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## 1 SUBSEA PRODUCTION CONTROL SYSTEM (SPCS)

The SPCS comprises the integration between the Floating Production Unit (FPU) Central Control Room (CCR) and Control & Safety System (CSS) equipment and the following types of subsea control systems:

- Electrohydraulic Multiplex Subsea Control System (EHMUXSCS), for all wells and manifolds that can be connected to the FPU;
- Direct Hydraulic Control System (DHCS) for the FPU's subsea emergency shutdown valves (SESDV).

During early execution phase, PETROBRAS will submit to CONTRACTOR a Subsea Operating Philosophy, to describe the intended operations. Detailed Subsea Operational Procedures will be provided by PETROBRAS 4-5 months prior to start of operations, in order to guide the interface relations between PETROBRAS and CONTRACTOR. With this information, CONTRACTOR shall prepare and submit for PETROBRAS approval an Interface (FPU-Subsea) Operating Manual.

### 1.1 ELECTROHYDRAULIC MULTIPLEX SUBSEA CONTROL SYSTEM (EHMUXSCS)


#### 1.1.1 ELECTROHYDRAULIC MULTIPLEX SUBSEA CONTROL SYSTEM (EHMUXSCS)

This type of subsea control system combines two fundamental characteristics at the same time:

- It allows the use of a small number of common hydraulic supplies from topside to actuate all subsea valves. This is accomplished locally subsea by opening or closing an electrohydraulic valve that provides hydraulic pressure from a common supply header from topside to the subsea equipment valve actuator.
- It allows the use of a small number of common electrical supplies and a communication link from topside with a "Subsea Electronics Module (SEM)" subsea to select electrohydraulic valve that provides hydraulic pressure from a common supply header from topside to the subsea equipment valve actuator to open or close it according to the Operator command selected topside.

The electrohydraulic valve is typically a three-way, two position, solenoid operated Directional Control Valve (DCV) or "Solenoid Valve". The DCV pressurize or depressurize the hydraulic control line to the subsea valve actuator whenever commanded to open or close by the SEM after this one receives the respective command from the SPCS. A given number of DCV are housed together with two SEM inside a retrievable Subsea Control Module (SCM) installed in a Wet Christmas Tree (WCT) or subsea manifold. A typical gate valve counts as one SCM Function, while manifold choke valves and some types of downhole valves with two actuators requires two SCM Functions.

The EHMUXSCS used by PETROBRAS is an open-type system. When the hydraulic pressure from the SCM common supply header for the subsea actuators is removed by its respective DCV in the SCM, a given volume of hydraulic fluid between the DCV and valve actuator is expelled (vented) to seawater by the SCM. The EHMUXSCS will use water-based

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hydraulic fluid that needs to be maintained according to ISO 4406 Class 17/15/12 cleanliness standard by the CONTRACTOR at all times.

Each subsea equipment with EHMUXSCS will be provided with two sets of dual redundant hydraulic supplies from the SPCS HPU topside:

- The “Low Pressure” set with two individual supplies referred as LP1 & LP2 providing between 4,000 psi and 5,000 psi operating pressure range for subsea gate valves;
- The “High Pressure” set with two individual supplies referred as HP1 & HP2 providing between 6,500 psi and 7,500 psi for the WCT’s downhole valve(s). The upper limit may be raised to 10,000 psi in the future if needed by PETROBRAS.

Data acquisition from subsea sensors is provided by the SCM. The SCM also provides its own internal “housekeeping” data for periodic record and display by the SPCS. The open or closed status of a subsea valve is provided by indirect means using the fast scan monitoring of the pressure in the respective control function DCV outlet, together with other measurements such pressure or flow rates in the SCM hydraulic headers and fluid vent.


Electrical power and communication for the SCM is provided from topside by a pair of EHMUXSCS Control Cabinets. Power and communication are combined in a same pair of wires of the umbilical electrical cable. This combination is referred as a “Channel or Line”. A topside EHMUXSCS Control Cabinet pair provides two Channels for the SCM. The Channels are referred as “Channel A” or “Line A” and “Channel B” or “Line B. Each Channel will use one twisted pair among the four or six provided in the WCT umbilical electrical cable. Two other pairs are a backup against umbilical cable or electrical connector failures.

Each topside EHMUXSCS Control Cabinet pair is composed by two identical Control Cabinet racks, with each rack dedicated to a SCM Channel. An EHMUXSCS Control Cabinet rack typically houses the Channel A or B electrical modem, power supply, and data servers. Each EHMUXSCS Control Cabinet rack also have a Programmable Logic Controller (PLC) or industrial grade computer with the logic memory map of all subsea valves, sensors, housekeeping data and status functions that the SPCS will access to send valve commands and read all EHMUXSCS data relevant to SPCS operation.

Both EHMUXSCS Control Cabinet racks belonging to the same pair will normally operate in “hot stand-by” redundancy mode, with periodic update of their memory map variables. One of the two SCM Channels will be always the “active” or “master”, with automatic or manual change over to the other (“stand-by”) Channel in case of communication loss or failure. Each EHMUXSCS Control Cabinet rack has network communication and hardwired I/O interface with the CCR and CIS Systems in the FPU.

Although the SPCS operation shall be fully integrated in the CCR, a limited degree of stand-alone EHMUXSCS operation will be possible from a dedicated Operator Work Station (OWS) to be supplied by PETROBRAS. The OWS is intended to offer temporary operation back-up capability during CONTRACTOR integration work for EHMUXSCS Control Cabinet racks. The OWS software and display graphics may not allow the same flexibility and resources available in the CCR System. A pair of OWS will be provided for use in a network with all EHMUXSCS Control Cabinet pairs from the same Supplier.

