	TECHNICAL SPECIFICATION		N°	I-ET-3000.00-5529-850-PEK-005							
	CLIENT	PETROBRAS						SHEET	1	of	19
	JOB	RIGID RISER SYSTEMS									
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JOB	RIGID RISER SYSTEMS	SHEET 2 of 19
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1 SUBJECT

This document presents the Technical Specification of the FPU (floating production unit) scope of an integrity monitoring system applicable for rigid steel risers. This Technical Specification is applicable only for spread mooring FPU.

1.1 RISER SYSTEMS

This informative section presents an overview of the riser configurations covered by this monitoring system specification.

1.1.1 Steel Lazy Wave Riser (SLWR)

A Steel Lazy Wave Riser (SLWR) consists of a steel riser with an intermediary section lifted by buoyancy modules. An illustration is presented in Figure 1.

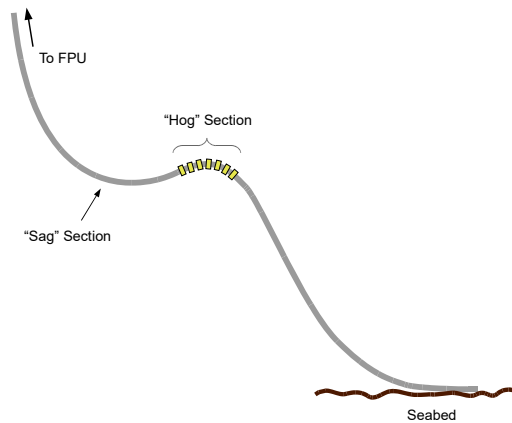


Figure 1 — SLWR illustration

1.1.2 Steel Catenary Riser (SCR)

A Steel Catenary Riser (SCR) is a steel riser that hangs from the FPU in a free single-catenary configuration. This concept is illustrated in Figure 2.

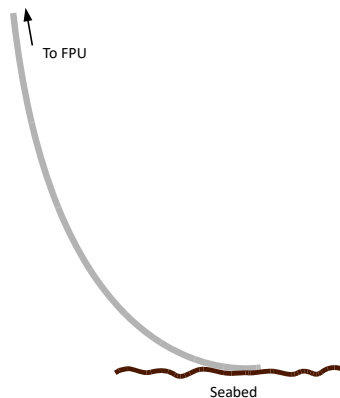


Figure 2 — SCR illustration

2 ABBREVIATION

AHRS	Attitude and Heading Reference System
FO	Fiber Optic
FPSO	Floating Production, Storage and Offloading
FPU	Floating Production Unit
GPS	Global Positioning System
IMU	Inertial Measurement Unit
IP	Ingress Protection
JB	Junction Box
PSU	Power Supply Unit
RDCS	Riser Data Collection System
RRMS	Rigid Riser Monitoring System
RSMS	Riser Support Monitoring System
SCR	Steel Catenary Riser
SESDV	Subsea Emergency Shut Down Valve
SLWR	Steel Lazy Wave Riser
TSP	Twisted Shielded Pair
UPS	Uninterruptible Power Supply

3 REFERENCE DOCUMENTS, CODES AND STANDARDS

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

3.1 INTERNATIONAL STANDARDS

- [1] API 17F - Standard for Subsea Production Control Systems
- [2] API 17Q - Recommended Practice on Subsea Equipment Qualification
- [3] API 17H – Remotely Operated Tools and Interfaces on Subsea Production Systems
- [4] ASME B16.5:2013 - Pipe Flanges and Flanged Fittings
- [5] ASTM A320:2015 - Standard Specification for Alloy-Steel and Stainless Steel Bolting for Low-Temperature Service
- [6] DNVGL-RP-B401:2017 - Cathodic Protection Design
- [7] IEC 60079 (latest revision) - Series Explosive Atmosphere Standards
- [8] IEC 60092 (latest revision) - Electrical installations in ships - ALL PARTS
- [9] IEC 60502-1 (latest revision) - Power cables with extruded insulation and their accessories for rated voltages from 1 kV ($U_m = 1,2$ kV) up to 30 kV ($U_m = 36$ kV) – Part 1: Cables for rated voltages of 1 kV ($U_m = 1,2$ kV) and 3 kV ($U_m = 3,6$ kV);
- [10] IEC 60529 (latest revision) - Degrees of Protection Provided by Enclosures (IP Code)
- [11] IEC 61892-6 - Mobile and fixed offshore units – Electrical installations – Part 6: Installation
- [12] ISO 13628-6:2006 - Design and Operation of Subsea Production Systems – Subsea Production Systems
- [13] NMEA 0183 V 4.10 - Standard for Interfacing Marine Electronics Devices

3.2 PETROBRAS DOCUMENTS

- [14] I-ET-3010.00-1300-850-PEK-002 - HULLSIDE UMBILICAL FOR RISER SYSTEMS
- [15] I-ET-3010.00-1300-850-PEK-001 - CONTROL AND MONITORING SYSTEM FOR RISER SUPPORTS
- [16] I-DE-3000.00-5520-850-PEK-001 - BLOCK DIAGRAM – SUBSEA MONITORING SYSTEMS
- [17] I-ET-3000.00-1500-823-PEK-001 Qualification of Wet-Mate Electrical Connectors and Accessories

