

16  PETROBRAS	TECHNICAL SPECIFICATION				I-ET-3010.00-5529-854-PX9-002					
	CLIENT	PETROBRAS					SHEET	1	of	23
	JOB	RIGID RISER SYSTEMS								
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1 SUBJECT

This document presents the Technical Specification of the FPU 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.

- **Steel Lazy Wave Riser (SLWR):** A Steel Lazy Wave Riser consists of a steel riser with an intermediary section lifted by buoyancy modules as illustrated on Figure 1a.
- **Steel Catenary Riser (SCR):** A Steel Catenary Riser is a steel riser that hangs from the FPU in a free single-catenary configuration as illustrated on Figure 1b.

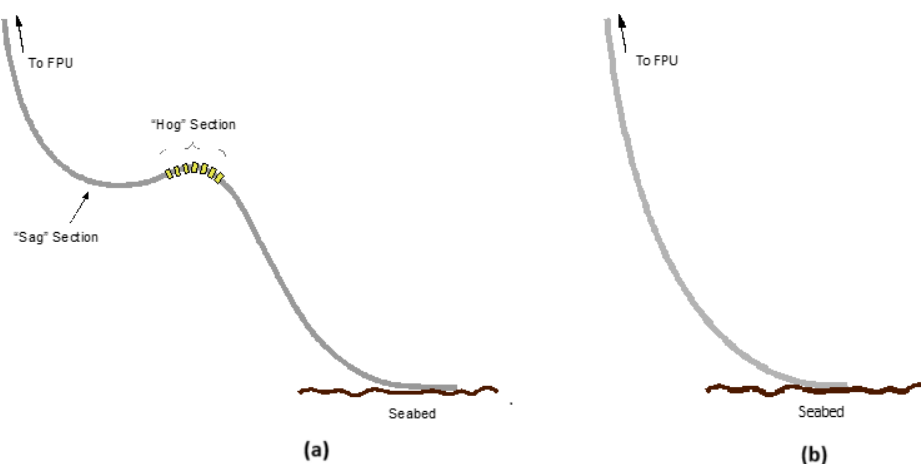


Figure 1: SLWR (a) and SCR (b) illustration.

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
SLWR	Steel Lazy Wave Riser
TSP	Twisted Shielded Pair
UPS	Uninterruptible Power Supply

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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 (Um = 1,2 kV) up to 30 kV (Um = 36 kV) – Part 1: Cables for rated voltages of 1 kV (Um = 1,2 kV) and 3 kV (Um = 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] IEC 60992 Electrical installations in ships
- [13] ISO 13628-6:2006 - Design and Operation of Subsea Production Systems – Subsea Production Systems
- [14] ITU-T G.652 Characteristics of a single-mode optical fibre and cable.
- [15] ITU-T G.654 Characteristics of a cut-off shifted single-mode optical fibre and cable
- [16] NMEA 0183 V 4.10 - Standard for Interfacing Marine Electronics Devices
- [17] SEAFOM TSD-02 - Functional Design and Test Specification for Subsea Electrical and Optical Connectors and Jumpers

3.2 BRAZILIAN STANDARDS

- [18] NR 10 – Segurança em Instalações e Serviços em Eletricidade

3.3 PETROBRAS DOCUMENTS

- [19] I-ET-3010.00-1300-279-PX9-001 – Unified Diverless Support Tube (TSUDL) – General Requirements

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4 DEFINITIONS

RISER CONTRACTOR	The company that is responsible to design, supply and install the risers, including the monitoring system (focus of this technical specification)
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
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
DUMMY CAP	Specific connectors used for long term protection. Will be used for protecting the wet mate connectors from FPU side while riser scope is not delivered

5 TECHNICAL CHARACTERISTICS

5.1 DESIGN AND FABRICATION

5.1.1 All subsea equipment shall be designed in accordance with [1] and [3].

5.1.2 Selection of materials for all subsea structures shall be in accordance with [6] 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 [7].

5.1.4 All enclosures with a required degree of ingress protection shall comply with [10].

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 [1], [2] or [13].