PETROBRAS E&P Pre-salt 10k EHMUXSCS-WCT is already prepared to control hydraulic-type Intelligent Completion system typically for, but not limited to, production wells. Four functions are reserved in the SCM for this purpose. They will be included in the P&ID of the EHMUXSCS-WCT for each well that has this type of Intelligent Completion system installed.

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The well completion may use some downhole valves to select and control the production of reservoir zones. When these valves have the possibility to be topside controlled, the system is defined as Intelligent Well Completion. There are two possibilities:

- Intelligent Well Completion with Direct Hydraulic Control or CI-HD (*Completação Inteligente Hidráulica Direta*)
- Intelligent Well Completion with Electrohydraulic Multiplex Control or CI-MUX (*Completação Inteligente Multiplexada*)

Control for CI-HD downhole valves is provided by the WCT EHMUXSCS. The WCT SCM has dedicated valves and lines to supply and return hydraulic fluid to downhole valves of intelligent completion system and interface with downhole sensors. EHMUXSCS Control Cabinets are able to send commands to open and close these valves and also read data from these sensors. To perform correctly this specific operation, the commands will be sent to EHMUXSCS Cabinets only by equipment named Intelligent Well Completion System (IWCS) that will be installed inside WCS cabinet (see 1.6).

In case of not full electric CI-MUX, the supply and return of hydraulic fluid will continue be provided by WCT SCM but the electric signals from/to well will be directly interconnected to this extra subsea module. The topside interface with this subsea module will be done by a dedicated electrical pair in the control umbilical, to command and read the information of this subsea system. There will be dedicated cabinets, named CI-MUX Cabinets.

### 1.1.2 Direct Hydraulic Control System (DHCS)

This type of control system is defined here as the one which each valve actuator, downhole valve, SESDV is directly connected to topside electrohydraulic valve through a dedicated umbilical line (thermoplastic hose or tube) in the control umbilical. The electrohydraulic valve, also referred as solenoid operated Directional Control Valve (DCV) or “Solenoid Valve”, pressurizes or depressurizes the umbilical control line directly to the subsea valve actuator.

The SESDV will be actuated by a dedicated control panel. The return fluid from each SESDV Valves will not be allowed to return to the SPCS HPU.

The WCR and the SESDV Control Panel will provide the following operating pressures according to type of equipment used:


Subsea Emergency Shutdown Valve (SESDV) and PLEM Valves:

- Between 1,350 psi and 3,300 psi.

### 1.2 SPCS MAIN SPECIFICATIONS

The SPCS includes (but it is not limited to) the following types of subsea and topside equipment listed below:

- Wet Christmas Tree fitted with electrohydraulic multiplex subsea control system (EHMUXSCS–WCT) - Supplied by PETROBRAS;
- Downhole valves: DHSV (safety), VHIF (formation isolation valve, if installed) – Supplied by PETROBRAS;

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- Downhole Direct Hydraulic Intelligent Completion system (CI-HD) – Supplied by PETROBRAS;
- Downhole stand-alone Multiplex Intelligent Completion system (CI-MUX) – Supplied by PETROBRAS;
- Downhole Pressure & Temperature Transmitter (PDG) – Supplied by PETROBRAS;
- Subsea Umbilical – Supplied by PETROBRAS;
- Topside EHMUXSCS Type 1 Control Cabinet pair for up to five (5) EHMUX-WCT per cabinet, – Supplied by PETROBRAS;
- Topside EHMUXSCS Type 3 Control Cabinet pair for up to two (2) subsea interconnected pair of wells – Supplied by PETROBRAS;
- Topside EHMUXSCS Type 5 Control Cabinet pair for up to two (2) steel tubing umbilical, shared by up to five (5) wells each– Supplied by PETROBRAS;
- Topside Control Cabinet for stand-alone Multiplex Intelligent Completion system (CI-MUX) – Supplied by PETROBRAS;
- Topside stand-alone Operator Workstation (OWS) pair for all EHMUXSCS Control Cabinet pairs from the same EHMUXSCS Supplier – Supplied by PETROBRAS;
- Topside Well Completion System (WCS) Cabinet – Supplied by CONTRACTOR;
- Rack mounted Intelligent Well Completion System (IWCS) equipment – Supplied by PETROBRAS;
- Subsea Emergency Shutdown Valve (SESDV) – Supplied by PETROBRAS;
- Topside SPCS Hydraulic Power Unit (HPU) – Supplied by CONTRACTOR;
- Topside Portable Umbilical Pressurization System (PUPS) – Supplied by CONTRACTOR.

The SPCS shall provide operation control and monitoring of up to twenty seven (27) subsea equipment from the CCR. Each EHMUXSCS-WCT control and monitor the respective well downhole valves (DHSV and VHIF, if installed) and PDG. The WCTs could be connected to the FPU in three different ways:


- Satellite wells: the WCT is connected directly to the FPU by its own control umbilical.
- Subsea interconnected pairs: two WCT share one umbilical
- Subsea distribution: a single umbilical could be share by up to five WCTs, limited to 2 producer wells by umbilical.

Note 1: The number of WCT valves will be confirmed by PETROBRAS during the detail design phase.

Note 2: PDGs data shall be read by CCR from Topside EHMUXSCS Control Cabinet and from CI-MUX Cabinet, depending on well completion type.

Normal operation shall be performed from CCR screens selected by the Operator.

PETROBRAS will provide P&ID's for each subsea equipment according to their respective type of control system, for CONTRACTOR to include in the SPCS CCR screens. The P&ID's

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will include a selection of the most important EHMUXSCS and DHCS parameters that shall be displayed.

