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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 & Interlocking System (CIS) equipment and the following types of subsea control systems:
- Electrohydraulic Multiplex (EHMUX) for the total number of subsea production manifold and subsea water injection manifold connected to FPU. Each subsea production manifold will group up to four (4) production wells and each subsea water injection manifold will group up to six (6) water injection wells. Five (5) subsea production manifolds (one of them spare) and four (4) subsea water injection manifolds will be connected to FPU.
- Direct Hydraulic (DH) for ten (10) production wells connected directly to FPU. Direct Hydraulic (DH) must be used to control of the FPU's subsea emergency shutdown valves (SESDV).

1.1 TYPES OF CONTROL SYSTEM USED BY THE SUBSEA EQUIPMENT

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)" 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 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 and is expelled (vented) to seawater by the SCM. The EHMUXSCS will use water-based 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 3,000 psi operating pressure range for subsea gate valves;

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- The “High Pressure” set with two individual supplies referred as HP1 & HP2 providing between 3,000 psi and to 5,000 psi for the WCT’s downhole valve(s), operating pressure range for subsea downhole safety valves.

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 (4) provided in the manifold umbilical electrical cable. Two other pairs are a back-up 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 (up to 4 suppliers).

1.1.2 Direct Hydraulic Control System (DHCS):

This type of control system is defined here as the one which each valve actuator of a Wet Christmas Tree (WCT), downhole valve, or SESDV valves is directly connected to topside electrohydraulic “switch” 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.

A given number of DCV are housed together topside in a Well Control Rack (WCR), with electrical power provided from the FPU CIS and the pressurized hydraulic fluid supplied by the SPCS HPU. Except in the case of actuation of SESDV, the Direct Hydraulic control system used by PETROBRAS is a closed type system where the control fluid depressurized from an umbilical line by a DCV returns to the SPCS HPU

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return reservoir. The SESDV will be actuated by a dedicated control panel. The return fluid from SESDV 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:

a) 5k-Type DHCS-WCT:

- Between 3,000 psi for all WCT gate valves;
- Between 3,000 and 5,000 psi for the WCT's well downhole safety valve(s).

b) Subsea Emergency Shutdown Valve (SESDV):

- Between 2500 psi and 3,300 psi.

The open or closed status of a given subsea equipment gate valve is provided by indirect means by monitoring the pressure in the respective control function DCV valve outlet in the WCR or SESDV's Control Panel for display in the respective well P&ID on the CCR. For SESDV the open or closed status will be provided also by 4-20mA pressure and temperature sensor installed in the subsea valve and connected directly to the CIS by two electrical pair in the umbilical. The others three 4-20mA analog sensors of typical PETROBRAS 5k or 10k Direct Hydraulic WCT (production pressure; production temperature and annulus or gas injection pressure) are typically connected directly to the CIS by two electrical pairs in the umbilical. The exact configuration will be provided by PETROBRAS during the detail design phase.


The downhole pressure and temperature gauge will be connected directly to the topside Signal Acquisition System (SAS) Panel (see item 1.7).



1.2 SPCS MAIN SPECIFICATIONS

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

The equipment listed below, from the seabed to the Unit, comprises the SPCS:

- Wet Christmas Tree for direct hydraulic control system (DHCS-WCT)– Supplied by PETROBRAS;
- Subsea production manifold fitted with electrohydraulic multiplex subsea control system (MSP) – Supplied by PETROBRAS;
- Subsea Water injection manifold fitted with electrohydraulic multiplex subsea control system (MSIA) – Supplied by PETROBRAS;
- Downhole valves: DHSV (safety) Supplied by PETROBRAS;
- Downhole pressure & temperature transmitter (PDG) – Supplied by PETROBRAS;
- Subsea Emergency Shut Down Valve (SESDV) (Gas Export Line) – Supplied by PETROBRAS;
- Subsea Umbilical – Supplied by PETROBRAS;
- Topside EHMUXSCS Control Cabinet pair for each one of five (4 + 1) subsea production manifolds and four (4) subsea water injection manifolds – Supplied by PETROBRAS;
- Topside stand-alone Operator Workstation (OWS) pair for all EHMUXSCS Control Cabinet pairs from the same EHMUXSCS Supplier (up to 4 suppliers) – Supplied by PETROBRAS;

