INDEX OF REVISIONS

REV.	DESCRIPTION AND/OR AFFECTED SHEETS
0	ORIGINAL.

	REV. 0	REV. A	REV. B	REV. C	REV. D	REV. E	REV. F
DATA	26/12/2024						
PROJETO	SUB						
EXECUÇÃO	CTMK						
VERIFICAÇÃO	BFN7						
APROVAÇÃO	U4SZ						

INDEX

1. INTRODUCTION

This Technical Specification (TS) defines the minimum requirements that shall be considered by CONTRACTOR in supply the Floating Production Unit (FPU) infrastructure needed to interface with the Subsea Production Control System and Well Completion System.

2. REFERENCE DOCUMENTS

[1] I-ET-3000.00-5139-800-PEK-004	HYDRAULIC POWER UNIT FOR SUBSEA EQUIPMENT WITH MULTIPLEXED ELECTROHYDRAULIC AND DIRECT HYDRAULIC CONTROL SYSTEM (OWN FLOATING PRODUCTION UNIT)
[2] I-LI-3D10.12-5139-800-PEK-002	LIST OF CONSUMERS FOR SUBSEA HPU OF THE BUZIOS 12 PROJECT

3. TERMS, DEFINITIONS, ACRONYMS AND ABREVIATIONS

CCR: Central Control Room

CIS: Control & Interlocking System

DATS: Distributed Acoustic and Temperature Sensing

DCV: Directional Control Valve

EHMUXSCS: Electrohydraulic Multiplex Subsea Control System

e-IC: Intelligent Completion with electrical actuator

FMS: Flow Metering System

FPU: Floating Production Unit

HMXO: Hydrate Mitigator Crossover

HPU: Intelligent Hydraulic Power Unit

IWCS: Intelligent Well Control System

MCS: Master Control Station

MSGL: Subsea Gas-lift Manifold

OWS: Operator Workstation

PDG: Permanent Downhole Gauge

SIP: Subsea Interface Painel

SCM: Subsea Control Module from Subsea Production Control System

SCM-COMP: Subsea Control Module from Well Completion System

SEM: Subsea Electronics Module

SRM: Subsea Router Module

SESDV: Subsea Emergency Shutdown Valve

SPCS: Subsea Production Control System

TEOAP: Topside Electrical Optical Assignment Panel

TWAP: Topside Well Assignment Panels

TS: Technical Specification

WCS: Well Completion System

WCT: Wet Christmas Tree

4. SUBSEA PRODUCTION CONTROL SYSTEM (SPCS)

4.1. The SPCS comprises the integration between the Floating Production Unit (FPU) Central Control Room (CCR), Flow Metering System (FMS) and Control & Interlocking System (CIS) equipment and the following types of subsea control systems:

- Electrohydraulic Multiplex Subsea Control System (EHMUXSCS), for all wells, Manifold (MSGL), and PLEM that can be connected to the FPU.
- Direct Hydraulic Control System (DHCS) for subsea emergency shutdown valves (SESDVs).

4.2. 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.

4.3. ELECTROHYDRAULIC MULTIPLEX SUBSEA CONTROL SYSTEM (EHMUXSCS)

4.3.1. 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.

4.3.2. 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.

4.3.3. 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 the sea 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.

4.3.4. 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 3,000 psi and 10,000 psi for the WCT’s downhole valve(s).

4.3.5. 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.

4.3.6. Electrical power and communication for the SCM is provided from topside by a pair of EHMUXSCS Control Cabinets, which is known as the Master Control Station (MCS). 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 eight provided in the WCT umbilical electrical cable. Two other pairs are a backup against umbilical cable or electrical connector failures.

4.3.7. 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.

4.3.8. 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.

4.3.9. CONTRACTOR shall implement a robust solution within the Supervisory System to ensure seamless communication with the MCSs, regardless of which cabin is active (Master). This solution must accommodate automatic switching between MCS-A and MCS-B without manual intervention. The CONTRACTOR is required to provide a redundancy mechanism to manage the communication interface between the Supervisory System and the MCSs. This mechanism must ensure:

- **Automatic detection and switching:** The Supervisory System must automatically detect and switch communication to the active (Master) MCS.
- **Seamless transition:** No disruption in data flow or operational commands during the transition from one MCS to another.
- **Diagnostic capability:** The Supervisory System should log and report the active MCS status and any failures or transitions between MCS-A and MCS-B.