PETROBRAS will provide the CI-MUX P&ID's for CONTRACTOR to include in the SPCS CCR screens

The SPCS HPU shall provide hydraulic supplies for EHMUXSCS and DHCS. CONTRACTOR shall provide the SPCS HPU, the SESDV control panel and the PUPS according to the specifications and 1.7.

Note: Hydraulic supplies for CI-MUX system will be provided from the respective well EHMUXSCS-WCT subsea

The SPCS hydraulic system shall be fully compatible with the following water-based control fluids: MacDermid HW443, MacDermid HW525P and Castrol Transaqua DW. PETROBRAS will select the fluid during execution phase.

CONTRACTOR shall provide the whole SPCS hydraulic system topside flushed to ISO 4406 class 17/15/12 cleanliness standard (former standard NAS1638 Class 6), using either MacDermid HW443, MacDermid HW525P or Castrol Transaqua DW fluids (to be defined by PETROBRAS).

CONTRACTOR shall maintain the SPCS fluid cleanliness on all SPCS topside equipment according to ISO 4406 Class 17/15/12 specification at all times. Fluid cleanliness shall be analyzed and recorded by the CONTRACTOR at least on a weekly basis and that information shall be available to PETROBRAS at any time.

CONTRACTOR is required to always recirculate the SPCS hydraulic fluid transferred from fluid manufacture's barrels to the SPCS HPU until achieving the required ISO 4406 Class 17/15/12 cleanliness specification.

Each umbilical slot hang off position shall be provided with four hydraulic supplies LP1, LP2, HP1 and HP2 directly from the SPCS HPU.

CONTRACTOR shall provide the topside hydraulic distribution for all LP1 and LP2 EHMUXSCS supplies with ½" Internal Diameter (ID) thermoplastic hoses or Stainless Steel Tubes suitable rated for continuous operation with 5,000 psi (maximum) internal pressure.


CONTRACTOR shall provide the topside hydraulic distribution for all HP1 and HP2 EHMUXSCS supplies with ½" Internal Diameter (ID) Stainless Steel Tubes suitably rated for continuous operation with 10,000 psi (maximum) internal pressure.

CONTRACTOR shall provide the integration (see below the definition for "integration") of Third Party SPCS equipment supplied by PETROBRAS. The main types of such equipment are:

- a) Topside Control Cabinets for EHMUXSCS;
- b) Topside Control Cabinets for CI-MUX;
- c) WCS Cabinets.

Note: Topside Control Cabinets for EHMUXSCS and CI-MUX applications are herein referred only as "SPCS Control Cabinets", except when each specific type is identified.

For the "Integration" specified above, CONTRACTOR shall provide the complete installation and commissioning of all SPCS Control Cabinets' racks and their OWS to be supplied by

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PETROBRAS. CONTRACTOR scope of supply shall also include (but it is not limited to): All cables (power; signal; instrumentation) with suitable connectors and terminations required; CIS/CCR hardware and software; configuration of CIS/CCR for communication with SPCS Control Cabinets; configuration of CIS/CCR for SPCS cause and effect chart; configuration of SPCS operation screens in the CCR.

PETROBRAS will provide the dimension drawings and interface documentation for each type of topside SPCS Control Cabinet and IWCS equipment. PETROBRAS will also provide Third Party technical assistance to CONTRACTOR's integration work.

VERY IMPORTANT: The assignment of each well or manifold to specific SPCS Control Cabinets is preliminary. PETROBRAS will provide the first assignment configuration of at least one EHMUXSCS Cabinet pair up to three months in advance of the scheduled start of operation offshore Brazil for CONTRACTOR make the interconnections in the Control Cabinet room.


CONTRACTOR shall provide installation, integration and commissioning for topside EHMUXSCS Control Cabinets manufactured by four (4) different subsea control system suppliers.

PETROBRAS will provide the topside SPCS Control Cabinets according to the Table 1.2.1 below:

**Table 1.2.1: SPCS Topside Control Cabinets**

Individual Control Cabinet Number	Cabinet Pair Type (note 1)	Channel or Line	Preliminary assignment				
1	Type 5	A	P1 - P2 - I1A - I1B - I5A				
2		B	P1 - P2 - I1A - I1B - I5A				
3	Type 5	A	P3 - P4 - I2A - I2B - I5B				
4		B	P3 - P4 - I2A - I2B - I5B				
5	Type 5	A	P5 - P6 - I3A - I3B				
6		B	P5 - P6 - I3A - I3B				
7	Type 5	A	P7 - P8 - I4A - I4B				
8		B	P7 - P8 - I4A - I4B				
9	Type 1	A	P9	P10	I6	I7	P11
10		B	P9	P10	I6	I7	P11
11	Note 1	A	Cabling connecting to TEAP-A				
12		B	Cabling connecting to TEAP-B				
13	CI-MUX		CI-MUX 1	CI-MUX 2	CI-MUX 3	CI-MUX 4	
14	CI-MUX		CI-MUX 5	CI-MUX 6	CI-MUX 7	CI-MUX 8	
15	WCS Cabinet		IWCS 1		IWCS 2		
16	WCS Cabinet		IWCS 3		IWCS 4		
Note 1: To be defined by PETROBRAS during detail design							



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At least two EHMUXSCS Control Cabinets (one pair) will be delivered to CONTRACTOR prior to PROVISIONAL ACCEPTANCE (to be discussed and confirmed during execution phase). PETROBRAS will provide 60 man-days of technical assistance to the CONTRACTOR for this first integration.

CONTRACTOR shall provide installation, integration and commissioning for topside CI-MUX Control Cabinets manufactured by up to three (3) different suppliers.