6 TECHNICAL REQUIREMENTS

6.1 SYSTEM OVERVIEW

6.1.1 Figure 2 presents a general diagram of the riser monitoring system.

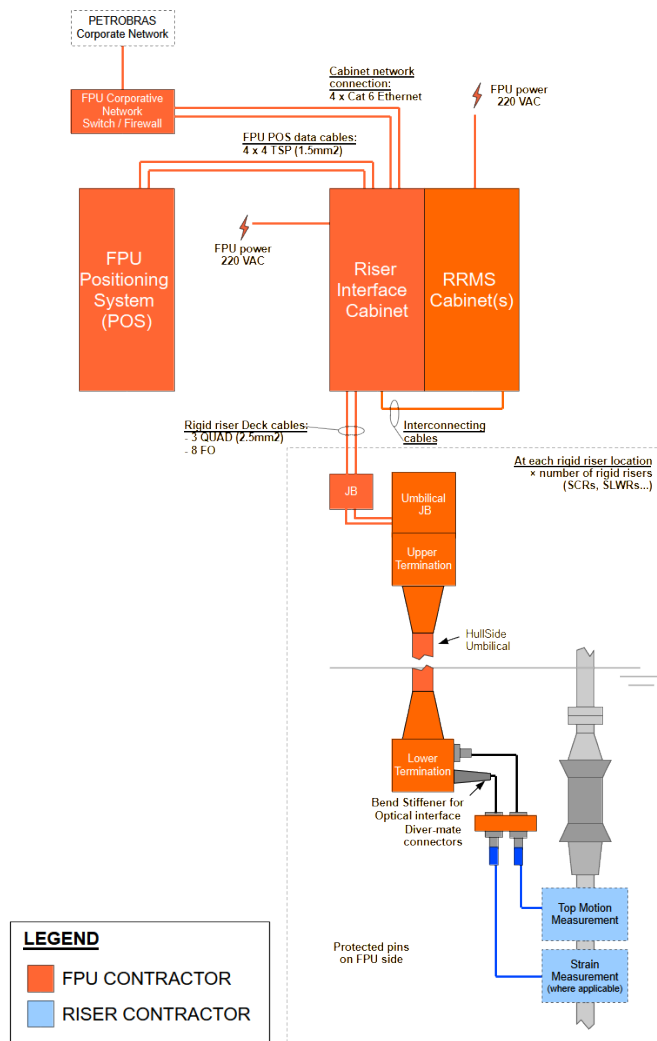


Figure 2: General system diagram.

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 All electrical cables shall follow [12] and be water blocked and Flame retardant (100% LSZH).

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6.2.4 All optical cables shall be single mode fibers [14] e [15] and water blocked and Flame retardant (100% LSZH).

6.2.5 Connectors/terminations shall be properly protected from exposure before final assembly to junction boxes and other equipment.

6.2.6 All junction boxes/cabinets shall be properly identified with visible tags.

6.2.7 All cabling (at dry area) shall be properly identified with visible tags.

6.2.8 Individual conductors within a bundle (multi-cable) shall be properly identified on both ends, through tags or color coding.

6.2.9 Cabling shall conform to the [9].

6.3 RISER INTERFACE CABINET

6.3.1 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.

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

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

6.4 RRMS CABINETS

6.4.1 FPU CONTRACTOR/SELLER shall design, supply and install cabinet(s) for the RRMS System, as illustrated on Figure 3. Number of cabinets are project specific and will be detailed in the MD.

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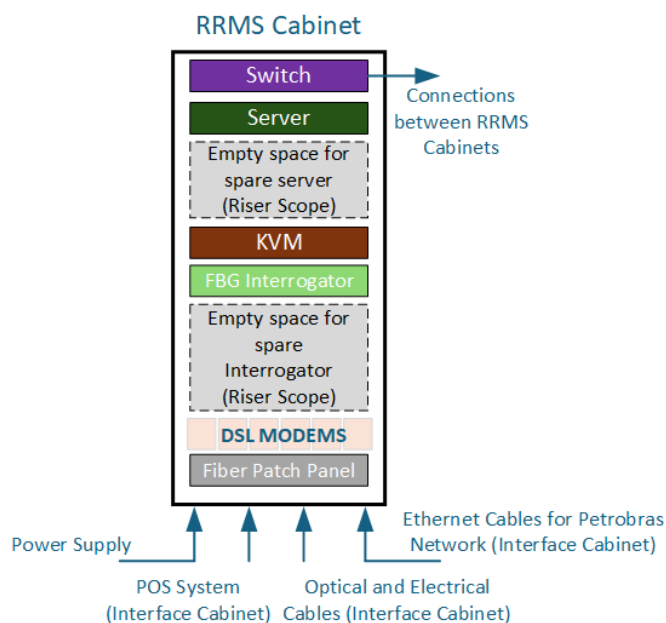


Figure 3: RRMS Cabinet Simplified Diagram

- 6.4.2** The cabinet(s) shall be installed in the Electrical Module and have the following dimensions 1000mm X 1000mm X 2000mm (42U or more). The space designated to this (these) cabinet(s) shall be sided by Riser Interface Cabinet.
- 6.4.3** Cabinet(s) shall be installed at safe and temperature controlled (24 °C) area.
- 6.4.4** Each cabinet shall be designed for frontal and back access for proper racks/devices installation and for maintenance purposes.
- 6.4.5** FPU CONTRACTOR/SELLER shall provide bottom cable access between Riser Interface Cabinet and RRMS Cabinet(s). FPU CONTRACTOR/SELLER shall supply/install/interconnect this cabling.
- 6.4.6** Each RRMS Cabinet shall be a replica of each other, i.e. contains the same equipment as detailed in Section 6.5. Cabinets shall be interconnected by using Cat 6 cables using bottom cable access mentioned on 6.4.5.
- 6.4.7** FPU CONTRACTOR/SELLER is responsible for interconnecting all the equipment on each RRMS Cabinet at FPU CONTRACTOR/SELLER scope of supply.
- 6.4.8** The following connections shall be supplied to RRMS Cabinet(s) through the Riser Interface Cabinet (See specific MD for details):
- FPU Positioning System Information
 - Connection to PETROBRAS Network.
 - Electrical and Optical Cables (Deck Cables).