The proposed solution and its implementation details must be submitted for review and approval prior to deployment.

4.3.10. 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 Workstation (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.

4.3.11. 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 (4) 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.

4.4. DIRECT HYDRAULIC CONTROL SYSTEM (DHCS)

4.4.1. This type of control system is defined here as the one which each 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.

4.4.2. 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.

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

.

a) Subsea Emergency Shutdown Valve (SESDV):

- Between 3,000 psi and 4,000 psi.

4.4.4. The open or closed status valves from SESDV are provided by subsea pressure and position sensors. The signal from these sensors shall be connected on the CCR for display the status on the respective subsea equipment P&ID. Each subsea equipment (SESDV) is electrically connected on topside by 3 (three) twisted pair electrical cable in 4-20mA current loop protocol. The exact electrical configuration will be provided by PETROBRAS during the detail design phase.

4.5. SPCS MAIN SPECIFICATIONS

4.5.1. The SPCS may include (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;
- Subsea gas lift manifold fitted with electrohydraulic multiplex subsea control system (MSGL) Supplied by PETROBRAS;
- Subsea PLEM-CHK, the Pipe Line End Manifold equipped with a Choke Valve, limited for two wells, which can be applied for oil production (OP), gas production (GP) and water injection (WI), according to the respective P&IDs established in the project;
- Subsea Umbilical – Supplied by PETROBRAS;
- Topside EHMUXSCS **TYPE 1**: Control Cabinet pair for up to five (5) steel tubing electric-optical-hydraulic umbilical, connecting up to five wells, one umbilical per well which implies one SCM per umbilical – Supplied by PETROBRAS;
- Topside EHMUXSCS **TYPE 5**: Control Cabinet pair for up to two (2) steel tubing electric-optical-hydraulic umbilical, shared by up to five (5) wells each. In this configuration, optical fiber is allocated to the well completion system. Supplied by PETROBRAS;

- Topside EHMUXSCS **TYPE 5A**: Control Cabinet pair for up to two (2) steel tubing electric--hydraulic umbilical, where each electro-hydraulic umbilical can be shared by up to 4 ANMs and 1 MSGL. Up to a maximum of 6 (six) SCMs will share the same electro-hydraulic umbilical – Supplied by PETROBRAS;
- Topside EHMUXSCS **TYPE 7**: Control Cabinet pair for up to two (2) steel tubing electric-optical-hydraulic umbilical, shared by up to five (5) wells and two (2) PLEM (PO and/or PG and /or IA). Up to seven (7) SCM and two (2) SRM shares the same electric-optical-hydraulic umbilical – Supplied by PETROBRAS;
- Topside stand-alone Operator Workstation (OWS) pair for all EHMUXSCS Control Cabinet pairs from the same EHMUXSCS Supplier – Supplied by PETROBRAS;
- Subsea Emergency Shutdown Valve (SESDV) – Supplied by PETROBRAS;
- Subsea Interface Painel (SIP) Cabinet – Supplied by CONTRACTOR;
- Topside SPCS Hydraulic Power Unit (HPU) [1] – Supplied by CONTRACTOR;
- Topside Portable Umbilical Pressurization System (PUPS) – Supplied by CONTRACTOR.

4.5.2. As a reference, the SPCS shall provide operation control and monitoring of up to fifty-two (52) subsea equipment from the CCR:

- Up to Forty (40) EHMUXSCS-WCT. Each EHMUXSCS-WCT control and monitor the respective well downhole valves (DHSV and VHIF, if installed) and PDG.
- Up to eight (8) EHMUXSCS-PLEM-CHK. Each EHMUXSCS-PLEM-CHK control and monitor its PLEM-CHK which is equipped with choke valve.
- One (1) EHMUXSCS-MSGL. The EHMUXSCS-MSGL control and monitor its manifold only for SEAP II.
- Up to three (3) DHCS for Subsea Emergency Shutdown Valves (SESDV);