CONTRACTOR shall take into account that not all topside SPCS Control Cabinets will be available for shipyard installation before the FPU starts production.

CONTRACTOR shall provide at any time with no cost to PETROBRAS the installation, integration and commissioning of any quantity of SPCS Control Cabinets up to the total specified by Table 1.2.1, whenever requested by PETROBRAS, including while the FPU is offshore. PETROBRAS will deliver SPCS Control Cabinets to CONTRACTOR in Brazil (onshore or offshore). PETROBRAS will request to CONTRACTOR this offshore installation and integration work with at least three months in advance. CONTRACTOR shall plan and carry out this work with minimum or no impact for the FPU's operation.

The layout of the SPCS Control Cabinet room shall allow the easy installation and removal of each SPCS Control Cabinet rack, including while the FPU is offshore. Special attention shall be given to position cable trays and junction boxes in order to cope with installing and removing cable interconnections. Cable entries to each SPCS Control Cabinet shall be from the bottom of each Cabinet rack.


CONTRACTOR shall provide the cabling between each umbilical slot hang off electrical junction box and the SPCS Control Cabinet room with at least six (6) high grade 0.6/1.0 kV class 6.0 mm<sup>2</sup> twisted pairs with individual shield per pair with PE (Protection Earth). Four (4) such pairs shall be dedicated to EHMUXSCS use while the other two (2) shall be dedicated to CI-MUX use.

CONTRACTOR shall provide at any time with no cost to PETROBRAS the reassignment of the electrical connections between the six (6) twisted pairs from each EHMUXSCS umbilical to any individual topside SPCS Control Cabinet.

For this purpose, CONTRACTOR shall provide two (2) TOPSIDE ELECTRICAL ASSIGNMENT PANELS (TEAP-A and TEAP-B). Each TEAP (A or B) will be connected to all EHMUXSCS control cabinets, respective A or B channels, i.e., TEAP-A to all EHMUXSCS Channel A control cabinets and TEAP-B to all EHMUXSCS Channel B control cabinets.

Each TOPSIDE ELECTRICAL ASSIGNMENT PANEL shall be in the form of a single, enclosed type rack with front and rear doors that allows the electrical connection of the two (2) of the six (6) twisted pairs from each EHMUXSCS umbilical to any individual topside EHMUXSCS Control Cabinet of the same Channel. The TEAP shall allow changing the connections very easily whenever required, without the need to reposition the cables arriving to the panel itself. The use of wire jumpers between the TEAP cable termination blocks or something similar for this purpose may be considered. The final configuration assignment between wells, manifolds and their respective control cabinets will be confirmed by PETROBRAS up to 90 days before the FPU leaves the integration shipyard.

CONTRACTOR shall provide one (1) TOPSIDE CI-MUX ASSIGNMENT PANELS (TCAP). The TCAP will be connected to all CI-MUX cabinets.

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The TOPSIDE CI-MUX ASSIGNMENT PANEL shall be in the form of a single, enclosed type rack with front and rear doors that allows the electrical connection of the two (2) of the six (6) twisted pairs from each EHMUXSCS umbilical to any individual topside CI-MUX Cabinet. The TCAP shall allow changing the connections very easily whenever required, without the need to reposition the cables arriving to the panel itself. The use of wire jumpers between the TCAP cable termination blocks or something similar for this purpose may be considered. The final configuration assignment between wells and their respective CI-MUX cabinets will be confirmed by PETROBRAS up to 90 days before the FPU leaves the integration shipyard.

CONTRACTOR shall consider housing all Control Cabinets, TEAP-A, TEAP-B, TCAP and WCS Cabinet in the same room to facilitate cable routing among them.

CONTRACTOR shall submit to PETROBRAS for approval the design documents for the complete installation and commissioning of SPCS Control Cabinets, TEAP-A, TEAP-B, TCAP and WCS Cabinet. CONTRACTOR shall also submit to PETROBRAS for approval the SPCS cause and effect chart.

CONTRACTOR shall guarantee the SPCS Control Cabinet room ambient temperature to be kept lower than 35°C at all times, taking as a premise that all SPCS Control Cabinets listed in Table 1.2.1 will be in full operation. The room temperature shall be monitored and recorded at all times by the CCR.

Each EHMUXSCS Control Cabinet and CI-MUX Cabinet will be based on 19" type rack with preliminary dimensions of: 900 mm (W) x 1,400 mm (D) x 2,500 mm (H). The exact dimensions will be confirmed by PETROBRAS during the detail design phase.

CONTRACTOR shall provide permanent front and rear accesses for each SPCS Control Cabinet rack. The access shall allow both front and rear doors to fully open when necessary.

PETROBRAS will provide to CONTRACTOR two (2) desktop Operator Work Stations for all EHMUXSCS Control Cabinets from the same supplier. The Operator Work Stations can be used as a local Master Control Station (MCS) with limited operator interface capabilities, allowing some back up to the full operation of the EHMUXSCS from the CCR.

CONTRACTOR shall provide room and desktop facilities in the CCR or nearby room for the Operator Work Stations. Specifications of the cables and connectors between the EHMUXSCS Control Cabinets and the Operator Work Stations will be provided by PETROBRAS during the detail design.


CONTRACTOR shall request PETROBRAS to specify the communication network and protocol interface between the following topside equipment:

- a) CIS/CCR with each EHMUXSCS Control Cabinet rack, each IWCS, and each CI-MUX control Cabinet;
- b) Each EHMUXSCS Control Cabinet rack from the same subsea control system supplier and their pair of OWS (three (3) such networks shall be implemented, being one for each subsea control system supplier equipment);

CONTRACTOR shall provide all necessary switches to connect the equipment as above.