4 DEFINITIONS

RISER CONTRACTOR	The company contracted by PETROBRAS to design, supply and install the risers, including the monitoring system (focus of this technical specification)
FPU CONTRACTOR	The company contracted by PETROBRAS to construct the Floating Production Unit
DIVING TEAM	The party responsible for execution of diving-related tasks related to RRMS System.
MAY	Is used when alternatives are equally acceptable
SHOULD	Is used when a provision is not mandatory, but is recommended as a good practice
SHALL	Is used when a provision is mandatory
WET-MATE [CONNECTOR]	Connector designed for plugging/mating in underwater environments
COVERAGE INTERVAL	Interval containing the set of true values of a measured quantity with a stated probability, based on the information available
COVERAGE PROBABILITY	Probability that the set of true values of a measured quantity is contained within a specified COVERAGE INTERVAL
SUBSEA INTERFACE CABINET	Cabinet of FPU CONTRACTOR scope, that will support some subsea monitoring systems: RSMS, RRMS and SESDV Monitoring System.

5 TECHNICAL CHARACTERISTICS

5.1 DESIGN AND FABRICATION

- 5.1.1 All subsea equipment shall be designed in accordance with API 17F and API 17H.
- 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).
- 5.1.5 Electrical and communication analyses shall be performed, including simulations

considering the parameters of specified cable types (for deck, hull and subsea cables).

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 For electrical wet-mate connector, Ref. [17] shall be observed.

6 TECHNICAL REQUIREMENTS

6.1 SYSTEM OVERVIEW

6.1.1 Figure 1 presents a general diagram of the riser monitoring system.

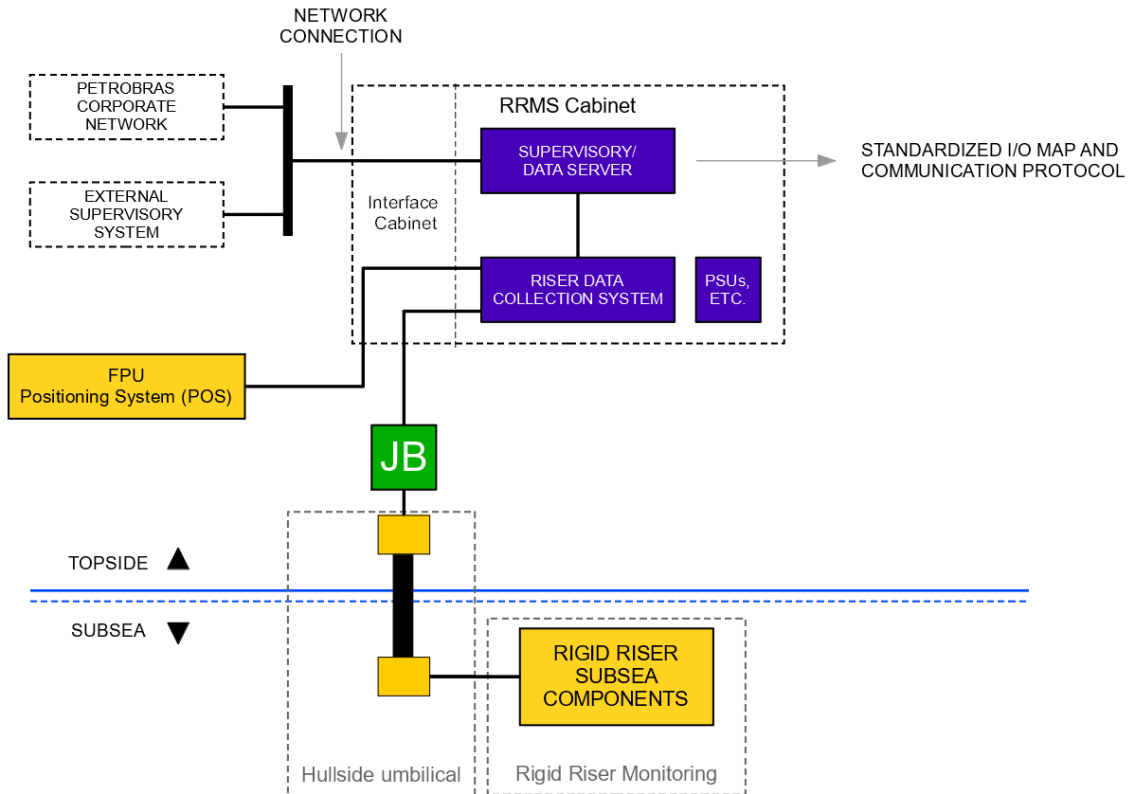


Figure 1 — General system diagram

6.1.2 The system is composed of a topside processing system which communicates with sensors and equipment installed on subsea riser structures and FPU Positioning System (POS).

6.2 GENERAL REQUIREMENTS

6.2.1 This section describes FPU provisions which are specific for monitored rigid risers



(RRMS). In case PETROBRAS requests that provisions be made for future rigid risers at given locations, the scope presented in this section shall be executed accordingly.