4.5.3. Each EHMUXSCS-WCT control and monitor the respective well downhole valves (hydraulic DHSV and VHIF, if installed) and PDG. The WCTs controls can be connected to the FPU in different Subsea distribution ways, such as:

- A single umbilical could be shared by up to five SCM (WCTs), limited to 2 producer wells per umbilical.
- A single umbilical could be shared by up to five SCM (WCTs and PLEM-CHK), limited to 2 producer wells per umbilical.
- A single umbilical could be shared by up to seven SCM (WCTs and MSGL), limited to 2 producer wells per umbilical.
- A dedicated umbilical per well, interconnecting up to five (SCM) to the same MCS.

Note 1: The number of WCT, manifolds and SESDVs 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 e-IC Cabinet, depending on well completion type.

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

4.5.5. 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.

4.5.6. 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 4.8, 8 and 7.

Note: Hydraulic supplies for intelligent completion system will be provided from the respective EHMUXSCS-WCT.

4.5.7. 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.

4.5.8. 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).

4.5.9. 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.

4.5.10. 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.

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

4.5.12. 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.

4.5.13. 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.

4.5.14. 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: Topside Control Cabinets for EHMUXSCS, WCS Cabinets, and SIP Panels.

Note: Topside Control Cabinets for EHMUXSCS 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 PETROBRAS. CONTRACTOR scope of supply shall also include (but it is not limited to): SIP Cabinet, 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.

4.5.15. PETROBRAS will provide the dimension drawings and interface documentation for each type of topside SPCS Control Cabinet and SIP Panels. 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.

4.5.16. CONTRACTOR shall provide installation, integration and commissioning for topside EHMUXSCS Control Cabinets manufactured by three (3) different subsea control system suppliers.

4.5.17. PETROBRAS will provide the topside SPCS Control Cabinets according to the Table 1 below:

Table 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	I1	I2	I3
2		B	P1	P2	I1	I2	I3
3		A	P3	P4	I4	I5	I6
4		B	P3	P4	I4	I5	I6
5	Type 7	A	P5	P6	I7	I8	PLEM-1
6		B	P5	P6	I7	I8	PLEM-1
7	Type 7	A	P7	P8	I9	I10	PLEM-2
8		B	P7	P8	I9	I10	PLEM-2
9	Type 7	A	P9	P10	I11	I12	PLEM-3

10		B	P9	P10	I11	I12	PLEM-3
11	Note 1	A	Cabling connecting to TEOAP-A				
12		B	Cabling connecting to TEOAP-B				
13	SIP Panel		IWCS 1			IWCS 2	
14	SIP Panel		IWCS 3			IWCS 4	
Note 1: To be defined by PETROBRAS during detail design							

4.5.18. 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.

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

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

4.5.21. 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 required to control the equipment referred in section 4.5, 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.

4.5.22. 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.

4.5.23. CONTRACTOR shall provide electrical cabling between each umbilical slot hang off electrical junction box and the SPCS Control Cabinet room with at least eight (8) high grade 0.6/1.0 kV class 6.0 mm² twisted pairs with individual shield per pair with PE (Protection Earth). Four (4) such pairs shall be dedicated to EHMUXSCS use while the other four (4) shall be used by e-IC, DHSV-e, PLEM-HMXO or SESDV or another EHMUXSCS.

4.5.24. CONTRACTOR shall provide the optical cabling between each Type 5 and Type 7 umbilical slot hang off junction box and the SPCS Control Cabinet room with at least two (2) optic cables, with 8 monomode fibers type ITU-T 657 each, to be used by the EHMUXSCS, and PDG optical cabinet.

4.5.25. CONTRACTOR shall provide at any time with no cost to PETROBRAS the reassignment of the electrical and optic connections between the eight (8) twisted pairs and two (2) optic cables from each EHMUXSCS umbilical to any individual topside SPCS Control Cabinet. For this purpose, CONTRACTOR shall provide two (2) TOPSIDE ELECTRICAL OPTICAL ASSIGNMENT PANELS (TEOAP-A and TEOAP-B). Each TEOAP (A or B) will be connected to all EHMUXSCS control cabinets, respective A or B channels, i.e., TEOAP-A to all EHMUXSCS Channel A control cabinets and TEOAP-B to all EHMUXSCS Channel B control cabinets.