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<ul style="list-style-type: none"> • Topside Signal Acquisition System (SAS) for downhole pressure & temperature transmitter (PDG) used for each well with DHCS – Supplied by PETROBRAS; • Topside SAS Panel to install SAS equipment – Supplied by CONTRACTOR; • Topside SPCS Hydraulic Power Unit (HPU) – Supplied by CONTRACTOR; • Topside Well Control Rack (WCR) for WCT fitted with Direct Hydraulic control system – Supplied by CONTRACTOR; • Topside SESDV control panel – Supplied by CONTRACTOR; • Topside Portable Umbilical Pressurization System (PUPS) – Supplied by CONTRACTOR; <p>The SPCS shall provide operation control and monitoring of the following subsea equipment from the CCR:</p> <ul style="list-style-type: none"> • ten (10) DHCS-WCT, a set of downhole valves (DHSV), PDG and TPT for six (6) satellite wells, six (6) of which are production wells; • Five (5) subsea production manifolds (one of them spare) (MSP) and four (4) subsea water injection manifold (one of them spare) connected directly to the FPU by its own control umbilical. The subsea production manifold can be connected to a maximum of four (4) wells and subsea water injection manifold can be connected to a maximum of six (6) wells. • One (1) Subsea Emergency Shutdown Valves (SESDV). <p>Note: The number of WCT and SESDV will be confirmed by PETROBRAS during the detail design phase. 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 will include a selection of the most important EHMUXSCS and DHCS parameters that shall be displayed. The SPCS HPU shall provide hydraulic supplies for EHMUXSCS and DHCS. CONTRACTOR shall provide the SPCS HPU, the WCR, the SESDV control panel and the PUPS according to the specifications 1.5, 1.6 and 1.8.</p> <p>The SPCS hydraulic system shall be fully compatible with the following water-based control fluids: MacDermid HW443 and Castrol Transaqua DW. PETROBRAS will select the fluid during execution phase.</p> <p>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 or Castrol Transaqua DW fluids (to be defined by PETROBRAS).</p> <p>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.</p> <p>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.</p> <p>The umbilical hang off position for the spare manifold shall allow the operation of a Manifold (EHMUXSCS) or DHCS-WTC (dual control system capability).</p>			

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

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

SESDV umbilical slot hang off position shall be provided with ½” ID control lines rated for 5,000psi maximum operating pressure from the SESDV Control Panel. The number of control lines will be provided by PETROBRAS during the detail design phase.

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) SAS Panels.

Note: Topside Control Cabinets for EHMUXSCS application is 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 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 SAS Panels. PETROBRAS will also provide Third Party technical assistance to CONTRACTOR’s integration work.

PETROBRAS will provide the topside SPCS Control Cabinets according to the Table 1.2.1.1 below:

Table 1.2-1.1: SPCS Topside Control Cabinets

SPCS Topside Control Cabinets			
Individual Control Cabinet Number	Cabinet Pair Type (note 1)	Channel or Line	Preliminary assignment for Marlim and Voador
1	Type 1	A	MSIA or MSP (note 2)
2		B	MSIA or MSP (note 2)
3	Type 1	A	MSIA or MSP (note 2)
4		B	MSIA or MSP (note 2)
5	Type 1	A	MSIA or MSP (note 2)
6		B	MSIA or MSP (note 2)
7	Type 1	A	MSIA or MSP (note 2)
8		B	MSIA or MSP (note 2)
9	Type 1	A	MSIA or MSP (note 2)
10		B	MSIA or MSP (note 2)
11	Type 1	A	MSIA or MSP (note 2)
12		B	MSIA or MSP (note 2)
13	Type 1	A	Spare MSP (note 2)
14		B	Spare MSP (note 2)
Notes and abbreviations:			
Note 1	Type 1 is for PETROBRAS standard EHMUXSCS Cabinet pair Types		

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Note 2	Includes the WCT connected to each manifold
MSIA	Subsea water injection manifold for up to six (6) wells
MSP	Subsea production manifold for up to four (4) wells
Quantity of SPCS Control Cabinet racks per FPU: seven (7).	

