for PETROBRAS approval prior to implementation.

10.6.25 Real-time data shall be made available for external access through a standardized OPC UA Data Access interface.

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

10.6.27 Alarms shall be made available for external clients through an OPC UA Alarms & Conditions interface.

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

11 TESTS, INSTALLATION AND COMMISSIONING REQUIREMENTS

11.1.1 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.

11.1.2 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.

11.1.3 All equipment (TSUDLs, BSDLs, umbilical lines, JBs, Cabinet and local panels) shall be tested onshore before deployment at FPSO.

11.1.4 FPU CONTRACTOR shall perform Factory Acceptance Test (FAT) of the Hydraulic Actuator and Monitoring System with riser supports FAT itself. For this test, shall be used TSUDL and BSDL-SI dummy caps in order to simulate pull-in and pull-out operations. See bellow an example of setup for this test.

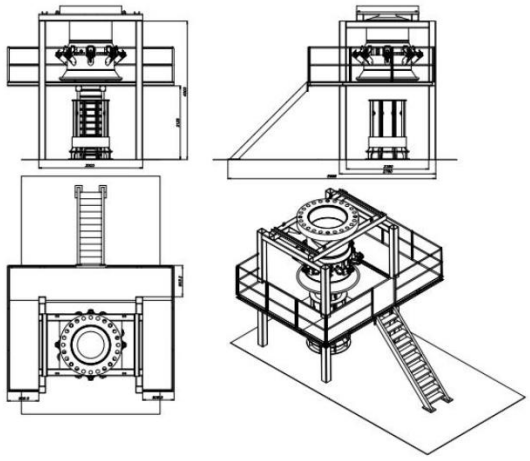

Figure 11 – Example of FAT set-up

11.1.5 The commissioning of hydraulic actuator and monitoring system in TSUDL/BSDL-SI shall be done in dry dock.

12 SYSTEM AVAIBILITY

12.1.1 The availability of CONTROL & MONITORING SYSTEM shall be guaranteed by adequate MTTF values.

12.1.2 The MTTF of the entire CONTROL & MONITORING SYSTEM shall also be informed, calculated for the operating conditions indicated in this technical specification. FPU CONTRACTOR shall clearly inform which methods used to calculate availability, as well as, the assumptions adopted.

13 CONDITIONING

13.1.1 FPU CONTRACTOR shall be responsible for the conditioning of MONITORING SYSTEM equipment from the beginning of manufacture until delivery to the PETROBRAS staff for which it is intended, including the period of transportation.

13.1.2 FPU CONTRACTOR shall submit for approval of PETROBRAS, the procedures for the implementation of the conditioning of CONTROL & MONITORING SYSTEM equipment, according even to the PETROBRAS standard N-858.

14 TRAINING

14.1.1 Training shall be provided to qualify personnel appointed by PETROBRAS to operate and maintain – subsea pull-in/out team (install, dismantle, replace parts and make adjustments) each system component.

14.1.2 Training shall be performed at PETROBRAS facilities in Rio de Janeiro, Brazil (on-shore) before FPU mooring offshore at final location. Training courses shall be given for two classes of 6 students (total of 12 students). The two classes shall be scheduled at least 1 month apart, to accommodate for PETROBRAS offshore labor regime. Training course shall be sized for 3 days as a minimum. Lessons shall be taught in Portuguese.

14.1.3 The training program shall cover basic system operation and maintenance aspects. A detailed training program shall be submitted for PETROBRAS approval.

14.1.4 The training program shall cover, at least, the following items:

- Complete description of equipment and system;
- Technical and operational characteristics;
- Operating principles;
- Operational cautions and warnings;
- Operational procedures and routines;

- Preventive maintenance routines;
- ROV/Divers operations (subsea equipment retrieval, operations and installation);
- Storage and conservation of equipment.

15 DOCUMENTATION REQUIREMENTS

15.1.1 Documentation shall be issued in compliance with agreed standards and formal processes.

15.1.2 The documentation shall include at least the following:

- Block diagram;
- Piping and Instrumentation Diagram (P&ID);
- General arrangement of BSDL-SI system with hydraulic actuator;
- General arrangement with routing of hydraulic circuit;
- General arrangement of local panels;
- Factory Acceptance Test Procedure/Reports;
- Factory Integration Test Procedure/Reports;
- Acceptance and Performance test (TAP) Procedure/Reports;
- Operational procedure for BSDL-SI in pull-in and pull-out operations;

15.1.3 During the executive design shall be issued to PETROBRAS approval a Technical Proposal of the Hydraulic Actuator and Monitoring System for TSUDL/BSDL-SI, including the following information:

- Datasheet of each component of the system;
- Detail of each material used in the system;
- Evidences of SUBCONTRACTOR experience (items 11.1.1 and 11.1.2);

16 SCOPE OF SUPPLY

16.1 Hydraulic Actuator and Monitoring System for BSDL

16.1.1 FPU CONTRACTOR shall provide all BSDLs with a Hydraulic Actuator and monitoring system.

16.2 Hydraulic Actuator and Monitoring System for TSUDL

16.2.1 FPU CONTRACTOR shall provide all TSUDLs with a Hydraulic Actuator and monitoring system.

16.3 Optical/Electrical wet mate connectors for RRMS

16.3.1 FPU CONTRACTOR shall provide all wet mate connectors for RRMS.

16.4 Lower Riser Balcony infrastructure

16.4.1 FPU CONTRACTOR shall provide all hydraulic tubings with all connections to

TSUDL/BSDL-SI hydraulic actuators and lower umbilical termination plates and fixing supports.

16.4.2 FPU CONTRACTOR shall provide all subsea electrical cabling with all connections to TSUDL/BSDL-SI monitoring system and lower umbilical termination plates and fixing supports.

16.4.3 FPU CONTRACTOR shall provide all subsea optical and electrical cabling with all connections to TSUDL and Receptacle for RRMS and lower umbilical termination plates and fixing supports.

16.4.4 FPU CONTRACTOR shall supply all lower umbilical termination plates and umbilical line mechanical fixations at lower balcony structure.

16.5 Topside Structure

16.5.1 FPU CONTRACTOR shall supply all upper umbilical termination plates and umbilical line mechanical fixations at upper balcony structure;

16.5.2 FPU CONTRACTOR shall provide all hydralic tubings with all connections to upper umbilical termination plates and local panel hydraulic circuits with all fixing supports;

16.5.3 FPU CONTRACTOR shall provide all optical and electrical cabling with all connections to upper umbilical termination plates, balcony JBs, local panels and Monitoring Riser Cabinet with all fixing supports and cable trays;

16.5.4 FPU CONTRACTOR shall provide local panels to manual operate TSUDL or BSDL-SI.

16.5.5 FPU CONTRACTOR shall provide moniting riser JBs.

16.5.6 FPU CONTRACTOR shall provide monitoring riser cabinet.

17 SCOPE OF WORK

17.1 Executive Design

17.1.1 FPU CONTRACTOR shall design and detail a Control and monitoring system for riser supports locking/unlocking mechanism.

17.1.2 FPU CONTRACTOR shall design and detail local panels, JBs and Cabinet.

17.1.3 FPU CONTRACTOR shall design and detail umbilical line system including accessories.

17.2 Factory acceptance tests

17.2.1 FPU CONTRACTOR shall perform factory tests to confirm acceptance for all TSUDL/BSDL with Control and monitoring system.

17.2.2 FPU CONTRACTOR shall perform factory tests to confirm acceptance for all umbilical lines and accessories.

17.2.3 FPU CONTRACTOR shall perform factory tests to confirm acceptance for all local panels, JBs and Cabinet.

17.3 Factory integration tests

17.3.1 FPU CONTRACTOR shall perform factory integration tests to confirm acceptance for all sets that are going to be installed at dry dock. In order to perform this test, is not mandatory using the umbilical lines.

17.4 Installation/Commissioning at dry dock

17.4.1 FPU CONTRACTOR shall install at dry dock all TSUDL/BSDLs with Control and monitoring system.

17.4.2 FPU CONTRACTOR shall install at dry dock all umbilical lines with installation accessories.

17.4.3 FPU CONTRACTOR shall install at dry dock all hydraulic tubings connecting all TSUDL/BSDLs with Hydraulic Actuator system to umbilical lines.

17.4.4 FPU CONTRACTOR shall install at dry dock all electrical cabling connecting all TSUDL/BSDLs with Monitoring system to umbilical lines.

17.4.5 FPU CONTRACTOR shall install at dry dock all optical and electrical cabling connecting all TSUDL/Receptacles for RRMS to umbilical lines.

17.4.6 FPU CONTRACTOR shall install at dry dock all local panels.

17.4.7 FPU CONTRACTOR shall install at dry dock all monitoring riser JBs.

17.4.8 FPU CONTRACTOR shall install at dry dock all optical and electrical cabling connecting Local Panels, JBs, umbilical lines and Cabinet.

17.4.9 FPU CONTRACTOR shall install at dry dock all hydraulic tubings connecting Local Panels, umbilical lines and Subsea HPU and electrical cables for activation of solenoid hydraulic header supply for Hydraulic Actuation system.