4.5.26. Each TOPSIDE ELECTRICAL OPTICAL ASSIGNMENT PANEL shall be in the form of a single, enclosed type rack with front and rear doors that allows connection (four (4) electrical twisted pairs and eight (8) FO) from each EHMUXSCS umbilical to any individual topside EHMUXSCS Control Cabinet of the same Channel. The TEOAP 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 TEOAP 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, TEOAP-A, TEOAP-B, and SIP Panel in the same room to facilitate cable routing among them.

NOTE: CONTRACTOR shall ensure that ~~there will be no crosstalk or electromagnetic interference among the electrical cables in TEOAP~~ no crosstalk or electromagnetic interference (EMI) occurs between internal cables within the TEOAP panel or in any other segment of the electrical circuit associated with the infrastructure of the EHMUXSCS.

4.5.27. CONTRACTOR shall consider housing all Control Cabinets, TEOAP-A, TEOAP-B, TWAP Cabinet in the same room to facilitate cable routing among them.

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

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

4.5.30. Each SPCS Control Cabinets 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.

4.5.31. 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.

4.5.32. PETROBRAS will provide to CONTRACTOR up to three (3) desktop Operator Workstations for all EHMUXSCS Control Cabinets from the same supplier. The Operator Workstations 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.

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

4.5.34. 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 between the two following options:

i. Ethernet TCP/IP with OPC UA 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.

4.5.35. 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.

4.5.36. 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.

4.5.37. The EHMUXSCS Control Cabinet will provide the signals of the subsea gas lift flowmeters to the FMS. This signal connection will require the following interfaces between each EHMUXSCS Control Cabinet and the FMS:

- 4x MODBUS RTU over EIA/TIA 485 communication links;
- 12x 4-20 mA analog outputs;

These interfaces will be used to send gas lift instruments variables to the FMS flow computer, for flow calculation. The subsea gas lift instrument will be either a Venturi or a Cone type primary element. For each gas lift instrument, MCS will provide to the FMS the differential pressure across the primary element, static pressure and temperature.

Cabling and interfaces into the FMS for this application is under CONTRACTOR's scope.

Additionally, MEG injection flowrates, measured by individual flowmeters in each topside MEG line connected to the subsea umbilicals, shall be available in the CCR to be acquired by the EHMUXSCS Control Cabinet, either by OPC or Modbus TCP (to be defined with PETROBRAS during execution phase).

4.5.38. Each SPCS Control Cabinet rack shall be powered by 220 VAC @ 60 Hz from the FPU via UPS (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.

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.

4.5.39. CONTRACTOR shall provide the interface between the SIP Panel and the CCR. All DHCS-WCT sensors shall be displayed in the respective well P&ID screen.

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

4.6. SPCS UMBILICALS AND TOPSIDE UMBILICAL INTERFACES

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

a) 10,000 psi STU (Steel Tube Umbilical) for SESDV:

- 5 x 1/2" x 10,000 psi – Steel Tubes (see notes below);
- 1x Electrical cable with four (4) individually screened (shielded) twisted pairs of 6 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)); (see note III and IV below)
- Optic fiber.

Note: The exact SESDV umbilical configuration will be provided by PETROBRAS during the detail design phase.

b) 5,000 psi TPU (Thermoplastic Umbilical) for SESDV:

- 5 x 1/2" x 5,000 psi – Thermoplastic hoses (see notes below);
- 1x Electrical cable with four (4) individually screened (shielded) twisted pairs of 6 mm² (or 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)); (see note III and IV below)
- Optic fiber.

Note: The exact SESDV umbilical configuration will be provided by PETROBRAS during the detail design phase.