MOST 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 three (3) different subsea control system suppliers. At least two EHMUXSCS Control Cabinets (one pair) will be delivered at the CONTRACTOR shipyard. PETROBRAS is going to provide 60 man-days of technical assistance to the CONTRACTOR for this first integration. 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 1.2.1.1, 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.

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 four (4) high grade 0.6/1.0kV class 6.0mm² twisted pairs with individual shield per pair with PE (Protection Earth) to be dedicated to EHMUXSCS use.

CONTRACTOR shall provide at any time with no cost to PETROBRAS the reassignment of the electrical connections between the four (4) 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 cabinet.

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 four (4) 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 consider housing all Control Cabinets, TEAP-A, TEAP-B and SAS Panels in the same room to facilitate cable routing among them.

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CONTRACTOR shall submit to PETROBRAS for approval the design documents for the complete installation and commissioning of SPCS Control Cabinets, TEAP-A, TEAP-B and SAS Panels. 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 1.2.1.1 will be in full operation. The room temperature shall be monitored and recorded at all times by the CCR.

Each EHMUXSCS Control Cabinet will be based on 19" type rack with preliminary dimensions of: 900 mm (W) x 1400 mm (D) x 2500 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 of 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
- 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 among the two following options:

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

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- 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 FOR OFFSHORE PRODUCTION UNITS.



Each SPCS Control Cabinet rack shall be powered by 220V AC @ 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 5.0 kVA and heat dissipation of each Control Cabinet will be 3.5 kW.



CONTRACTOR shall provide the interface between the SAS Panel and the CCR. All DHCS-WCT sensors shall be displayed in the respective well P&ID screen, as well as the SESDV sensor shall be displayed in the SESDV P&ID screen.

1.3. SPCS UMBILICALS AND TOPSIDE UMBILICAL INTERFACES

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

- a) 5,000psi Standard TPU (Thermoplastic Umbilical) for SESDV and Production Wells with 5k DHCS-WCT:
 - 9 x 3/8" x 5,000 psi – Thermoplastic hoses for direct hydraulic control of the WCT and downhole valves;
 - 3 x 1/2" x 5,000 psi – High Collapse Resistant (HCR) hoses for chemical injection;
 - 1 x Electrical cable with three twisted pairs of 2.5mm² 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)) for the WCT pressure and temperature transmitters, and the PDG for the respective well.
- b) 5,000psi Standard TPU (Thermoplastic Umbilical) for Water Injection Wells with 5k DHCS-WCT:
 - 5 x 3/8" x 5,000 psi – Thermoplastic hoses for direct hydraulic control of the WCT and downhole valves;
 - 1 x Electrical cable with three twisted pairs of 2.5mm² 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)) for the WCT pressure and temperature transmitters, and the PDG for the respective well.
- c) 5,000psi Standard TPU (Thermoplastic Umbilical) for Subsea Production Manifolds:
 - 4 x 1/2" x 5,000 psi – Thermoplastic hoses for direct hydraulic control of the WCT and downhole valves;
 - 9 x 1/2" x 5,000 psi – High Collapse Resistant (HCR) hoses for chemical injection;

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<ul style="list-style-type: none"> • 1 x Electrical cable with four twisted pairs of 10 mm² 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)) for the SCM installed in subsea manifold. <p>d) 5,000psi Standard TPU (Thermoplastic Umbilical) for Subsea Water Injection Manifolds:</p> <ul style="list-style-type: none"> • 4 x 1/2" x 5,000 psi – Thermoplastic hoses for direct hydraulic control of the WCT and downhole valves; • 6 x 1/2" x 5,000 psi – High Collapse Resistant (HCR) hoses for chemical injection; • 1x Electrical cable with four twisted pairs of 4 mm² 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)) for the SCM installed in subsea manifold. <p>e) 10,000 psi STU (Steel Tube Umbilical):</p> <ul style="list-style-type: none"> • 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 mm² 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: <ul style="list-style-type: none"> ○ EHMUXSCS: four (4) ST for EHMUXSCS hydraulic supplies and eight (8) ST for chemical injection; <p>Hydraulic connections for umbilical hoses or steel tube shall be provided by their respective fittings grouped in a plate herein referred as “Topside Umbilical Termination Unit” Plate (TUTU Plate). Umbilical hydraulic hose pig-tails are typically 600mm long and will be provided with the following fittings, to be confirmed by PETROBRAS during the detail design phase:</p> <ul style="list-style-type: none"> • HCR ½” 5000 psi: 1/2 " – Female JIC 37° 3/4" - 16UNF, AISI 316L • Thermoplastic Hose 3/8” 5000 psi: 3/8 " – Female JIC 37° 9/16" - 18UNF, AISI 316L <p>All subsea control umbilical slot hang off positions shall allow the operation of any of the following umbilical types:</p> <p>a)5,000 psi TPU for one WCT or MSIA and/or MSP with EHMUXSCS;</p> <p>b)10,000 psi STU for one MSIA or MSP with EHMUXSCS.</p> <p>The TUTU Plates shall be equipped with male JIC connector according to the umbilical tail connector. SESDV umbilical slot hang off position shall be provided with a TUTU Plate for 5,000psi TPU.</p>			

