PETROBRAS	**TECHNICAL SPECIFICATION**	Nº I-ET-3000.00-1518-814-PEK-001	
	CLIENT PETROBRAS		SHEET 1 of 20
	JOB HISEP™ TECHNOLOGY DEVELOPMENT		
	AREA –		
SUB/ES	TITLE **SUBSEA LEVEL MONITORING SYSTEM FOR SUBSEA SEPARATION SYSTEM**		PUBLIC SUB/ES/EECE/ECE

REVISION INDEX

REV.	DESCRIPTION AND/OR REVISED SHEETS
0	Original
A	Included additional HSE requirements for handling radioactive sources and revised qualification requirements.

Note: This technical specification has been done with collaboration works and technical assistance of:

LIBRA/SOE/SUB
CTL6

SUB/ES/EECE/ECE
ES34
CXS2

	REV. 0	REV. A	REV. B	REV. C	REV. D	REV. E	REV. F	REV. G	REV. H
DATE	09/11/2020	31/03/2021							
DESIGN	EECE/ECE	EECE/ECE							
EXECUTION	BYE8	BYE8							
CHECK	Y5UJ	Y5UJ							
APPROVAL	UR6A	UR6A							

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1 INTRODUCTION

This document presents the Technical Specification of the subsea level monitoring system applicable for a subsea fluid separator system installed inside gravitational separator vessels.

1.1 SUBSEA LEVEL MONITORING SYSTEMS

1.1.1 The purpose of a subsea level monitoring system (SLMS) is to detect the levels of sand, water, emulsion, oil, foam and gas inside the gravitational separator vessel outlet section in order to support the process control of a subsea separation system (Figure 1).

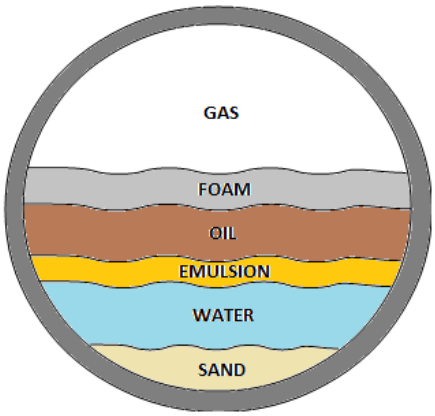

Figure 1 — Typical vessel separator levels

1.1.2 The SLMS has to accurately detect the water, oil and gas levels in the vessel according to a density calibration values, as well as measuring the buildup of sand at the bottom of the separator vessel.

1.1.3 The SLMS main instrumentation shall be a density profiler using nucleonic measurement technology. The radiation received by one of the sensor element (e.g. Geiger-Müller tubes) in the detector is proportional to the average density of the medium between the radiation source and the sensor element.

1.1.4 The SLMS backup instrumentation shall be a DP level measurement. The DP measurement consists of a dual separate pressure sensors that senses fluid pressure from bottom part of the vessel as the LP input and from top part of the vessel as the HP input.

2 ABBREVIATION

CCR	Central Control Room
DP	Differential Pressure
EFL	Electrical Flying Lead
FAT	Factory Acceptance Test
FPU	Floating Production Unit
HP	High Pressure
HSE	Health, Safety and Environment
ICSS	Integrated Control and Safety System
I/O	Input/Output
JB	Junction Box
LAN	Local Area Network
LP	Low Pressure
OPC	Open Platform Communications (from OPC Foundation)

OPC UA	OPC Unified Architecture
PBOF	Pressure Balanced Oil-Filled
PCB	Printed Circuit Board
PLC	Programmable Logic Controller
QA	Quality Assurance
QC	Quality Control
RIM	Reliability and Integrity Management
ROV	Remotely Operated Vehicle
SCM	Subsea Control Module
SIIS	Subsea Instrument Interface Standardization
SIT	System Integration Test
SLMS	Subsea Level Monitoring System
SSS	Subsea Separation System
SSS-CS	Subsea Separation System – Control System
SSS-OWS	Subsea Separation System – Operational WorkStation
SSS-MCS	Subsea Separation System – Master Control Station
SSS-SCS	Subsea Separation System – Supervisory and Control System
TMA	Technology Maturity Assessment
TRC	Technology Risk Categorization
TRL	Technology Readiness Level
UTA	Umbilical Termination Assembly

3 REFERENCE DOCUMENTS, CODES AND STANDARDS

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

API 17F	Standard for Subsea Production Control Systems
API 17Q	Recommended Practice on Subsea Equipment Qualification
API 17N	Recommended Practice on Subsea Production System Reliability, Technical Risk, and Integrity Management
ASME B16.5:2013	Pipe Flanges and Flanged Fittings
ASTM A320:2015	Standard Specification for Alloy-Steel and Stainless Steel Bolting for Low-Temperature Service
DNVGL-RP-B401:2017	Cathodic Protection Design
VIM 2012	International Metrology Vocabulary: Fundamentals, general concepts and associated terms (INMETRO, 2012)
CNEN NN 3.01	Basic Guidelines for Radiation Protection