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- 6.4.9** Optical cables (Deck Cables) shall be properly terminated on fiber optical patch panels.
- 6.4.10** Each RRMS Cabinet shall be designed for at least 10U spare spaces for future use of the RISER CONTRACTOR. On the detailed design (drawings), FPU CONTRACTOR/SELLER shall demonstrate that the design complies with this requirement.
- 6.4.11** Each RRMS Cabinet shall be designed with spare DIN-rails for DSL Modems. On the detailed design (drawings), FPU CONTRACTOR/SELLER shall demonstrate that the design complies with this requirement.
- 6.4.12** Each riser to be monitored shall have a dedicated DC power supply protected by a dedicated circuit breaker. This power supply shall provide power to the correspondent DSL modem installed in the RRMS Cabinet and its riser subsea equipment, as described in Figure 4.
- 6.4.13** DC Power Supply shall be capable to provide at least nominal 24 Vdc (with adjustment range from 24 V to 28 V) and at least 12 A. Each DC Power Supply will be shared between Topside DSL Modem (FPU CONTRACTOR/SELLER scope) and respective riser subsea equipment (RISER CONTRACTOR scope).
- 6.4.14** Optical and electrical cables shall be installed in cable trays, also supplied and installed by the FPU CONTRACTOR/SELLER, respecting the cable minimum bending radius. The optical cables shall withstand any mechanical loads that may be imposed on installation and operation, including tensile and crush loads.

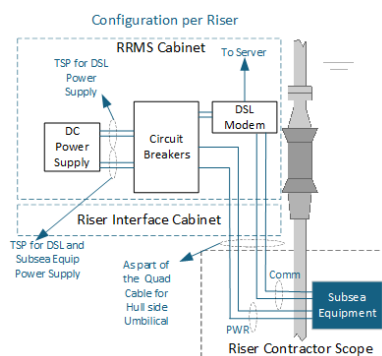


Figure 4: General Concept of the DC Power Supply and Circuit Breakers

- 6.4.15** FPU CONTRACTOR/SELLER shall supply and install one UPS for each RRMS Cabinet. The Local UPS shall be fed by electrical normal loads bus of FPU and designed to supply all equipment for 30 minutes at least, in case of feeding fail. In case of solution proposed is not possible, FPU CONTRACTOR/SELLER shall present alternative solution for PETROBRAS approval.
- 6.4.16** For RRMS Cabinet(s) UPS design, FPU CONTRACTOR/SELLER shall consider power consumption of at least 3 kW per cabinet. Estimation is done considering that future equipment will be installed offshore by the RISER CONTRACTOR.

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6.4.17 For each UPS, FPU CONTRACTOR/SELLER shall provide surge protectors connected to FPU grounding system.

6.4.18 Electrical power consumption and heat dissipation shall be calculated by the FPU CONTRACTOR/SELLER (based on the specifications of the equipment listed on the next session) and submitted for PETROBRAS approval to be compliant with 6.4.16.

6.4.19 The FPU CONTRACTOR/SELLER shall propose a detailed design of the RRMS cabinet(s) and submit for PETROBRAS approval.

6.4.20 The interface between RRMS and other subsea systems is illustrated at specific MD.

6.5 RRMS CABINETS EQUIPMENT AND ACCESSORIES

6.5.1 The FPU CONTRACTOR/SELLER shall supply and install all the equipment (eg: servers, switches, interrogators, KVMs, DSL modem, UPS) for the RRMS Cabinet(s).

6.5.2 The FPU CONTRACTOR/SELLER shall supply and install cabinet accessories (circuit breakers, surge protectors, power strips, heat dissipation fans, electrical cabling, network cabling, optical patch cords, patch panels, rear and front lighting, etc) according to the detailed design of the RRMS Cabinet(s).

6.5.3 The FPU CONTRACTOR/SELLER shall install RRMS equipment and accessories in the RRMS Cabinet(s). All equipment shall be tested by the FPU CONTRACTOR/SELLER. Before the test, the FPU CONTRACTOR/SELLER shall submit the testing procedure for PETROBRAS approval. After the test, the FPU CONTRACTOR/SELLER shall submit to PETROBRAS a report with the test results.