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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 approval.

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 600mm long.

Each EJB shall have terminal blocks capable to accept any conductor size between 2,5mm² and 10mm². 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 approval.

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.

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 and associated wells, according to their respective P&IDs;
- c) Assignment of individual wells to a manifold;
- d) SPCS HPU monitoring;
- e) SCM monitoring;
- f) 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);

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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 manifold respective P&ID:

a) The respective manifold well's P&ID;

b) Valve status (opened or closed);

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 WCR and 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);

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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;
- b) Pressure and Temperature for SESDV;
- c) Pig detection.

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.

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 and SESDV. 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:

- ET-3000.00-5139-800-PEK-007 (Unidade Hidráulica (HPU) para equipamentos submarinos que poderão estar equipados com Sistema de Controle Eletro-Hidráulico Multiplexado ou Sistema de Controle Eletro-Hidráulico Direto, em qualquer combinação, e que requerem até 5000 psi de pressão máxima de atuação (HPU-FLEX 5000) – see item 1.2.1.


In case of conflicting information between item 1.5 and ET-3000.00-5139-800-PEK-007 PETROBRAS shall be consulted.

1.5.1. Manifolded wells

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 **"DADOS PARA O PROJETO DE HPU DOS EQUIPAMENTOS SUBMARINOS DO FPSO REVIT DE ALBACORA"** (FD-3530.00-1500-800-PEK-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.

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.

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

- LP1: Operation between 1,500 psi and 3,000 psi;
- LP2: Operation between 1,500 psi and 3,000 psi;
- HP1: Operation between 3,000 psi and 5,000 psi;
- HP2: Operation between 3,000 psi and 5,000 psi.

The SPCS HPU will provide two unregulated hydraulic supplies outlets for the WCR operate the following subsea valves (according to WCT Type used):

- WCT gate valves requiring 3,000 psi;
- Downhole valves requiring between 3,000 psi and 5,000 psi;

The SPCS HPU will provide two hydraulic supplies for the SESDV Control Panel. Both will allow the operation of the SESDV between 2,500 psi and 3,300 psi.

MOST IMPORTANT: Fluid depressurized from SESDV shall NOT be allowed to return to the SPCS HPU reservoirs. This fluid shall be disposed by the CONTRACTOR whenever necessary.

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

1.5.2. Satellite wells

The Vendor list shall be composed by: AKER SOLUTIONS, COOPER-CAMERON, FMC, ANZZET, FRAMES, W-INDUSTRIES HITEC and CONTROLS ELECTRIC PTE LTD.

The HPU and all associated hydraulic equipment shall be designed to maintain the cleanliness of control fluid according to NAS 1638 Class 6. In order to meet this requirement, the HPU shall have a supply reservoir and a return reservoir, connected by circulation pump and filters.

Fluid cleanliness shall be analyzed and recorded by the CONTRACTOR on a weekly basis and that information shall be available to PETROBRAS at any time.

The hydraulic control fluid will be water-based MacDermid Canning HW443, Castrol Transaqua DW. PETROBRAS will define the fluid during execution phase.

The hydraulic supply and return headers between the HPU and the WCRs shall be sized (minimum) according to the Hydraulic analysis, in order to avoid flow restrictions.