Each network above shall have its own and exclusive cable network. For each one, CONTRACTOR shall provide PETROBRAS's choice between the two following options:

- i. Ethernet TCP/IP with OPC UA protocol;

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ii. MODBUS/TCP;

Each network cable interface shall be 100-BASE-T or 100-BASE-FX type optical connection, also to be defined by PETROBRAS together with the interface protocol.

CONTRACTOR shall provide the following digital hardwire shutdown signals from CIS to each individual EHMUXSCS Control Cabinet rack:

- ASD (Abandon Ship and Total FPU Shutdown): 1-off signal activated by the CIS to perform the shutdown sequence in all wells and the respective DHSV;
- ESD (Emergency Shutdown): 1-off signal activated by the CIS to perform the shutdown sequence in all wells without closing the respective DHSV;
- PSD (Process FPU Shutdown): 1-off signal activated by the CIS to close the WCT Crossover and Pig Crossover valves;
- USD (Well Shutdown): 1-off digital signal per well, activated by the CIS to perform the shutdown sequence in each well individually except for the DHSV. The number of signals shall be according to the number of wells controlled from the respective EHMUXSCS Control Cabinet. Each subsea manifold requires 1-off USD signal per well. The exact configuration will be provided by PETROBRAS during the detail design phase.

For each shutdown signal above, CONTRACTOR shall provide a CIS-powered 24VDC two wire signal, hardwired to a relay type Digital Input interface on each EHMUXSCS Control Cabinet rack. PETROBRAS will inform the maximum current drawn by each coil during the detail design phase. For further information about ASD, ESD, PSD and USD see SAFETY GUIDELINES.


CONTRACTOR shall provide the following digital hardwire shutdown signals from CIS to each individual CI-MUX Control Cabinet rack (PETROBRAS will confirm during execution phase):

- ASD (Abandon Ship and Total FPU Shutdown): 1-off signal activated by the CIS to perform the shutdown of the DHSV of each well with CI-MUX

Each SPCS Control Cabinet rack shall be powered by 220 VAC @ 60 Hz from the FPU Uninterruptable Power Supply, allowing 15 minutes of full power operation after an electrical shutdown. Power consumption of each EHMUXSCS Control Cabinet rack will be 6.0 kVA and heat dissipation of each Control Cabinet will be 3.5 kW. Power consumption of each CI-MUX cabinet will be 5.0 kVA and heat dissipation of each Control Cabinet will be 3.5 kW. PETROBRAS will confirm CI-MUX heat dissipation during the execution phase

NOTE: The higher power consumption of each EHMUXSCS Control Cabinet when compared to previous projects is to consider the application of three (3) Subsea Chemical Injection Valves in the WCT. This higher power consumption requirement will be confirmed by PETROBRAS during the execution phase.

CONTRACTOR shall provide the interface between the WCS Cabinet and the CCR.

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### 1.3. SPCS UMBILICALS AND TOPSIDE UMBILICAL INTERFACES

The SPCS shall be designed for operation with the following types of control umbilical:

a) 7,500 psi Standard TPU (Thermoplastic Umbilical):

- 4 x 1/2" x 7,500 psi – Thermoplastic hoses for the four EHMUXSCS hydraulic supplies;
- 6x 1/2" x 7,500 psi – High Collapse Resistant (HCR) hoses for chemical injection;
- 1x electrical cable with four (4) or six (6) individually screened (shielded) twisted pairs of 4.0 mm<sup>2</sup> or 6.0 mm<sup>2</sup> conductors with Voltage Class 0.6/1.0 (1.2) kV, according with IEC 60502-1 (Power cables with extruded insulation and their accessories for rated voltages from 1 kV (Um = 1.2 kV) up to 3 kV (Um = 3.6 kV)).

b) 10,000 psi STU (Steel Tube Umbilical):

- 12 x 1/2" x 10,000 psi – Steel Tubes (see note below);
- 1x Electrical cable with four (4) or six (6) individually screened (shielded) twisted pairs of 6.0 mm<sup>2</sup> conductors with Voltage Class 0.6/1.0 (1.2) kV, according with IEC 60502-1 (Power cables with extruded insulation and their accessories for rated voltages from 1 kV (Um = 1.2 kV) up to 3 kV (Um = 3.6 kV));

Note about configuration according to WCT control system:

- I. EHMUXSCS: four (4) ST for EHMUXSCS hydraulic supplies and eight (8) ST for chemical injection;

All subsea control umbilical slot hang off positions shall allow the operation of any of the following umbilical types:

- a) 7,500 psi TPU for one WCT or subsea interconnected pair of wells with EHMUXSCS;
- b) 10,000 psi STU for one WCT or Subsea Distribution Unit (SDU) with EHMUXSCS.

Hydraulic connections for umbilical hoses or Steel Tubes shall be provided by their respective fittings grouped in a plate herein referred as "Topside Umbilical Termination Unit" Plate (TUTU Plate). The specifications for umbilical hose and Steel Tube fittings will be provided by PETROBRAS during the detail design phase. Umbilical hydraulic hose pig-tails are typically 600 mm long.

For Steel Tube Umbilicals, connection from the umbilical and the TUTU plate is to be done using stainless steel tubes. Connection work, materials, installation and maintenance are CONTRACTOR'S scope.

Each control umbilical slot hang off position shall have combined or individual TUTU Plate(s) for both types of EHMUXSCS umbilical.


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Figure 1.1 presents a block diagram of the SPCS interfaces.