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

- 9 x 1/2" x 10,000 psi – Steel Tubes (see notes below);
- 1x Electrical cable with eight (8) individually screened (shielded) twisted pairs of 6 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)); (see note III and IV below)

Note about configuration according to WCT control system:

I. EHMUXSCS: four (4) ST for EHMUXSCS hydraulic supplies and six (6) or eight (8) ST for chemical injection;

II. The exact assignment will be provided by PETROBRAS during the detail design phase.

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

- 9 x 1/2" x 10,000 psi – Steel Tubes (see notes below);
- 1x Electrical cable with eight (8) individually screened (shielded) twisted pairs of 6 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)); (see note II below)
- Optic fiber 8F monomode specified according to ITU-T 657; (see note II below)

Note about configuration according to WCT control system:

I. EHMUXSCS: four (4) ST for EHMUXSCS hydraulic supplies and six (6) or eight (8) ST for chemical injection;

II. The exact assignment will be provided by PETROBRAS during the detail design phase.

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

- 12 x 1/2" x 10,000 psi – Steel Tubes (see note below);
- 1x Electrical cable with eight (8) individually screened (shielded) twisted pairs of 6.0 mm² (or 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));

Note about configuration according to WCT / MSGL control system:

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

II. The exact assignment will be provided by PETROBRAS during the detail design phase.

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

- 12 x 1/2" x 10,000 psi – Steel Tubes (see note below);
- 1x Electrical cable with six (6) or eight (8) 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));
- 2x Fiber optic 8F monomode specified according to ITU-T 657; (see note II below).

Note about configuration according to SDU control system:

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

II. The exact assignment will be provided by PETROBRAS during the detail design phase.

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

- 16 x 1/2" x 10,000 psi Steel Tubes (see notes below);
- 1x Electrical cable with six (6) individually screened (shielded) twisted pairs 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)) (see note below VI);
- 2x Fiber optic 8F monomode specified according to ITU-T 657;(see note II below).

Note about configuration according to WCT and PLEM-CHK control system:

I. EHMUXSCS: four (4) ST for EHMUXSCS hydraulic supplies and twelve (12) ST for chemical injection;

II. VI. The exact assignment will be provided by PETROBRAS during the detail design phase

4.6.2. All subsea control umbilical slot hang off positions shall allow the operation with 10,000 psi STU for WCT, MSGL, PLEM-CHK or Subsea Distribution Unit (SDU) with EHMUXSCS.

4.6.3. 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.

4.6.4. 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.

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

4.6.6. 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.

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

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

4.6.9. 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.

4.6.10. The subsea umbilical’s electrical pigtails are typically 600 mm long.

4.6.11. Each EJB shall have terminal blocks capable to accept any conductor size between 4 mm² and 10 mm². Terminal blocks shall be dimensioned with individual ground connections for every pair of umbilical conductors.

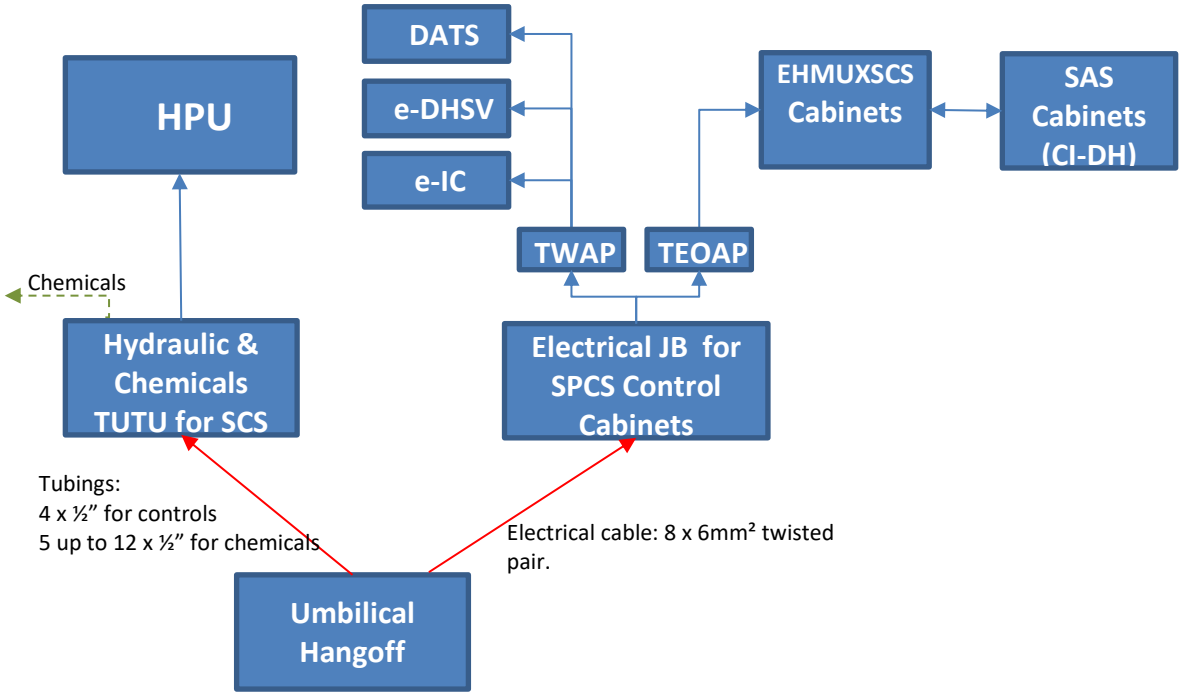
4.6.12. Each EJB shall be positioned in order to not block or interfere with pull-in/pull-out operations. Where this cannot be fully guaranteed, they shall be made removable.