The hydraulic power for the Christmas Trees and ESDVs shall be provided by the HPU through pressure regulator valves, set up at pressure levels, according to requirements of the consumers defined by the SUBSEA LAYOUT see item 1.2.1.

HIGHER LEVEL (Typical): pressure of 5,000 psi for the actuation of the Downhole Safety Valve (DHSV), adjustable by a pressure regulator between 3,000 psi and 5,000 psi).


LOWER LEVEL (Typical): pressure of 3,000 psi for the actuation of the other valves, adjustable by a pressure regulator between 2,500 psi and 3,000 psi).



SESDV operation pressure (Typical): pressure of 2500 to 3300 psi adjustable by a pressure regulator.

Note: PCVs shall be able to operate at any specific set within pressure ranges listed above.

The HPU shall be designed considering the following:

1. Accumulators shall be designed to open the farthest well, from the maximum pressure (High) to minimum pressure (Low), with no need of hydraulic pump;

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<p>2. Pumps shall be designed to replenish the whole hydraulic system (accumulators), from the minimum pressure (Low) to the maximum pressure (High), within 5 minutes. In addition, the minimum HPU flow rate to the WCR, shall be 50 litres per minute;</p> <p>3. The hydraulic fluid reservoir shall be split into two totally segregated reservoirs - the supply reservoir and the return reservoir;</p> <p>4. A hydraulic pump shall be installed to recirculate the hydraulic fluid from the return reservoir to the supply reservoir. Filtering and sample collectors shall be installed to allow commissioning of the fluid to guarantee the required cleanness class and to enable hydraulic fluid analysis. Minimum circulating pump flow rate shall be 20 litres per minute;</p> <p>5. The net internal volume of the supply reservoir shall be sufficient to pressurize the whole subsea system (all hydraulic lines from the Unit to the wells and Sub- Surface Safety Valve). For the design, the pressurization from zero to maximum working pressure shall be considered;</p> <p>6. The return reservoir shall be sized to receive twice the internal volume of all subsea system (during an ESD 3 or 4);</p> <p>7. Two independent pressure headers shall be segregated with the use of independent pressure regulators. The first, to be distributed and used at the WCR for WCT valves actuation. The second to be distributed and used at the WCR for DHSV actuation.</p> <p>8. The hydraulic tubings in the umbilicals are pre-filled with hydraulic fluid before launching.</p> <p>In addition, materials of tanks, accumulators, pumps, tubing, valves, etc. shall be specified to meet the hydraulic fluid and cleanness (NAS class 6 or better) requirements.</p> <p>For the design of the hydraulic system, CONTRACTOR shall consider the subsea lay-out for a Spread Moored FPSO.</p> <p>The HPU shall have stand-by equipment (filters, pumps, accumulators) to allow an adequate maintenance during all operational lifetime, with no influence on the hydraulic system performance.</p> <p>All pressure switches, manometers and level switches shall have shutoff and draining valves so that any of these instruments from the pneumatic or hydraulic circuits can be removed without affecting the operation of the HPU. These valves shall be positioned so as to prevent accidental closure due to vibration. The pressure switches, transmitters and manometers shutoffs will be effected by means of manifold valves.</p> <p>The HPU shall be designed to operate even in case of a continuous subsea hydraulic fluid leakage, that causes a fluid loss smaller than the HPU design flowrate capacity.</p> <p>The HPU shall be provide with local control and monitoring as well as remote control from the CCR.</p> <p>MOST IMPORTANT: The return fluid from the ESDV Panel shall not be allowed to the HPU reservoirs. This fluid shall be always disposed by the CONTRACTOR.</p>			

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1.6. WELL CONTROL RACK (WCR) FOR DIRECT HYDRAULIC CONTROL SYSTEM

CONTRACTOR shall provide the WCR for the number of wells that may be equipped with DHCS-WCT according with specifications 1.2 above.