- 6.2.2** Cabling shall be designed in accordance with international standards. In no occasion shall the design or installation of any item described herein infringe norms or standards in force at the FPU.
- 6.2.3** Connectors/terminations shall be properly protected from exposure before final assembly to junction boxes and other equipment.
- 6.2.4** All junction boxes/cabinets shall be properly identified with visible tags.
- 6.2.5** All cabling (at dry area) shall be properly identified with visible tags.
- 6.2.6** Individual conductors within a bundle (multi-cable) shall be properly identified on both ends, through tags or color coding.
- 6.2.7** Cabling shall conform to the IEC 60502-1 standard.
- 6.2.8** The Figure 2 presents the general topology of the system.

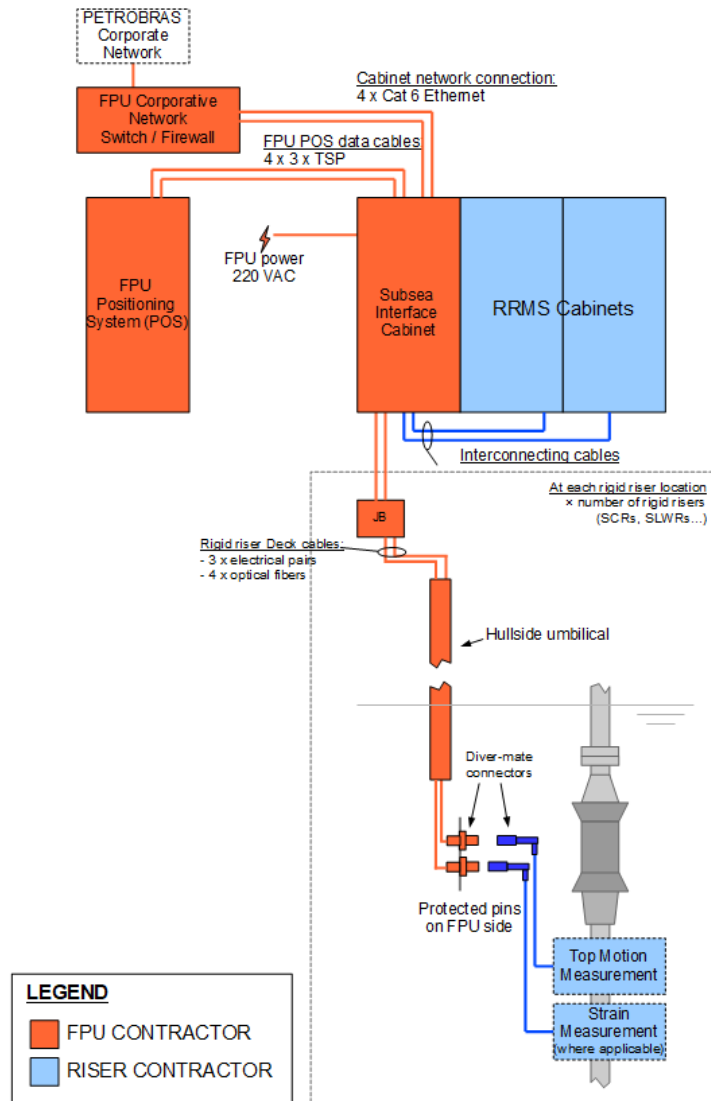


Figure 2 — General topology – RRMS System

6.3 RRMS CABINETS

- 6.3.1** FPU CONTRACTOR shall supply and install one cabinet (named as **SUBSEA Interface Cabinet**) in Electrical Module, where shall be terminated all cabling from Risers (Deck Cables), FPU Positioning system and PETROBRAS Corporate Network;
- 6.3.2** The **SUBSEA Interface Cabinet** shall have the minimum dimension of **800mm x 1000mm x 2000mm**. All cables shall be terminated in properly terminals (see Table 1), in order to provide interface to RRMS cabinets that will be installed and commissioned by RISER CONTRACTOR.
- 6.3.3** FPU CONTRACTOR shall provide power supply to RRMS system from FPU normal bus. FPU CONTRACTOR shall install two local UPS in **SUBSEA Interface Cabinet** in order to power supply each RRMS Cabinet. FPU CONTRACTOR shall consider consumption of 3000W and voltage of 220VAC 50/60Hz for each RRMS cabinet. The UPS shall feed each RRMS cabinet during 30 minutes at least, in case of

feeding fail.

- 6.3.4** In case of solution proposed in item 6.3.3 is not possible, FPU CONTRACTOR shall present alternative solution for PETROBRAS approval.
- 6.3.5** FPU CONTRACTOR shall provide inside SUBSEA Interface Cabinet two surge protectors connected to FPU grounding system for each future RRMS Cabinets.
- 6.3.6** The supply of RRMS Cabinets and its internal equipment is scope of RISER CONTRACTOR. However, FPU CONTRACTOR shall provide the infrastructure to install onshore or offshore this equipment as described in this section. FPU CONTRACTOR shall provide a proper lifting/handling system and access of RRMS Cabinets at Electrical Module.
- 6.3.7** FPU CONTRACTOR shall provide space and foundation to install two cabinets (RRMS Cabinets from Field phases I & II) in Electrical Module with the following dimensions 800mm X 1000mm X 2000mm. General arrangement of these cabinets can be requested to PETROBRAS during the engineering design. The space designated to these cabinets shall be sided by SUBSEA Interface Cabinet.
- 6.3.8** FPU CONTRACTOR shall provide bottom cable access between SUBSEA Interface Cabinet and RRMS Cabinets. RISER CONTRACTOR shall supply/install this cabling.
- 6.3.9** FPU CONTRACTOR shall provide assistance to all activities to be performed by the RISER CONTRACTOR aboard the FPU, including crane operation, transportation of loads (cabinets, etc.), heavy mechanical installations (such as cabinets, etc.) and issuance of work permits when needed.
- 6.3.10** SUBSEA Interface Cabinet shall be connected to FPU Positioning System (POS) and PETROBRAS corporative network as detailed in table 1.