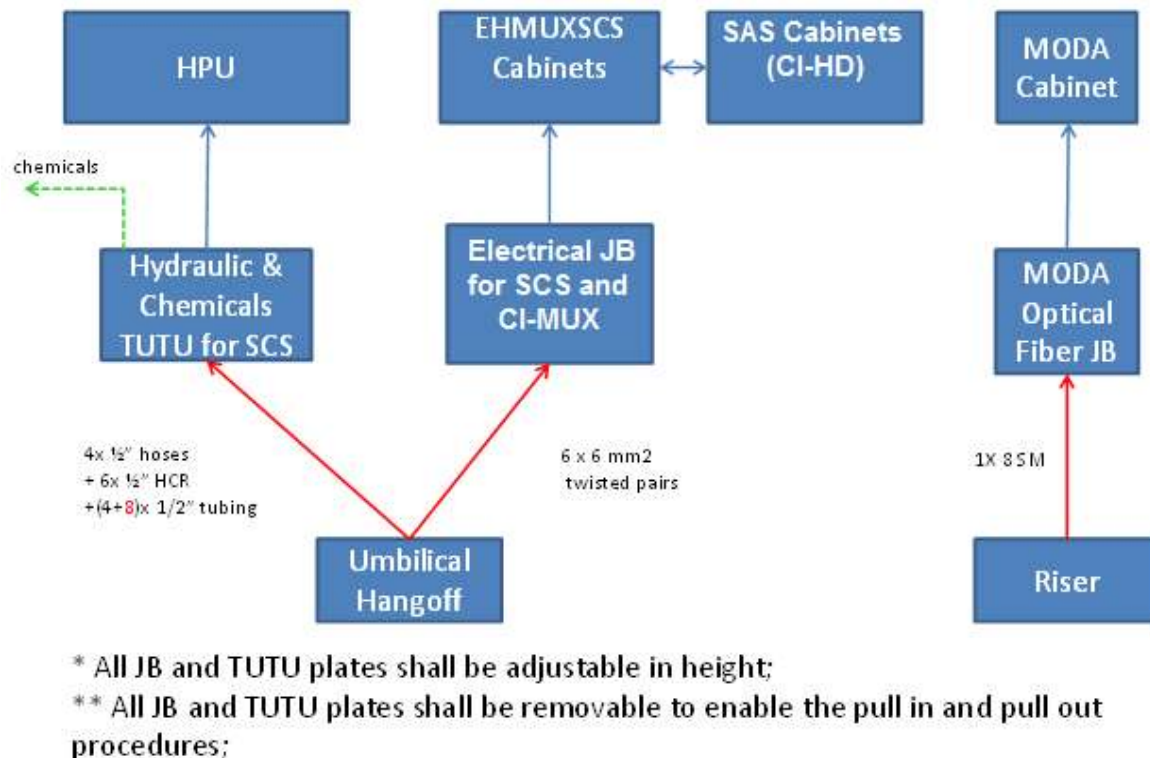


Figure 1.1 – SPCS Interface Diagram

TUTU Plates shall be positioned in order to not block or interfere with pull-in/pull-out operations. Where this cannot be fully guaranteed, they shall be made removable.

CONTRACTOR shall present each TUTU Plate design for PETROBRAS comments / information.

Each umbilical hang off position shall be provided with an Electrical Junction Box (EJB) for the termination of the umbilical electrical cable.

For the umbilical hang off positions where PETROBRAS specified the capability to use umbilicals with different electrical cable configurations, the EJB shall have one cable entry specific for each type of umbilical cable or a single cable entry adaptable according to the type of umbilical installed.


The subsea umbilical's electrical pig-tails are typically 600 mm long.

Each EJB shall have terminal blocks capable to accept any conductor size between 2.5mm<sup>2</sup> and 10 mm<sup>2</sup>. Terminal blocks shall be dimensioned with individual ground connections for every pair of umbilical conductors.

Each EJB shall be positioned in order to not block or interfere with pull-in/pull-out operations. Where this cannot be fully guaranteed, they shall be made removable.

CONTRACTOR shall present EJB design for PETROBRAS comments / information.

The electrical cable pig-tails preparation and connection inside the EJB is CONTRACTOR's scope of work. Details on the cables nominal diameters will be provided by PETROBRAS during the design phase.

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#### 1.4. SPCS OPERATOR INTERFACES

The SPCS shall be operated from the CCR using dedicated screens and pop-up menus according to the particular CCR system used.

As a preliminary requirement, the following screens shall be implemented as an intuitive way of navigating through the system in a logical manner as the main building blocks are connected:

- a) Well type, according to respective P&IDs;
- b) Subsea manifolds or subsea distribution units and associated wells, according to their respective P&IDs;
- c) Assignment of individual wells to a manifold or SDU subsea interconnected pair of wells;
- d) CI-MUX (may be included in specific well's P&ID – to be informed by PETROBRAS);
- e) SPCS HPU monitoring;
- f) SCM monitoring;
- g) CI-MUX monitoring;
- h) SESDV.


CONTRACTOR shall implement without cost to PETROBRAS all CCR screen reconfigurations needed by future changes in the SPCS subsea layout. The reconfiguration shall be easily accomplished by the use of simple pop-up menus on the CCR screen under password protected supervisor level. PETROBRAS will request such reconfigurations at least three months in advance with the new subsea P&IDs for configuration of the HMI screens.