6.5.4 FPU CONTRACTOR/SELLER shall submit a TQF to PETROBRAS Telecom team asking to inform IP Address that shall be configured in each equipment with ethernet connectivity, prior the final approval of FAT Procedure documentation. Connectivity with this IP list shall be implemented and tested during FAT.

6.5.5 The **FBG Interrogator(s)** shall have the following minimum requirements:

- Measurement frequency: 125 Hz or better (per channel)
- Wavelength range: from 1510 to 1590 nm or wider including this range
- Wavelength bandwidth: 80 nm or wider (must include the wavelengths from the previous item)
- Optical channels: 15 or more channels per interrogator
- Wavelength accuracy: 10 pm or better (over full temperature operating range)
- Wavelength repeatability: 1 pm or better

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- Dynamic range (peak): 21 dB or better
- Full spectrum measurement
- Peak detection functionality (through on-board processing)
- Fanless design (to reduce dust contamination inside interrogator)
- ATEX certification for sensors operation in Zone 0, 1 or 2 environments (Ex op is T4 Ga) as defined in [7]
- SC/APC or LC/APC Optical Connectors
- Ethernet Port
- Sensing Analysis Software (freeware)
- Rack Mounted or supplied with rack mount kit
- Height: 70 mm or less

6.5.6 FPU CONTRACTOR/SELLER shall submit the technical proposal of the selected FBG Interrogator for PETROBRAS approval before making order.

6.5.7 The FBG Interrogator quantity is project specific, and more details can be found in the MD.

6.5.8 The **Server Computer(s)** shall have the following minimum requirements:

- Processor clock: 2x Intel Xeon-G 5220 18-Core (2.20GHz 24.75MB L3 Cache) or superior
- RAM memory: 32 GB or better
- 2 hard disk drives (SSD) of at least 1TB each
- 2 hard disk drives (HDD) of at least 4TB each for long term storage
- Support to RAID technology (use RAID-1 at final installation)
- 2 Ethernet ports
- Operational system: Microsoft Windows with licenses
- Software: FBG interrogator data acquisition software with all licenses and requirements
- Rack Mounted

6.5.9 The **Network Switch(es)** shall have the following minimum requirements:

- Gigabit Ethernet ports to accommodate all FBG interrogators and servers computers from the MODA Cabinet
- Support Spanning Tree Protocols, Virtual Local Area Networks, Link Aggregation, Flow Control, Class of Service, Remote Access, Simple Network Management Protocol, Remote Network Monitoring
- Rack Mounted
- Height: 1U

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6.5.10 The **KVM console switch(es)** shall have the following minimum requirements:

- LCD KVM (Keyboard, Video, Mouse) console integrated with KVM switch
- Enough ports to accommodate all server computers/FBG interrogator (if applicable) in the RRMS Cabinet(s)
- Minimum of 8 inputs
- Rack Mounted
- Height: 1U

6.5.11 The **DSL Modem(s)** shall have the following minimum requirements:

- Connection: Twisted Pair (Riser Interface) and RJ45 (Switch)
- Transmission speed: 5 Mbps or greater
- Transmission length: 500 m or greater
- Installation Method: 35 mm DIN-Rail
- Maximum Dimension (W x H x D): 63 mm X 108 mm X 136 mm (due to subsea constraints)
- Comprise the entire message and send through Ethernet protocol

6.5.12 FPU CONTRACTOR/SELLER shall submit a TQF containing the detailed model of the proposed DSL Modem for PETROBRAS review and approval before making order.

6.5.13 The DSL Modem quantity is project specific, and more details can be found in the MD.

6.5.14 The **Optical Patch Panels** have the following minimum requirements:

- SC/APC optical connectors
- Enough connectors to terminate every optical fiber from the riser according to system layout
- Rack mounted

6.5.15 The **Optical Patch Cords** have the following minimum requirements:

- The length and optical connectors of the optical patch cords shall allow the individual connection of the FBG Interrogator channels (SC/APC or LC/APC connectors) to any fiber patch panel (SC/APC connectors) of the cabinets.
- FPU CONTRACTOR/SELLER shall supply one optical patch cord per FBG interrogator optical channel.

6.5.16 The **FBG Sensors Array** have the following minimum requirements:

- The FBG sensors array shall be supplied from the same manufacturer of the FBG Interrogator

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- The FBG sensors array shall have a minimum of four (4) FBG sensors at the optical fiber
- The FBG sensors array shall be used in the pre-commissioning of the Cabinet(s) for troubleshooting purposes.
- The FBG sensors array shall have the same type of connector of the FBG Interrogators (SC/APC or LC/APC connectors)
- The FBG sensors array shall be housed in a protective cover, making possible to handle it with no damage to sensors.