Cable Specification	No. of Runs	From/To	Termination	Intended Function
Shielded CAT-6 Ethernet cable	4	SUBSEA Interface Cabinet to FPU PETROBRAS network switch	Standard RJ-45 female patch panel inside SUBSEA Interface Cabinet.	PETROBRAS corporative network
Signal – 4 TSPs 1.5 mm ²	4	SUBSEA Interface Cabinet to FPU Positioning System	SAK Terminals inside SUBSEA Interface Cabinet	FPU Positioning System (POS)

Table 1 — Common topside cabling interfaces

- 6.3.11** FPU CONTRACTOR shall provide GPS & AHRS data from Positioning System (POS) in full & half-duplex RS-485 standards at the Interface Riser Cabinet. If necessary, FPU CONTRACTOR shall supply and install protocol data converters with PSUs at the Interface Riser Cabinet.
- 6.3.12** FPU CONTRACTOR shall provide GPS & AHRS data from Positioning System (POS). The POS system shall broadcast FPU position to the Interface Riser Cabinet

by means of three (3) data connection loops (supplied in two sets, one for each future RRMS Cabinet):

- a) **GPS NMEA 0183 link:** GGA, GSA, GSV and ZDA.
- b) **AHRS TSS1 link:** FPU attitude in TSS1 protocol.
- c) **AHRS NMEA 0183 link:** HDT message.

6.3.13 The SUBSEA Interface Cabinet shall be shared between RRMS, RSMS and SESDV Monitoring system, if these systems are in FPSO scope.

6.3.14 The interface between RRMS and other subsea systems is illustrated at Ref. [16].

6.4 RISER DECK CABLING

6.4.1 Riser deck cabling means the electrical cables between the SUBSEA Interface Cabinet and Monitoring Riser junction boxes (or Monitoring Riser JB).

6.4.2 FPU CONTRACTOR shall provide Monitoring Riser Junction boxes in order to make the transition between Hullside Umbilical cabling and Deck cabling. One JB can be used to connect one or more risers. Monitoring Riser junction boxes shall be installed in the FPU main deck and FPU CONTRACTOR design shall evaluate if may require an intermediate JB close to the upper balcony.

6.4.3 Monitoring Riser Junction Boxes 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.

6.4.4 Monitoring Riser Junction Boxes shall be sealed against dust and powerful water jets (protection degree IP-66).

6.4.5 Monitoring Riser Junction Boxes and cable glands specification/installation shall be in accordance with its corresponding area classification.

6.4.6 For each monitored rigid riser, the following minimum cabling interfaces shall be available between SUBSEA Interface Cabinet and Monitoring Riser Junction Box.

Cable Specification	No. of Runs	From/To	Termination	Intended Function
Power – 3 TSP 2,5 mm ² 0.6/1 kV rating	1	SUBSEA Interface Cabinet to Monitoring Riser JB	Connected to corresponding hullside umbilical cable	Power and communication to monitoring equipment
4 single mode Optical fibers	1	SUBSEA Interface Cabinet to Monitoring Riser JB	Connected to corresponding hullside umbilical cable	Communications to rigid riser monitoring equipment

Table 2 — Topside cabling interfaces for rigid risers

6.4.7 Each deck cable meant for a rigid riser shall be connected, in a conductor-by-

conductor basis, to the corresponding hullside umbilical cable at a convenient junction box, as shown in Figure 3.

- 6.4.8 More cables connecting Riser JB and SUBSEA Interface Cabinet shall be provided to attend Control and Monitoring System for Riser Supports. This cabling requirements is detailed in Ref [15].
- 6.4.9 All corresponding shields belonging to each cable (deck vs. subsea) shall also be interconnected at the junction point.