The following minimum information shall be displayed on the CCR screens for each well P&ID:

- a) Downhole valve status (opened or closed);
- b) Downhole pressures and temperatures;
- c) WCT valve status (opened or closed);
- d) WCT pressures and temperatures;
- e) Pig detection;
- f) Corrosion monitoring of pipeline (to be confirmed by PETROBRAS during the detail design phase);
- g) ESD status;

The following minimum information shall be displayed on the CCR screens for each SDU respective P&ID:

- a) The respective SDU well's P&ID;
- b) Valve status (opened or closed);

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- c) Pressure and temperatures;
- d) Injection flow rates (measured and calculated);
- e) Choke position (measured by position sensor and calculated by control steps given);
- f) Pig detection;
- g) Corrosion monitoring of pipeline (to be confirmed by PETROBRAS during the detail design phase);
- h) ESD status;

The SPCS HPU shall be monitored from the CCR using dedicated screens and pop-up menus according to the particular CCR system used. At least the following data monitored from the SPCS HPU shall be displayed on the CCR screens:

- a) Reservoirs levels;
- b) Unregulated header pressure (both headers);
- c) Regulated header pressure (both headers);
- d) Pump status;
- e) Individual supply pressures LP1, LP2, HP1 and HP2 for each EHMUXSCS umbilical;
- f) Individual supply pressures for the SESDV Control Panel.

The hydraulic pressure of each umbilical line (control and chemical injection) shall also be monitored as close as possible of their respective hang off connection plate. Pressures shall be displayed on the CCR.

The following minimum information specific for the subsea equipment provided with EHMUXSCS shall be displayed on the CCR screens:


- a) Hydraulic supply pressures monitored by each Subsea Control Module;
- b) Active Line or Channel providing communication and power to each SCM;
- c) Subsea electronic module (two for each SCM) health status and internal temperature;
- d) Individual Control Cabinet statuses (to be confirmed by PETROBRAS during the detail design phase);
- e) ESD status;

The following minimum information shall be displayed on the CCR screens for each SESDV:

- a) Valve status (opened or closed) for SESDV;

#### 1.4.1. Time delay for subsea valve command operations

It shall be possible to configure a time delay for the SPCS initiate a subsea valve operation after the command is issued by the Operator. This configuration shall be available for each subsea valve tag and be easily accomplished by simple pop-up menus on the CCR screens at password protected supervisor level. Default values for time delays will be informed by PETROBRAS during the detail design phase.

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#### 1.4.2. Subsea valve open and close sequences

It shall be possible to configure open and close sequences for all valves of each subsea equipment. It shall also be possible to configure open and close sequences among the subsea equipment installed. Such configurations shall be easily accomplished by calling special CCR screens under password protected supervisor level. Default sequences will be informed by PETROBRAS during the detail design phase.

#### 1.5. SPCS HYDRAULIC POWER UNIT (HPU)

CONTRACTOR shall provide SPCS HPU according to PETROBRAS specification number:

- Unidade Hidráulica (HPU) para equipamentos submarinos de produção equipados com Sistema de Controle Eletrohidráulico Multiplexado – see item 1.2.1.

The SPCS HPU specification above is in Brazilian Portuguese language. All translations to other languages required by CONTRACTOR or by other third parties, such vendors, and suppliers (just to name a few), shall be CONTRACTOR's responsibility and shall be part of CONTRACTOR's scope of supply.

The SPCS HPU shall be dimensioned in terms of reservoirs, accumulator bank and pumps capacities according to the criteria specified by the SPCS HPU specification referred above and the "Datasheet of HPU Consumers" (I-FD-3A46.02-5139-800-P3D-001) provided as a reference document mentioned on item 1.2.1 of this GTD or as a separate document. The "Datasheet of HPU Consumers" for a given FPU specifies the quantities of subsea equipment according to each type. In case this GTD applies to more than one FPU, each's SPCS HPU shall be dimensioned according to the respective "Datasheet of HPU Consumers".

The first filling of the HPU fluid tanks falls under CONTRACTOR's scope. During operations PETROBRAS will provide the fluid make-up whenever necessary, if the HPU is operating properly and without leakages.


The SPCS HPU will provide the following pressure regulated supplies for each EHMUXSCS subsea equipment:

- LP1: Operation between 4,000 psi and 5,000 psi;
- LP2: Operation between 4,000 psi and 5,000 psi;
- HP1: Operation between 6,500 psi and 7,500 psi;
- HP2: Operation between 6,500 psi and 7,500 psi.

The SPCS HPU specification includes the capability for the conversion of all HP1 and HP2 supplies upper operating range to 10,000 psi. CONTRACTOR shall provide the HPU conversion whenever required by PETROBRAS during the Contract lifetime. PETROBRAS will request this conversion at least six months in advance.

All SPCS HPU supplies shall have individual pressure transmitters downstream of the HPU for Operator's monitoring on the CCR screens.



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## 1.6. WCS CABINETS AND IWCS EQUIPMENT

All WCS Cabinets shall be supplied by CONTRACTOR according with the quantities specified on Table 1.2.1.

Each WCS Cabinet is foreseen to accommodate IWCS equipment for up to eight (8) wells, distributed among two (2) IWCS equipment groups, each group for up to four (4) wells.

Each IWCS equipment group shall be according to the following configurations:

Up to four (4) rack mounted Engineering Workstations, each one for a single well with CI-HD from a given supplier. Each Engineering Workstation comprises a 6U Notebook with monitor;

One (1) rack mounted 6U Engineering Workstation with a Notebook and monitor for four (4) wells with CI-HD from the same supplier.

Maximum electrical power of each IWCS equipment group is 1,5 kVA, with heat dissipation of 400 Watts. The exact IWCS specifications for both options including network cable interface will be provided by PETROBRAS during the detail design phase.