4.6.13. CONTRACTOR shall present EJB design for PETROBRAS comments / information.

4.6.14. 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.

4.7. SPCS OPERATOR INTERFACES

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



Note 1: All JB and TUTU plates shall be adjustable in height;
Note 2: All JB and TUTU plates shall be removable to enable the pull in and pull out procedures.

Figure 4.4 – Typical SPCS and WCS Interface Diagram for the EHMUXSCS scenario.

4.7.2. As a preliminary requirement, the following screens shall be implemented in the Supervisory 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 PLEM, manifolds or subsea distribution units and associated wells, according to their respective P&IDs;
c) Assignment of individual wells to a PLEM, manifold or SDU subsea interconnected pair of wells;
d) e-IC (may be included in specific well's P&ID – to be informed by PETROBRAS);
e) SPCS HPU monitoring;
f) SCM monitoring;
g) e-IC monitoring;
h) e-DHSV monitoring;
i) DATS monitoring;
j) SESDV;
k) PLEM-CHK.

4.7.3. CONTRACTOR shall implement without additional 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.

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

a) Downhole valve status (open or closed);
b) Downhole pressures and temperatures;
c) WCT valve status (open 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);

4.7.5. The following minimum information shall be displayed on the CCR screens for each PLEM-CHK and MSGL respective P&ID:

a) The respective PLEM-CHK and MSGL well's P&ID;
b) Valve status (open or closed);
c) Pressure and temperatures;
d) Injection and Production 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.

4.7.6. 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;

g) Individual supply pressures for the PLEM-HMXO Control Panel.

4.7.7. 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.

4.7.8. 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;

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

Valve status (open or closed) for SESDV.

4.7.10. 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.

4.7.11. 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.

4.8. SPCS HYDRAULIC POWER UNIT (HPU)

4.8.1. CONTRACTOR shall provide SPCS HPU according to the HPU Technical Specification provided by PETROBRAS.

4.8.2. All translations of the Technical Specifications to other languages required by CONTRACTOR or by other third parties, such as vendors, and suppliers (just to name a few), shall be CONTRACTOR's responsibility and shall be part of CONTRACTOR's scope of supply.

4.8.3. The SPCS HPU shall be dimensioned in terms of reservoirs, accumulator bank, and pumps capacities according to the criteria specified by [1] and the “List of HPU Consumers”. The “List of HPU Consumers” for a given FPU determines the quantities of subsea equipment according to each type present in the project. In case this document applies to more than one FPU, each’s SPCS HPU shall be dimensioned according to the respective “Datasheet of HPU Consumers”.

4.8.4. The first 100% filling of the HPU fluid tanks is under CONTRACTOR´s scope. During operations PETROBRAS will provide the fluid make-up whenever necessary, if the HPU is operating properly and without leakages.

4.8.5. 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 3,000 psi and 10,000 psi; The upper limit may be raised to 10,000 psi in the future if needed by PETROBRAS.
- HP2: Operation between 3,000 psi and 10,000 psi. The upper limit may be raised to 10,000 psi in the future if needed by PETROBR/AS.