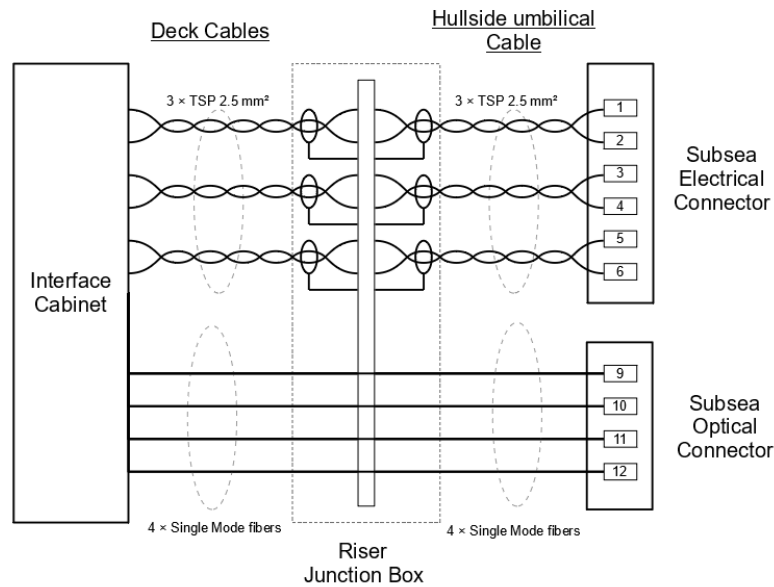


Figure 3 — Connection diagram for rigid riser cabling

6.5 FPU HULLSIDE UMBILICAL CABLING AND CONNECTORS

- 6.5.1 Hullside Umbilical Cabling means the cables between Monitoring Riser Junction Boxes and Diver Mate connectors supplied and installed by FPU CONTRACTOR in Lower Riser Balcony. This cabling is part of hullside umbilical provided to attend risers support automation.
- 6.5.2 The Hullside umbilical is detailed in Ref [14].
- 6.5.3 Wet mate connectors shall be provided on the FPU hull for connecting monitoring units attached to each rigid riser. The connection scheme is illustrated in Figure 4.

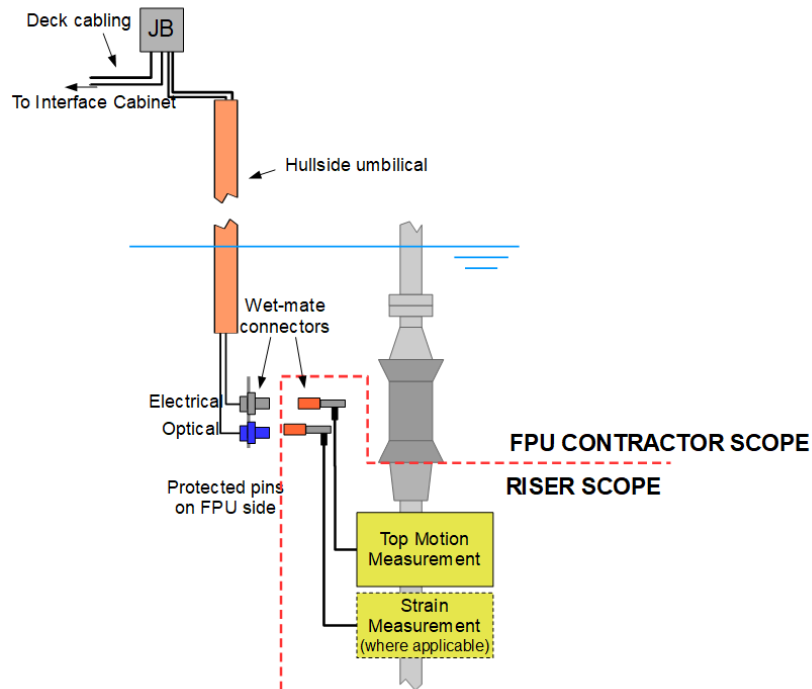


Figure 4 — Rigid riser connection scheme

- 6.5.4** FPU CONTRACTOR shall provide a panel to place wet mate connectors. This panel shall have easy access to divers. This panel shall foresee a structure to tie connector and cables from Riser (RISER CONTRACTOR scope).
- 6.5.5** The arrangement of lower riser balcony, considering position of Umbilical Lower Terminations, Risers Supports and Connectors Panel (item 6.5.4), shall be submitted for Petrobras approval.
- 6.5.6** FPU CONTRACTOR shall provide jumpers (electrical and optical) to connect lower umbilical termination to wet-mate connectors' panel. The cables of these jumpers shall follow the same specification of hullside umbilical cabling and deck cabling.
- 6.5.7** FPU CONTRACTOR shall supply proper fixation clamps solution for RRMS optical-electrical jumpers at lower balcony bottom structure in order to guarantee cabling integrity for the project's life. These clamps shall be designed in order to allow any possible future diver maintenance during project's life.
- 6.5.8** The riser side of electrical jumper cable shall be terminated in a wet-mate connector to connect the IMU with the following requirements:
- Diver-mate solution;
 - be 7 (seven) ways electrical pins;
 - Be housing made with stainless steel material (AISI 316L);
 - Be suitable for operation in the foreseen environment;
 - Have a dual barrier solution to protect the electrical connections/pins;

- f) Be able to withstand at least 100 connection/disconnection cycles;
- g) Be qualified according to API-17F (shall present evidences);
- h) Have a design life of at least 25 years.

6.5.9 The riser side of optical jumper cable shall be terminated on the lower side, the optical cable shall be terminated in a wet-mate connector to interface with FBG sensors sets following the requirements:

- a) Diver-mate solution (it shall be defined during detailed phase).
- b) be 4 (four) or more-ways optical fiber cores, with fibers end face Angled Physical Contact (APC);
- c) Be housing made with stainless steel material (AISI 316L);
- d) be suitable for operation in the foreseen environment;
- e) Have a dual barrier solution to protect the optical connections;
- f) be able to withstand at least 100 mates/demates cycles;
- g) have a design life of at least 25 years;
- h) be qualified according to API-17F (shall present evidences).

6.5.10 Each connector shall be fitted with a dummy connector for protection from the subsea environment until its corresponding jumper is connected.