Each WCS Cabinet shall comply with the following requirements:

Cabinet with external dimensions of at least 800 mm (W) x 800 mm (D) x 2,500 mm (H). The exact dimensions will be confirmed by PETROBRAS during the detail design phase;

Cabinet prepared to install 19" rack mountable equipment (IWCS);

External powered with 220 VAC, phase-to-phase, 60 Hz from UPS with available internal outlets to all equipment in NEMA 5-15 standard;

Be provided with circuit breakers, fans, terminal blocks, lightning and all required materials necessary for cabinet finishing;

Designed for frontal and back access for proper equipment installation and for maintenance purposes with transparent frontal door;


All cables shall be tagged, including electrical cables from riser balcony;

CONTRACTOR shall provide each WCS Cabinet with an Ethernet Switch to connect all IWCS equipment (worst case: two (2) groups of four (4) rack mounted 6U Notebooks) to all EHMUXSCS Control Cabinets.

The installation, integration and commissioning of the IWCS equipment manufactured by two (2) different suppliers in the WCS Cabinets are CONTRACTOR's Scope of work.

For the "Integration" specified above, CONTRACTOR shall provide the complete installation and commissioning of all IWCS equipment to be provided by PETROBRAS. CONTRACTOR scope of supply shall also include (but it is not limited to): All cables (power; signal; instrumentation) with suitable connectors and terminations required; configuration of CI-HD Ethernet Switches for communication with the EHMUXSCS Control Cabinets;

CONTRACTOR shall take into account that IWCS equipment may be not available for shipyard installation before the FPU starts production. CONTRACTOR shall provide at any time with no cost to PETROBRAS the installation, integration and commissioning of any quantity of IWCS equipment whenever requested by PETROBRAS, including while the FPU is offshore. PETROBRAS will request to CONTRACTOR this offshore installation and integration work with at least three months in advance. CONTRACTOR shall plan and carry out this work with minimum or no impact for the FPU's operation. For each WCS Cabinet, PETROBRAS is

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going to provide a total of 10 man-days of technical assistance to the CONTRACTOR for IWCS equipment installation.

CONTRACTOR shall provide to PETROBRAS no longer than 90 days after the contract award the preliminary drawings showing the WCS Cabinets according with the IWCS configuration to be informed by PETROBRAS by during the detail design phase.

### 1.7. PORTABLE UMBILICAL PRESSURIZATION SYSTEM (PUPS)

PUPS is a topside portable device to allow the CONTRACTOR to safely pressurize each control line of an umbilical during installation, from any LP or HP pressure supply from the SPCS HPU. The PUPS device shall allow for quick air removal and safe pressurization and depressurization of up to twelve (12) umbilical tubings or thermoplastic hoses from one or two hydraulic supplies at any TUTU Plate.

The PUPS device shall be composed of two identical hydraulic headers, each one with a common pressure inlet port, a pressure regulator, manometer, 6 (six) function branch outlet ports and one drain port to drain/bleed any of the 6 outlets. Each drain and outlet port, as well as each manometer shall have their own isolating valve. All components shall be stainless steel type with at least ½" O.D suitable for the above said control fluid and fluid cleanliness. The drain/bleed ports shall be used also to take fluid sampling when necessary.

JIC fittings mentioned below in this chapter are just for reference. CONTRACTOR shall provide the PUPS with the matching hydraulic terminations for umbilical hose and Steel Tube fittings to be informed by PETROBRAS during the detail design phase.

The PUPS device shall be able to pressurize each umbilical line with a regulated pressure between 1,000 psi and 3,000 psi, from any supply between 4,000 and 10,000 psi. However, all PUPS hydraulic components shall be rated to 10,000 psi operation. Each of the 12 (twelve) pressurization outlets shall be terminated with a quick connector adapter to allow the fitting of a ½" male JIC 37° termination prior the pressurization. Each PUPS device shall be provided with sets of at least 13x ½" male JIC 37° fittings. CONTRACTOR shall consider provide each PUPS with its own storage box for those fittings when not in use.

CONTRACTOR shall provide and maintain at least two identical PUPS devices always ready for use when asked so by PETROBRAS.

The PUPS device shall be used for CONTROL LINES only with water-based control fluids MacDermid HW443, MacDermid HW525P or Castrol Transaqua DW.


CONTRACTOR shall maintain the PUPS devices always flushed to ISO 4406 Class 17/15/12 cleanliness.

### 1.8. SUBSEA EMERGENCY SHUTDOWN VALVES CONTROL PANEL

CONTRACTOR shall provide the SESDV control panel for one SESDV valves according with specifications 1.1.2 above.

The SESDV control panel shall be provided with regulated pressure supplies from the HPU for actuation of:

- Up to one (1) SESDV valves with pressures between 1,350 psi and 3,300 psi;

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NOTE: The SESDV control panel shall have independent pressure regulators for each header.

The SESDV control panel shall be designed to avoid back pressures in the umbilical control lines, considering the worst case depressurization of all control lines at the same time to the SPCS HPU. Return fluid lines from the SESDV control panel shall be sized with sufficient flow capacity for this purpose. The return fluid from SESDV control panel shall not be allowed to return to the SPCS HPU.

The SESDV control panel shall allow all SESDV to close in less than two (2) minutes.

The Directional Control Valves for the SESDV control panel shall be spring return fail-close solenoid valve type energized from the CCR/CSS. They shall bleed the pressure when the electrical power for the solenoid is removed. The DCV shall be specified to avoid any pressure drop during subsea hydraulic lines pressurization and depressurization. Their minimum internal passages shall be equivalent in area to a 6mm<sup>2</sup> bore. It is important to take into account the pressure drop during the pressurization of the subsea system. This shall not cause any malfunction to the solenoid valves.

It is recommended that all DCVs and hydraulic components be installed in stainless steel manifold blocks. It is also recommended that SESDV control panel itself to be made in stainless steel.

Individual pressure transmitters shall be provided downstream of each SESDV control panel DCV for Operator's monitoring on the CCR screens.