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

5. WELL COMPLETION SYSTEM

5.1. The well completion system has Downhole Safety Valve (DHSV) as a failsafe barrier in the event of failures in the subsea or surface production system. The actuation of theses valves considers two possibilities which are herein presented:

- Hydraulic Control when theses valves are piloted by the SCM's HP hydraulic supply which are controlled by the EHMUXSCS;
- Electric control when these valves are electrically powered from surface and controlled by its own control cabinet.

5.2. 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*);
- Full electric Intelligent Completion or e-IC (Completação Inteligente Elétrica).

5.3. 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 can send commands to open and close these valves and also read data from these

sensors. To correctly perform this specific operation, the commands will be sent to EHMUXSCS Cabinets only by equipment named Intelligent Well Control System (IWCS) that will be installed inside Well Completion System (WCS) Cabinet.

5.4. Control for e-IC downhole valves will be provided by SCM-COMP. The WCS cabinets can send commands to open and close these valves, and also read data from the sensors. 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 e-IC Cabinets.

5.5. WCS AND IWCS MAIN SPECIFICATIONS

5.5.1. The WCS AND IWCS includes (but it is not limited to) the following types of downhole and topside equipment listed below:

- Downhole valves: DHSV (safety), VHIF (formation isolation valve, if installed) – Supplied by PETROBRAS;
- Downhole Direct Hydraulic Intelligent Completion system (CI-HD) – Supplied by PETROBRAS;
- Downhole stand-alone Multiplex Intelligent Completion system (e-IC) – Supplied by PETROBRAS;
- Downhole Pressure & Temperature Transmitter (PDG) – Supplied by PETROBRAS;
- Up to three (3) Topside Control Cabinet for stand-alone Multiplex Intelligent Completion system (e-IC) – Supplied by PETROBRAS;
- Up to four (4) Topside Control Cabinet for stand-alone electrical DHSV – Supplied by PETROBRAS;
- Topside Control Cabinet for stand-alone Distributed Acoustic and Temperature Sensing installed in one injection well – Supplied by PETROBRAS;
- Topside Well Completion System (WCS) Cabinet – Supplied by PETROBRAS;
- Rack mounted Intelligent Well Control System (IWCS) equipment – Supplied by PETROBRAS;

5.5.2. PETROBRAS will provide the e-IC P&ID’s for CONTRACTOR to include in the WCS CCR screens

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

a) Topside Control Cabinets for e-IC;
b) Topside Control Cabinets for e-DHSV;
c) Topside Control Cabinet for DATS (Distributed Acoustic and Temperature Sensing);

Note: Topside Cabinets for e-IC, e-DHSV and DATS applications are herein referred only as "WCS Cabinets", except when each specific type is identified.

5.5.4. CONTRACTOR shall request PETROBRAS to specify the communication network and protocol interface between CIS/CCR with the followings equipments:

- IWCS Cabinet;
- DATS Cabinet;
- e-DHSV Cabinet; and
- e-IC control Cabinet.

5.5.5. PETROBRAS will provide the topside WCS Cabinets according to the project necessities to be confirmed during the project detail. As a previous reference only, CONTRACTOR may consider the information on Table 2 below:

Table 2 - WCS Topside Cabinets.

Individual Control Cabinet Number	Cabinet Pair Type (note 1)	Channel or Line	Preliminary assignment				
15	e-IC		e-IC 1	e-IC 2	e-IC 3	e-IC 4	
16	e-IC		e-IC 5	e-IC 6	e-IC 7	e-IC 8	
17	e-IC		e-IC 9	e-IC 10	-	-	
18	e-DHSV		DHSV-e 1	DHSV-e 2	DHSV-e 3	DHSV-e 4	
19	e-DHSV		DHSV-e 5	DHSV-e 6	DHSV-e 7	DHSV-e 8	
20	e-DHSV		DHSV-e 9	DHSV-e 10	DHSV-e 11	DHSV-e 12	
21	e-DHSV		DHSV-e 13	DHSV-e 14	DHSV-e 15	DHSV-e 16	
22	DATS		DATS 1				
23	Note 1		Cabling connecting to TWAP				
Note 1: To be defined by PETROBRAS during detail design							