6.5.11 For cable integrity testing purposes, at electrical connector, the dummy shall internally connect each pair of pins with a resistor as specified in Table 3.

Connector Pin Number	Hull Cable Assignment	Dummy Resistance Value
1	Signal cable TSP 1	15 kΩ
2		
3	Signal cable TSP 2	22 kΩ
4		
5	Signal cable TSP 3	33 kΩ
6		


Table 3 — Hull connector pin assignment for rigid riser slots

6.5.12 For cable integrity testing purposes, at optical connector, the dummy shall internally connect each pair of pins with an optical loop (1-2 & 3-4).

6.5.13 The body of each subsea connector shall be electrically connected to the FPU cathodic protection system.

6.5.14 Each Hull-subsea connector shall be fastened to an appropriate supporting plate welded/bolted to the FPU hull.

6.5.15 FPU CONTRACTOR shall design this lower balcony infrastructure for proper diving and ROV accessibility for installation offshore.

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<p>6.5.16 Connections between subsea connector pins and hull cable conductors, for all connector types, shall be as specified in Table 3.</p> <p>6.5.17 On the topside, each hull-side subsea cable shall be connected to the corresponding deck cables.</p>			
<p>7 SCOPE OF SUPPLY</p>			
<p>7.1.1 Supply, install and interconnect SUBSEA Interface Cabinet as described in § 6.3.1, § 6.3.2, § 6.3.3 and § 6.3.4.</p> <p>7.1.2 Provide space and facilities (infrastructure) for the RRMS Cabinets, considering the requirements described in § 6.3.5, § 6.3.6, § 6.3.7 and § 6.3.8.</p> <p>7.1.3 Provide transmission of FPU positioning system data to the riser monitoring system as specified in item § 6.3.11 and § 6.3.12, including cable connections to the FPU POS cabinet (Item 6.3.10).</p> <p>7.1.4 Provide a network connection to the RRMS Cabinet, considering the requirements in § 6.3.10.</p> <p>7.1.5 Provide assistance to all activities to be performed by the RISER CONTRACTOR aboard the FPU, including crane operation, transportation of loads (cabinets, junction boxes, etc.), heavy mechanical installations (such as of junction boxes, cabinets, etc.) and issuance of work permits when needed.</p> <p>7.1.6 Supply and run all deck cabling, including termination, required in accordance with the requirements presented in § 6.4.</p> <p>7.1.7 Design, Supply and install Monitoring Riser Junction Boxes, providing connections between deck cables and hull/subsea cables for rigid risers including any interface required accessory (i.e., intermediate JB), as described in § 6.4.</p> <p>7.1.8 Supply hullside umbilical cabling considering specification in Ref [14] and § 6.4.</p> <p>7.1.9 Provide documentation with all information needed for the design of the monitoring system, including but not limited to: cabling information, wiring diagrams, area classification, mechanical, electrical interfaces and diving accessibility report.</p>			
<p>8 INSTALLATION AND COMMISSIONING REQUIREMENTS</p>			
<p>8.1.1 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.</p> <p>8.1.2 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.</p>			

- 8.1.3** All equipment shall be tested onshore before deployment at sea. Testing and interventions on equipment shall not be planned or performed during offshore deployment (on deck), save for emergency occasions, in which case approval shall be explicitly given by PETROBRAS.
- 8.1.4** The fully commissioning of RRMS system is in RISER CONTRACTOR scope, however, FPU CONTRACTOR, shall commission all infrastructure in its scope.
- 8.1.5** In terms of Acceptance Test, the FPU CONTRACTOR shall evidence, at least:
- Cabling and power supply in **SUBSEA Interface Cabinet**;
 - Certification of all network cables related to RRMS System;
 - Checking the receiving data from Positioning System;
 - Fully testing of each riser cable (end-to-end, from RRMS cabinet to Dummy conector), using the loop in Dummy connector to verify the resistance of each pair;
 - UPS discharge test.
- 8.1.6** FPU CONTRACTOR shall provide all infrastructure for RISER CONTRACTOR, in order to allow it to complete the fully commissioning of RRMS system, including access to installation, power supply and information related the system.

9 DOCUMENTATION REQUIREMENTS

- 9.1.1** Documentation shall be issued in compliance with agreed standards and formal processes.
- 9.1.2** The RRMS documentation shall include at least the following:
- One Line diagram;
 - Interconnection Diagram;
 - General arrangement of cabinet installation;
 - General arrangement of all external installation, including cable routing and mechanical details (including umbical lines and accessories);
 - Typical detail of installation at each riser showing at least junction box, conduits, cable tray (if applicable) connector, and fixation;
 - Wet mate connectors, panel and dummies datasheet and drawings;
 - Diving accessibly report.
- 9.1.3** During de executive design shall be issued to PETROBRAS approval a Technical Proposal of the FPU CONTRACTOR scope, including Datasheets, manuals and certificates for all equipment or cable supplied by FPU CONTRACTOR.

10 SCOPE OF SUPPLY & WORK

10.1 GENERAL TOPOLOGY

10.1.1 The General Topology in Figure 5 summarizes the supply scope division between FPU CONTRACTOR and RISER CONTRACTOR.