6.5.17 The **Local UPS** shall have the following minimum requirements:

- Input: 220VAC 50/60Hz (from Riser Interface Cabinet UPS)
- Output: 220VAC 50/60Hz
- Autonomy: 30 minutes in case of feeding fail
- The UPS shall have the capacity to turn off the output by external signal
- Short Circuit Protection
- FPU CONTRACTOR/SELLER shall consider the consumption of each equipment inside each cabinet to design the UPS capacity

6.6 MONITORING RISER JUNCTION BOXES

6.6.1 FPU CONTRACTOR/SELLER shall provide Monitoring Riser Junction boxes 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/SELLER design shall evaluate if may require an intermediate JB close to the upper balcony.

6.6.2 Monitoring Riser Junction Boxes shall be installed in places with easy access, in maximum height of 2 meters and where dismisses the use of safety harness for high work.

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

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

6.6.5 FPU CONTRACTOR/SELLER shall terminate all electrical cables into SAK terminals in a DIN RAIL.

6.6.6 FPU CONTRACTOR/SELLER shall provide inside the Monitoring Riser JB an Optical Patch Cord, as specified in Section 6.5.15. Optical Patch Cord will be used for interconnecting the system and for fiber optic testing. Optical Patch Cord shall be terminated in SC/APC or LC/APC connectors.

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6.6.7 FPU CONTRACTOR/SELLER shall provide inside the Monitoring Riser JB a splice tray for fiber fusion for future use by RISER CONTRACTOR.

6.6.8 When the FPU CONTRACTOR/SELLER installs the Optical Cable on the corresponding junction box, it is necessary to leave at least 2 meters of cable over length inside the splice/junction box. The over length allows a proper splice without mechanical stress, which is relieved by turns inside it. The over length also allows future rework in case of damaging the splices during operation.

6.6.9 Monitoring Riser JBs may be shared between RRMS system and RSMS system. See specific MD for general block diagram of the systems.

6.7 RISER DECK CABLING

6.7.1 Riser deck cabling means the electrical/optical cables between the Riser Interface Cabinet and Monitoring Riser Junction Boxes (or Monitoring Riser JB).

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

Table 1: Topside cabling interfaces for rigid risers

Cable Specification	No.of Runs	From/To	Termination	Intended Function
Power – 3 QUAD Cables - 2,5 mm² 0.6/1 kV rating	1	Riser Interface Cabinet to Monitoring Riser JB	Connected to corresponding hullside umbilical cable	Power and communication to monitoring equipment
8 single mode Optical fibers	1	Riser Interface Cabinet to Monitoring Riser JB	Connected to corresponding hullside umbilical cable	Communications to rigid riser monitoring equipment

6.7.3 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 5.

6.7.4 If JBs are shared between RRMS and RSMS systems more cables connecting Riser JB and Riser Interface Cabinet shall be provided to comply with the requirements. See specific MD for general block diagram of the systems.

6.7.5 All corresponding shields belonging to each cable (deck vs. subsea) shall also be interconnected at the junction point.

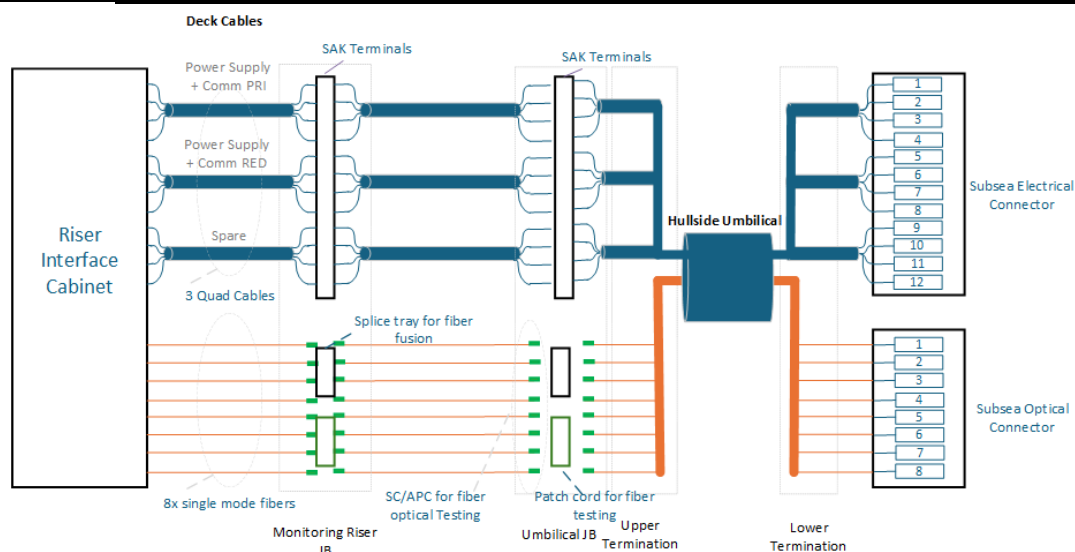


Figure 5: Wiring Schematic Diagram for rigid riser cabling.