5.5.6. CONTRACTOR shall provide one (1) TOPSIDE WELL ASSIGNMENT PANELS (TWAP) to interface with e-IC Cabinets, e-DHSV Cabinets and DATS Cabinet (Figure 4.4-1). The TOPSIDE WELL ASSIGNMENT PANEL shall be in the form of a single, enclosed type rack with front and rear doors that allows connection (up to four (4) electrical twisted pairs) from each EHMUXSCS umbilical to any individual topside e-IC Cabinet, e-DHSV Cabinets and DATS Cabinet. The TWAP 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 TWAP cable termination blocks or something similar for this purpose may be considered. The final configuration assignment between wells and their respective Cabinets will be confirmed by PETROBRAS up to 90 days before the FPU leaves the integration shipyard.

5.5.7. CONTRACTOR shall provide the following digital hardwire shutdown signals from CIS to each individual e-IC Control Cabinet rack and e-DHSV 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 e-IC.

5.6. WCS CABINETS AND IWCS EQUIPMENT

5.6.1. All WCS Cabinets shall be supplied by PETROBRAS according with the quantities specified on Table 2.

5.6.2. Each WCS Cabinet shall comply with the following requirements:

Cabinet with external dimensions of at least 900 mm (W) x 1400 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;

5.6.3. Power consumption of each e-DHSV Cabinet, DATS Cabinet and e-IC Cabinet will be up to 5.0 kVA. PETROBRAS will confirm the heat dissipation of these cabinets during the execution phase.

5.6.4. 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.

5.6.5. 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;

5.6.6. CONTRATOR shall take into account that WCS Cabinets 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 WCS Cabinets 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 going to provide a total of 10 man-days of technical assistance to the CONTRACTOR for equipment installation.

6. SIP PANEL

6.1. The SIP equipment is for topside data acquisition of Permanent Downhole Gauges (PDG) installed in wells completed with DHCS-WCTs.

6.2. The SIP equipment provides RS-232, RS-485 and Ethernet network interfaces with MODBUS RTU protocol. Power must be supplied with 220 VAC, phase-to-phase, 60 Hz from UPS with available internal outlets to all equipment in NEMA 5-15 standard and 24 VDC. Each SIP equipment requires standard 19" & 3U rack space.

6.3. CONTRACTOR shall install the SIP Equipment(s) in 19" type standard rack(s), herein referred as SIP Panel, with a height of 2,500 mm. Front and rear accesses shall be provided with transparent frontal door.

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

6.5. Depending on the hydraulic-type Intelligent Completion system that may be used, PETROBRAS will require up to three (3) panel mounted engineering workstations (IWCS) (each with monitor and notebook) to be installed in the SIP Panel.

6.5.1. 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.

6.6. CONTRACTOR shall provide to PETROBRAS no longer than 90 days after the contract award the preliminary drawings showing the space available in the SIP Panel to be used.

6.7. Each SIP Cabinet shall comply with the following requirements:

- Be provided with circuit breakers, fans, terminal blocks, lightning and all required materials necessary for cabinet finishing;
- All cables shall be tagged, including electrical cables from riser balcony.

6.8. CONTRACTOR shall provide each SIP 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.

6.9. 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.

6.10. For the “Integration” specified above, CONTRACTOR shall provide the complete installation and commissioning of all IWCS equipment to be provided by PETROBRAS. CONTRACTOR’s 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;

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

6.12. The installation, integration, commissioning and operation of these panels, onboard, are CONTRACTORS´s Scope of work.

7. PORTABLE UMBILICAL PRESSURIZATION SYSTEM (PUPS)

7.1. 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.

7.2. 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.

7.3. 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.

7.4. The PUPS device shall be able to pressurize each umbilical line with a regulated pressure between 1,000 psi and 5,000 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.

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

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

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

8. SESDV CONTROL PANEL

8.1. CONTRACTOR shall provide the SESDV and PLEM-HMXO control panel for three (3) SESDV valves according with specifications 4.5 above.

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

- Up to three (3) SESDV valves with pressures between 3,000 psi and 5,000 psi;

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

8.3. 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.

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

8.5. 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 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.

8.6. 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.

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