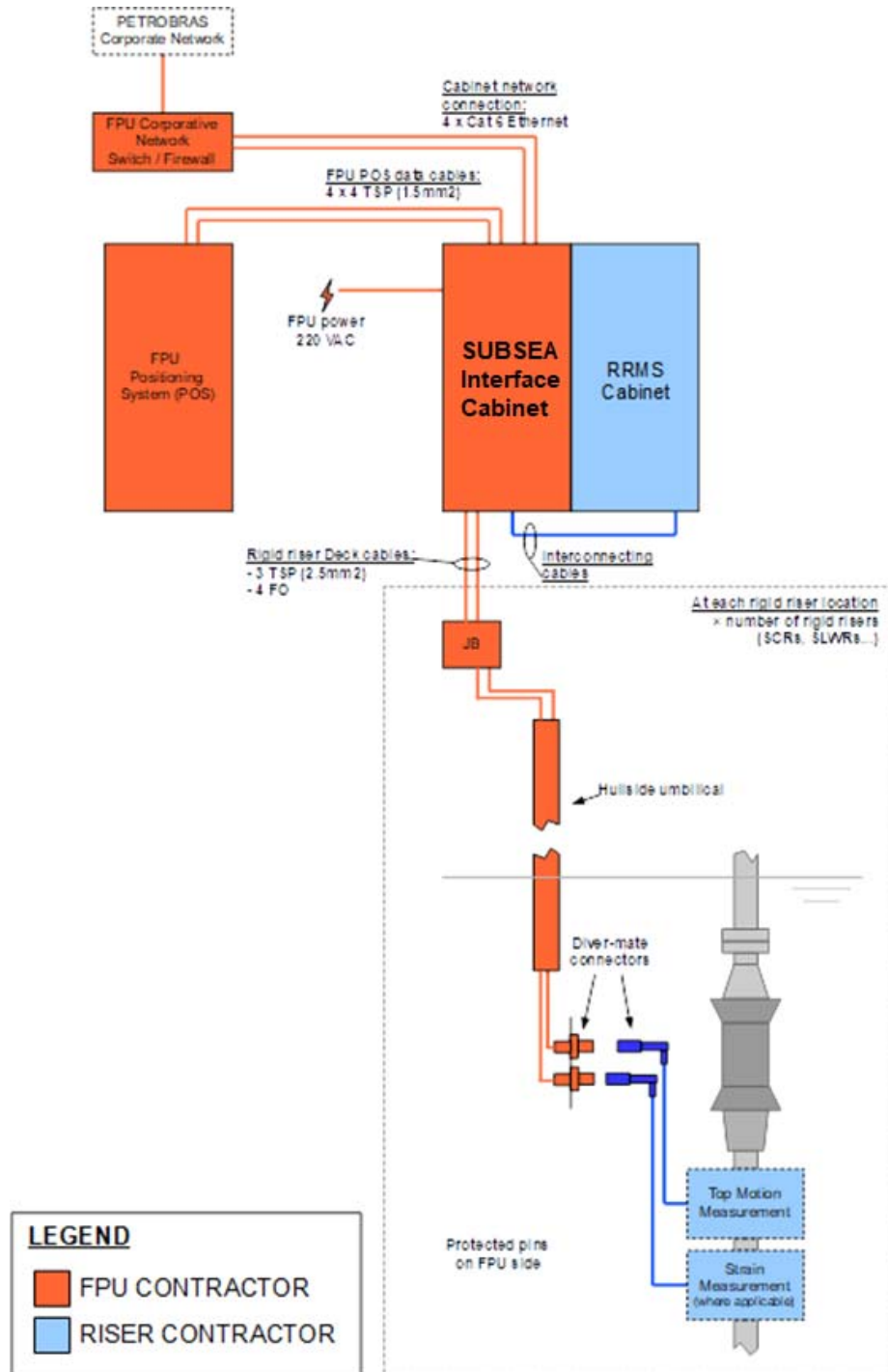


Figure 5 — Scope of supply – RRMS System

10.1.2 The General Topology in Figure 6 summarizes the installation scope division between FPU CONTRACTOR, RISER CONTRACTOR and DIVING TEAM.