6.8 FPU HULLSIDE UMBILICAL CABLING AND CONNECTORS

- 6.8.1** Hullside Umbilical means the cables between Monitoring Riser Junction Boxes and Diver Mate connectors supplied and installed by FPU CONTRACTOR/SELLER in Lower Riser Balcony. This cabling is part of hullside umbilical provided to attend risers support automation.
- 6.8.2** The Hullside umbilical is detailed in [19] and in the specific MD of the project.
- 6.8.3** FPU CONTRACTOR/SELLER shall provide inside de Umbilical JB a patch cord as specified in Section 6.5.15. Optical Patch Cord will be used for interconnecting the system and for fiber optic testing at dry dock phase. Optical Patch Cord shall be terminated in SC/APC or LC/APC connectors.
- 6.8.4** FPU CONTRACTOR/SELLER shall provide inside the Umbilical JB a splice tray for fiber fusion. Fiber fusion shall be performed by FPU CONTRACTOR/SELLER only after topside optical cable laying (Monitoring Riser JB to Umbilical JB).
- 6.8.5** The Optical Cables interconnecting Monitoring Riser JB to Umbilical JB are supplied and installed by the FPU CONTRACTOR/SELLER and in addition to the existing requirements (Section 6.2.4) shall be: Armored fiber optic cabling with Braided Galvanized Steel (BGS), aka Galvanized Steel Wire Braid (GSWB).
- 6.8.6** The Electrical Cables interconnecting Monitoring Riser JB to Umbilical JB are supplied and installed by the FPU CONTRACTOR/SELLER and in addition to the existing requirements (Section 6.2.3) shall be: Armored electrical cabling with Braided Galvanized Steel (BGS), aka Galvanized Steel Wire Braid (GSWB).
- 6.8.7** FPU CONTRACTOR/SELLER shall terminate all electrical cables in the Umbilical JB into SAK terminals in a DIN-rail.

- 6.8.8** 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 6.
- 6.8.9** FPU CONTRACTOR/SELLER 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 the Riser (RISER CONTRACTOR scope).
- 6.8.10** The arrangement of lower riser balcony, considering position of Umbilical Lower Terminations, Risers Supports and Connectors Panel (Section 6.8.9), shall be submitted for PETROBRAS approval.
- 6.8.11** FPU CONTRACTOR/SELLER 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.
- 6.8.12** FPU CONTRACTOR/SELLER shall supply proper fixation clamps solution for RRMS optical/electrical jumpers at lower balcony bottom structure to guarantee cabling integrity for the project's life. These clamps shall be designed to allow any possible future diver maintenance during project's life.

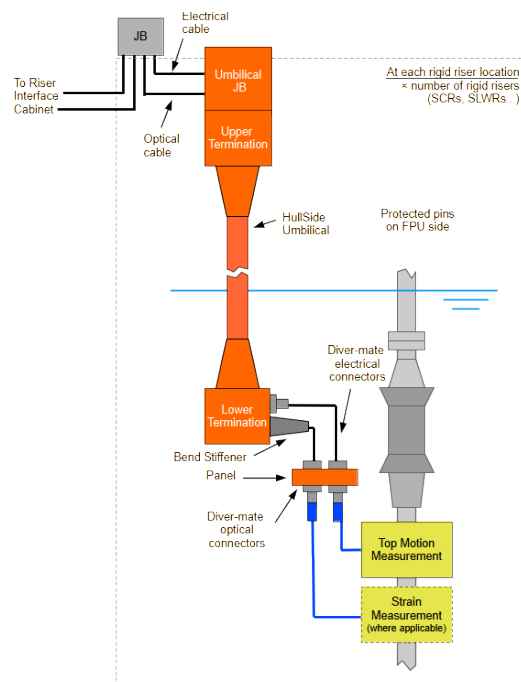


Figure 6: Rigid riser connection scheme

- 6.8.13** 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 12 (twelve) ways electrical pins
 - Be housing made with stainless steel material (AISI 316L)

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d) Be suitable for operation in the foreseen environment

e) 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 [1] (shall present evidence)

h) Have a design life of at least 25 years.

6.8.14 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 detailing phase)

b) be 8 (eight) 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 mate/demate cycles

g) have a design life of at least 25 years

h) be qualified according to [1] (shall present evidence)

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

6.8.16 FPU CONTRACTOR/SELLER shall submit a TQF containing the detailed model of the proposed optical/electrical wet mate connectors for PETROBRAS review and approval before making order.

6.8.17 For cable integrity testing purposes, at electrical connector, the dummy cap shall internally connect each pair of pins with a resistor as specified in Table 2.