CONTRACTOR shall provide the WCR capable of controlling the 5k DHCS-WCT types and the well's downhole valves. A total of ten (10) control functions for production wells and four (4) functions for injection wells (see below), each with a Directional Control Valve (DCV), shall be provided for each well. The P&ID for each DHCS-WCT type will be provided by PETROBRAS during the detail design phase. The WCR shall be provided with two (2) unregulated pressure supplies from the HPU for this purpose:

1. One to allow the operation of subsea valves with pressures between 2,500 psi and 3,000 psi;
2. One to allow the operation of downhole valves with pressures between 3,000 psi and 5,000 psi;

The WCR shall provide a set of two separate headers for each well, derived from the two DHCS supplies from the SPCS HPU. Each set of headers shall be provided with manually adjusted pressure regulators upstream of the respective well's Directional Control Valves (DCV) in order to allow the individual control of the 5 kpsi WCT and downhole valves. The two headers shall be divided according to:

1. One header to allow the operation of DHCS-WCT gate valves (2,500 - 3,000 psi range when used for a 5kpsi type WCT). This header will supply eight (8) WCT valve functions for the production wells and two (2) WCT valve functions for the injection wells;
2. One header to allow the operation of downhole valves typically used with 5kpsi type DHCS-WCT (3,000 - 5,000 psi range). This header will supply two (2) downhole valve functions for production and injection wells.


The WCR 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 WCR to the SPCS HPU shall be sized with sufficient flow capacity for this purpose. The WCR shall allow all WCT and downhole valves to close in less than 10 minutes.

The Directional Control Valves for the WCR shall be spring return fail-close solenoid valve type energized from the CCR/CIS. 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 6mm² 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 the DCV and most hydraulic components be installed in stainless steel manifold blocks. The same recommendation applies for the WCR itself to be made in stainless steel.

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

Umbilical hang off for the spare manifold shall allow dual control system capability. In addition to four (4) hydraulic supplies LP1, LP2, HP1 and HP2 for umbilical hang off position of the spare manifold CONTRACTOR shall provide hydraulic supplies at TUTU Plate for a DHCS-WCT operation as described above, that is, eight (8) supplies for WCT gate valves (2,500 - 3,000psi range) and two (2) supplies for the downhole safety valve (3,000 - 5,000psi range).

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1.7. DOWNHOLE DATA ACQUISITION SYSTEM (SAS PANEL)

The SAS equipment is topside data acquisition for the satellite wells. SAS acquires the signals from Permanent Downhole Gauges (PDG) installed in wells and the pressure and temperature (TPT) digitally transmitted from the production WCT.

The SAS equipment provide RS-232, RS-485 and Ethernet network interfaces with MODBUS RTU protocol. Power can be supplied from 85-240VAC @ 60Hz or 24VDC options. Each SAS equipment requires standard 19" & 3U rack space.

CONTRACTOR shall install the SAS Equipment(s) in 19" type standard rack(s), herein referred as SAS Cabinet, with a height of 2500mm. Front and rear accesses shall be provided.

PT & TPT 4-20mA transmitters from each DHCS-WCT shall be read by the FPSO CIS/CCR system PLC and displayed in the CCR. The DHCS-WCT electrical system schematic will be provided by PETROBRAS during the execution phase.

CONTRACTOR shall provide to PETROBRAS no longer than 60 days after the contract award the preliminary drawings showing the space available in the SAS Panel to be used.

The installation, integration, commissioning and operation of these panels, onboard, are CONTRACTOR's Scope of work.

1.8. 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 1,350 psi and 3,000 psi, from any supply between 3,000 and 5,000 psi. However, all PUPS hydraulic components shall be rated to 5,000 psi operation. Each of the 12 (twelve) pressurization outlets shall be terminated with a quick connector adapter to allow the fitting of a ½" or 3/8" male JIC 37° termination prior the pressurization. Each PUPS device shall be provided with sets of at least 13x 3/8" and 5x 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 or Castrol Transaqua DW.

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

1.9. SUBSEA EMERGENCY SHUTDOWN VALVES CONTROL PANEL

CONTRACTOR shall provide the SESDV control panel for the number of SESDV according with specifications 1.2 above.

- The SESDV control panel shall be provided with two (2) regulated pressure supplies from the HPU for actuation of one (1) SESDV valves with pressures between 2,500psi and 3,300 psi;

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 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/CIS. 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 6mm² 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.

TPT 4-20mA transmitter from SESDV shall be read by the FPSO CIS/CCR system PLC and displayed in the CCR. The SESDV electrical system schematic will be provided by PETROBRAS during the execution phase.