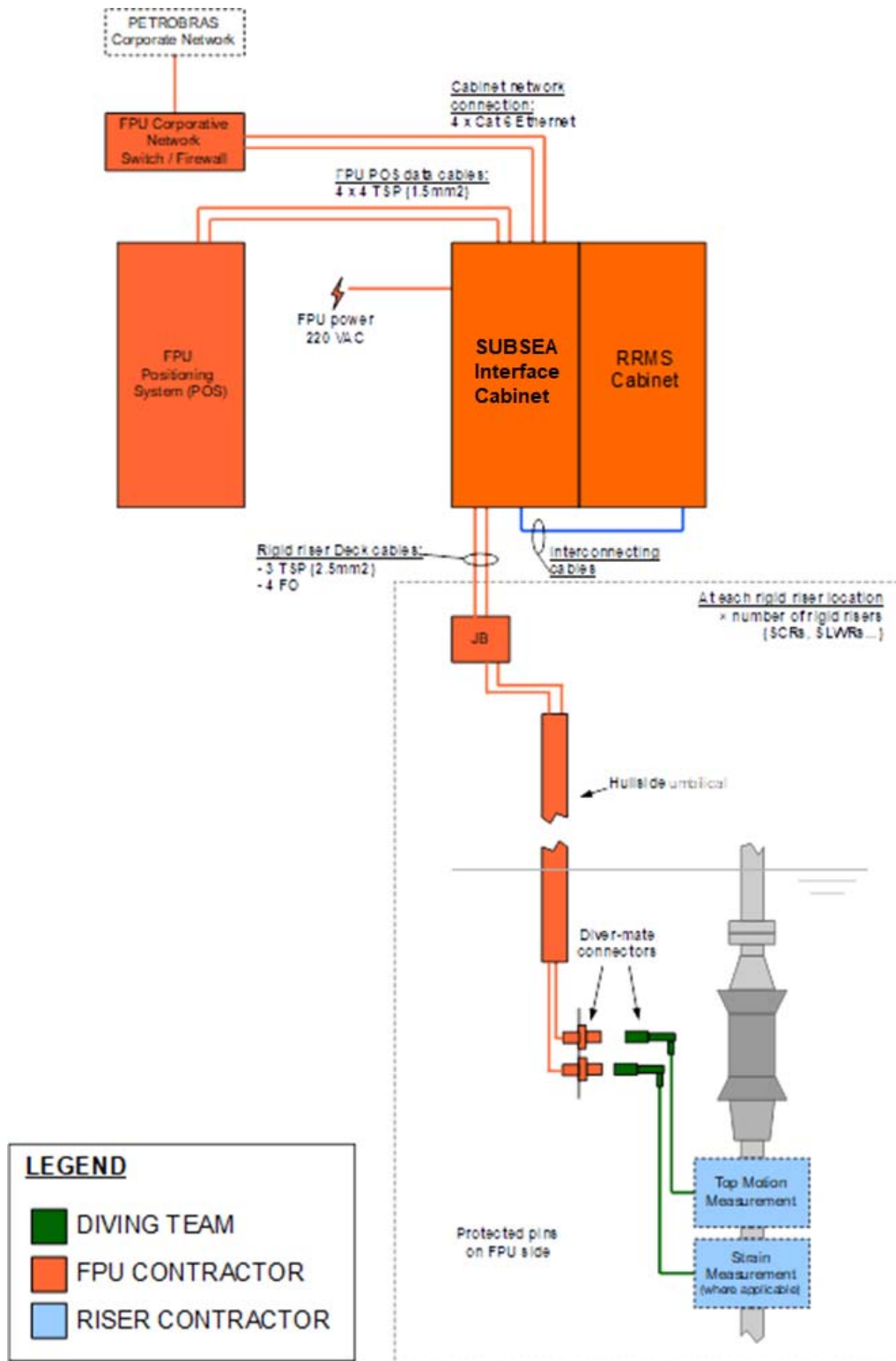


Figure 6 — Scope of installation – RRMS System

10.2 RISER CONTRACTOR

- 10.2.1 Design, supply and install (electrically) the topside processing system (RRMS Cabinet).
- 10.2.2 Execute topside installation and commissioning of complete RRMS
- 10.2.3 For each rigid riser: execute design, supply and installation scope of all subsea components and associated accessories (clamps, blister etc) onto rigid risers.
- 10.2.4 Design, supply the Subsea Cabling.
- 10.2.5 Define, supply and install any necessary interconnecting cabling between the SUBSEA Interface Cabinet and the RRMS Cabinet Topside system.
- 10.2.6 Provide assistance, with an offshore technician (with total know how of the diving activities), for diver operations for installation of monitoring units onto rigid risers.

10.3 FPU CONTRACTOR

- 10.3.1 Provide continuous transmission of FPU positioning system data to the riser monitoring system, including cable connections to the FPU POS cabinet.
- 10.3.2 Provide space and facilities (infrastructure) for the RRMS Cabinet and install (mechanically) the topside processing system (RRMS Cabinet) at space.
- 10.3.3 Provide a network connection to the RRMS Cabinet. This shall include configuration of firewalls and allocation of network addresses.
- 10.3.4 Design, supply and install FPU provisions for each rigid riser.
- 10.3.5 Supply and install deck cabling, including terminations.
- 10.3.6 Provide connections between deck cables and hull/subsea cables for rigid risers.
- 10.3.7 Provide assistance to all activities to be performed by the RISER CONTRACTOR aboard the FPU, including crane operation and transportation of loads (cabinets, junction boxes, etc.) and issuance of work permits when needed.
- 10.3.8 Provide documentation from the FPU side with all information needed for the design of the monitoring system, including but not limited to: cabling information, wiring diagrams, area classification, mechanical and electrical interfaces.

10.4 DIVING TEAM

- 10.4.1 DIVING TEAM shall execute diving operations to install monitoring components (i.e. IMUs, clamps and interconnecting subsea cabling, supplied by the RISER CONTRACTOR), if needed, onto rigid risers supported directly by the FPU.
- 10.4.2 DIVING TEAM shall be responsible to supply handling installation infrastructure to execute diving operations, i.e. shackles, slings, master links etc. **Note:** RISER



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CONTRACTOR shall be responsible to supply any specific subsea installation accessories, i.e. buoyancy modules, specific clamp installation tools etc.

10.4.3 RISER CONTRACTOR shall execute the diving guidelines procedures and risk assessments that shall be approved in accordance with PETROBRAS and DIVING TEAM shall execute the final executive procedures.