17.4.10 FPU CONTRACTOR shall fill and flush all hydraulic circuit with HPU 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) and ensure no air bubbles inside.

17.4.11 FPU CONTRACTOR shall perform commissioning of the complete system at dry dock.

17.4.12 Commissioning of umbilical lines for risers systems shall be witnessed by PETROBRAS representative.

17.4.13 Commissioning of umbilical lines for risers systems report shall be issued and shall contain at least:

- The following information for each BSDL-SI and each TSUDL: Pictures of each TSUDL/BSDL-SI tag number and umbilical hydraulic hoses identification on lower balcony and connected upper balcony connected hydraulic functions as shown below.

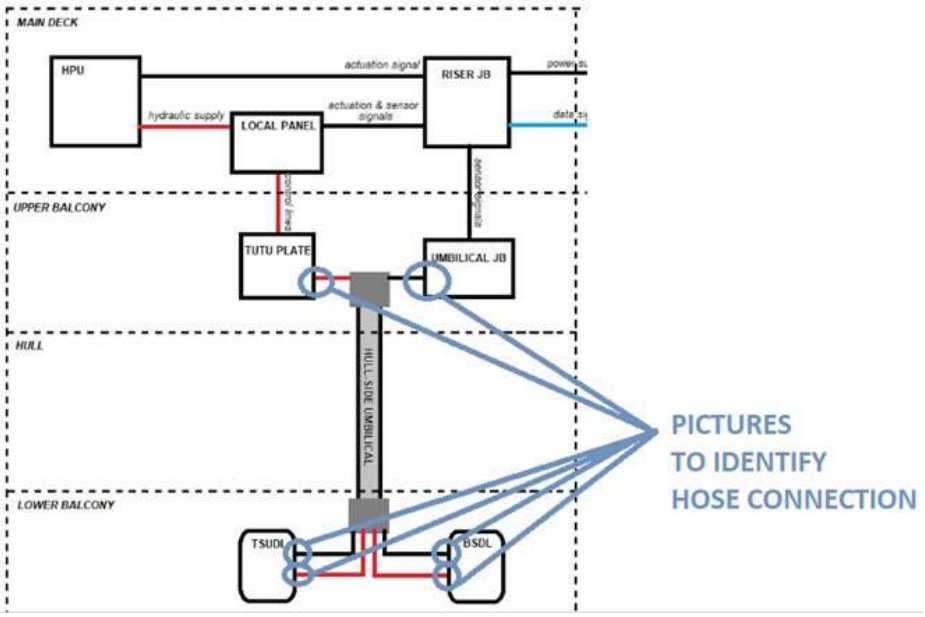

Figure 12 – Connections to be registered by photographs

- The torque evidence of each JIC connection using a torque tool.

17.4.14 Commissioning report of umbilical lines for riser systems shall provide enough information to assure that no failure in connection of TSUDL/BSDL on lower balcony and its corresponding Local Panel actuation line on topside has occurred.

Note: ***PAY SPECIAL ATTENTION IN ORDER TO PREVENT CONNECTING WRONG TO THE CORRESPONDING LOCAL PANEL AND BSDL/TSUDL UNIT SINCE IT RESULTS IN FUTURE ACCIDENTS OFFSHORE LIKE RISER OR BEND STIFFENER DROP***.

17.4.15 Commissioning tests for each control function:

- Each BSDL-SI shall be tested, at least, 5 times for each hydraulic function and 5 times for manual actuation;

- Each TSUDLI shall be tested, at least, 10 times for each hydraulic function and 10 times for manual actuation.

17.4.16 If during dry dock period, the installation items of topside structure (items 10.4.4 to 10.4.8) cannot be performed, FPU CONTRACTOR shall present to PETROBRAS an alternative plan to do the installation/commissioning by phases for formal approval.

18 SUBCONTRACTOR REQUIREMENTS

18.1.1 To design and supply the umbilical lines and accessories for the project of the Control and monitoring System for riser supports, FPU CONTRACTOR shall chose umbilical manufacturer with experience (track record) with PETROBRAS.

18.1.2 To design, supply, test and commission (subsea and topside scopes), FPU CONTRACTOR shall chose a MONITORING INTEGRATOR

(SUBCONTRACTOR) with experience (track record) in:

- Subsea systems;
- Hydraulic systems;
- Instrumentation systems.

18.1.3 During de executive design FPU CONTRACTOR shall submit to PETROBRAS approval a Technical Proposal of the Control and monitoring system for riser supports, including the evidences of attending items 15.1.1 and 11.1.2.