Table 2: Hull connector pin assignment for rigid riser slots

Connector Pin Number	Quad Cable	Hull Cable Assignment	Dummy Cap Resistance Value
1	Quad Cable #1	Signal cable TSP 1	10 MΩ
2		Signal cable TSP 2	15 MΩ
3			
4			
5	Quad Cable #2	Signal cable TSP 3	22 MΩ
6		Signal cable TSP 4	33 MΩ
7			
8			
9	Quad Cable #3	Signal cable TSP 5	47 MΩ
10		Signal cable TSP 6	56 MΩ
11			
12			

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

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

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

6.8.21 FPU CONTRACTOR/SELLER shall design this lower balcony infrastructure for proper diving and ROV accessibility for installation offshore. An analysis to guarantee ROV accessibility and no clashing between the RRMS equipment and other equipment that will be installed in the lower riser balcony is FPU CONTRACTOR/SELLER responsibility and shall be submitted to PETROBRAS for review and approval.

6.8.22 Connections between subsea connector pins and hull cable conductors, for all connector types, shall be as specified in Table 2.

6.8.23 On the topside, each hull-side subsea cable shall be connected to the corresponding deck cables.

7 SCOPE OF SUPPLY

7.1.1 Supply, install and interconnect Riser Interface Cabinet.

7.1.2 Supply, install and interconnect the RRMS Cabinet(s).

7.1.3 Provide all connections/interconnections such as network, FPU positioning system and others based on the system requirements for all cabinets.

7.1.4 Provide assistance to all activities to be performed by the RISER CONTRACTOR aboard the FPU, including crane operation, transportation of loads, heavy

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mechanical installations and issuance of work permits when needed.

7.1.5 Supply and run all deck cabling, including termination, required in accordance with the requirements.

7.1.6 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).

7.1.7 Supply hullside umbilical cabling, connectors and all infrastructure.

7.1.8 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.

8 INSTALLATION AND COMMISSIONING REQUIREMENTS

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.

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.

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/SELLER, shall commission all infrastructure in its scope.

8.1.5 In terms of Acceptance Test, the FPU CONTRACTOR/SELLER shall evidence, at least:

a) Cabling and power supply in Riser Interface Cabinet

b) Cabling, power supply and additional information in the RRMS Cabinet(s)

c) Certification of all network cables related to RRMS System

d) Checking the receiving data from Positioning System at RRMS Cabinet(s)

e) OTDR test of all optical fibers

f) Optical system test using FBG sensor array connected to each fiber at splice box

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(Inside Monitoring Riser JB)

- g) Checking Modem DSL information exchange by connecting a test box in the Monitoring Riser JB (See Section 8.1.7).
- h) Fully testing of each electrical riser cable (end-to-end, from RRMS Cabinet(s) to Dummy cap), using the loop in Dummy Cap to verify the resistance of each pair
- i) UPS discharge test

8.1.6 FPU CONTRACTOR/SELLER shall provide all infrastructure for RISER CONTRACTOR, to allow it to complete the fully commissioning of RRMS system, including access to installation, power supply and information related the system.

8.1.7 FPU CONTRACTOR/SELLER shall provide one test box per RRMS cabinet, that needs to be stored on a safe place in the cabinet (e.g. a specific drawer). Test Box shall be used for DSL modem testing and fiber optic testing as illustrated on Figure 7.

8.1.8 For testing the DSL Modem communication between the RRMS Cabinet(s) and Monitoring Riser JB, test box shall contain the same DSL Modem and a test interface (e.g laptop computer with compatible communication protocols such as RS232/RS422/RS485). Test shall be done by using this test box and the laptop computer into Monitoring riser JB and check the correct communication between the Cabinet and the JB. The laptop shall be stored on a safe place in the riser interface cabinet (e.g. a specific drawer).

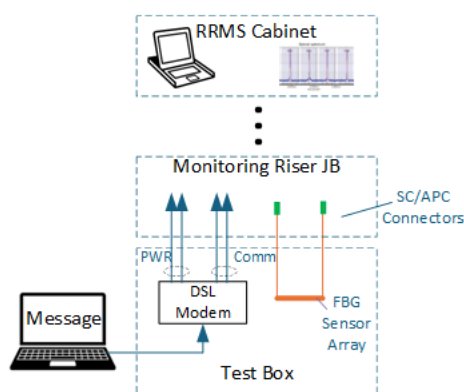


Figure 7: DSL and Fiber Optic Testing

8.1.9 For optical fiber testing using FBG sensor array, this test shall be done by using the sensor array connected by the SC/APC connectors into the Monitoring Riser JB. FBG Sensor Array shall be integrated into the test box.

8.1.10 Tests described on Sections 8.1.5 (g) and (h) are part of the FAT shall be delivered to demonstrate that the system complies with the requirements described in this technical specification.

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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:

- a) Design Basis and Technical Specifications
- b) List of Project Documents
- c) One Line diagram
- d) Interconnection Diagram
- e) General arrangement of cabinet(s) installation
- f) General arrangement of all external installation, including cable routing and mechanical details (including umbilical lines and accessories);
- g) Typical detail of installation at each riser showing at least junction box, conduits, cable tray (if applicable) connector, and fixation
- h) Wet mate connectors, panel and dummies datasheet and drawings
- i) Test Procedures and ITP
- j) Diving accessibility report
- k) Resistance Test Check Test Report
- l) Modem DSL communication Test Report
- m) Fiber Sensor Array Test Report
- n) Preservation and Maintenance Manual
- o) Test Reports
- p) List of all administrator login/passwords needed to operate and manage all equipment
- q) List of all software licenses for the system
- r) Report containing photos of the wet mate connectors installed on the hull including their respective dummy connectors.

9.1.3 During de executive design, a Technical Proposal of the FPU CONTRACTOR/SELLER scope shall be issued for PETROBRAS approval, including Datasheets, manuals and certificates for all equipment or cable supplied by FPU CONTRACTOR/SELLER

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10 SCOPE OF WORK

10.1 GENERAL TOPOLOGY

10.1.1 The General Topology in Figure 2 summarizes the supply scope division between FPU CONTRACTOR/SELLER and RISER CONTRACTOR.

10.1.2 The General Topology in Figure 8 summarizes the installation scope division between FPU CONTRACTOR/SELLER, RISER CONTRACTOR and DIVING TEAM.

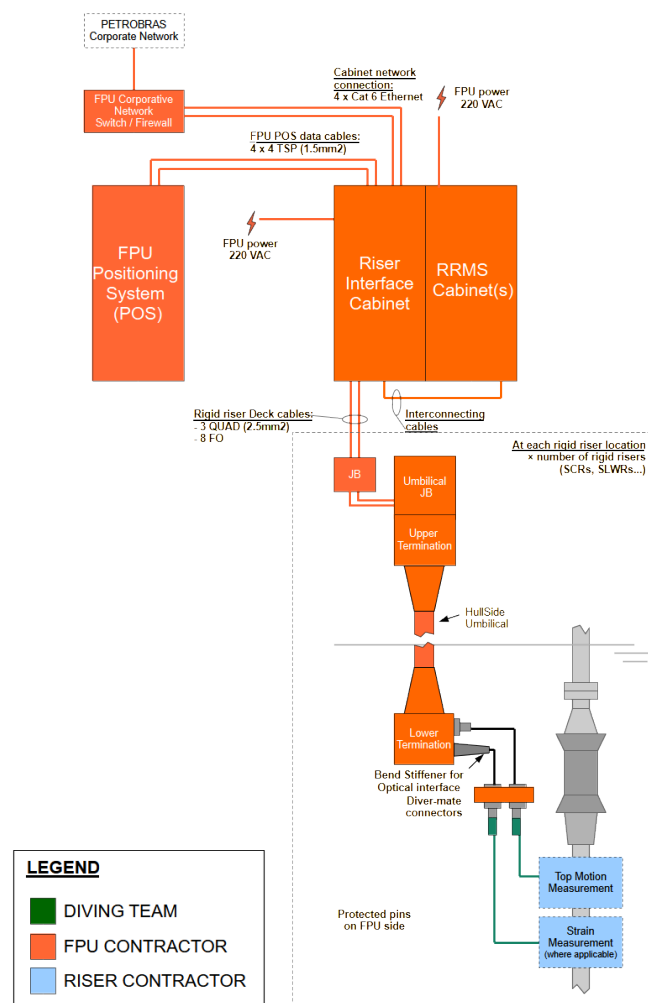


Figure 8: Scope of installation – RRMS System

10.2 RISER CONTRACTOR

10.2.1 Execute commissioning of complete RRMS

10.2.2 Design and install subsea cables

10.2.3 For each rigid riser: execute design, supply and installation scope of all subsea

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components and associated accessories (clamps, blister) onto rigid risers.

10.2.4 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.

10.2.5 Provide specialized RRMS operation training for PETROBRAS and Operations/Maintenance teams.

10.3 FPU CONTRACTOR/SELLER

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 RRMS Cabinet(s) and install all the equipment and connections.

10.3.3 Provide Riser Interface Cabinet and install all the equipment and connections.

10.3.4 Provide a network connection to the RRMS Cabinet(s). This shall include configuration of firewalls and allocation of network addresses.

10.3.5 Design, supply and install FPU provisions for each rigid riser.

10.3.6 Supply and install deck cabling, including terminations.

10.3.7 Provide connections between deck cables and hull/subsea cables for rigid risers.

10.3.8 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.

10.3.9 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, pictures to evidence the installation (including for connectors in the lower riser balcony that interfaces with the RISER CONTRACTOR).

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 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.