4 DEFINITIONS

SSS CONTRACTOR	The company contracted by PETROBRAS to design, supply and install the Subsea Separation System (SSS), including the level monitoring system (focus of this technical specification)
SLMS CONTRACTOR	The company contracted by Subsea Separation System CONTRACTOR to design, supply and install the level monitoring system (specifically, density profiler solution).
MAY	Is used when alternatives are equally acceptable

SHOULD	Is used when a provision is not mandatory, but is recommended as a good practice
SHALL	Is used when a provision is mandatory
WET-MATE [CONNECTOR]	Subsea connector designed for plugging/mating in underwater environments

5 TECHNICAL CHARACTERISTICS

5.1 DESIGN AND FABRICATION

5.1.1 All subsea equipment shall be designed in accordance with API 17F.

5.1.2 All subsea equipment shall be designed for the same water depth as the SSS design.

5.1.3 Selection of materials for all subsea structures shall be in accordance with DNVGL-RP-B401:2017 item 5.5, and be designed for the same design life as the subsea separation system.

5.1.4 Electrical and communication analyses shall be performed, including simulations considering the parameters of specified cable types (for deck, umbilical and subsea cables).

5.2 QUALIFICATION

5.2.1 All subsea equipment shall be qualified to reach TRL 4 and TRC C, as minimum, in accordance with API 17Q and API 17N, respectively; and API 17F to comply with the technical requirements from the SSS.

5.2.2 SSS CONTRACTOR shall perform a TMA before starting project's detailing phase, as per API 17Q and API 17N, of the SLMS and its components to evaluate the monitoring system and each of its component´s technical risk and maturity in line with SSS application characteristics and safety and performance goals.

5.2.2.1 TRL shall be assessed using the design requirements stated in this technical specification. Only TRL 4, i.e., product validated and tested, or Field Proven equipment, shall be proposed as part of SSS scope of supply.

5.2.2.2 TRC shall be assessed using, at least, the change risk factors stated in API 17N for equipment and for procedures. SSS CONTRACTOR shall implement actions in its RIM for each change risk factor classified as 'A – Very High' or 'B – High' to reduce it, at least, to 'C – Medium', as stated in API 17N.

5.2.2.3 SSS CONTRACTOR shall present the SLMS TMA Report in the first technical meeting, together with the action plan with detailed scope and schedule to assure TRC C achievement during all project life cycle stages, from Detail Design to Operation.

5.2.3 SSS CONTRACTOR shall provide a Qualification Assurance Report before starting project's detailing phase, as per API 17N, assuring TRL 4 to SLMS and its components and reporting, as a minimum, the following:

5.2.3.1 Design documentation of the production unit designed, built and tested to assure TRL 4 including the complete list of design documents with document number, title, revision, emission date and summary, covering, as a minimum:

- Design specification: including design datasheet, cathodic protection requirements and intended installation and intervention procedures.
- Design drawings: detailed, scaled mechanical drawings including weights, dimensions, cross sections and material and parts lists.

- Material specification: materials selection report including material list and properties. Compatibility details, test procedures and report.
- Design analysis report: containing electrostatic, magnetic, mechanical, electrical, thermal and materials calculations and theoretical studies.
- Handling, transportation and storage: Document containing intended handling, transport and storage procedures.

5.2.3.2 Qualification Process documentation of the production unit designed, built and tested to assure TRL 4 including the complete list of detailed test procedures and test reports with document number, title, revision, emission date and summary.

5.2.3.3 Improvements arising from the production unit manufacture and assembly procedures, tools and facilities.

5.2.3.4 Improvements arising from qualification testing and assessment.

5.2.3.5 Improvements in QC/QA procedures.

5.2.3.6 List of manufacturing, assembly, testing and QC/QA documents validated through SLMS qualification test program to achieve TRL 4 and TRC C with document number, title, revision and emission date.

5.2.3.7 Potential SLMS and component´s weaknesses, residual risks and uncertainties.

5.2.4 SSS CONTRACTOR shall provide, before starting project's detailing phase, a Track Record Report for SLMS and its components assured Field Proven reporting, as a minimum, the following:

5.2.4.1 List of previous installed SLMS informing:

- Operator and project name;
- Operation conditions: water depth, ambient temperature, maximum and minimum internal vessel pressure and temperature, vessel specifications (wall thickness, bill of material including any inner lining material, dimensions, maximum rate of deposition at inner vessel walls and types of compounds deposited);
- Main components: nucleonic density profiler solution, DP sensors instrumentation;
- Installation main characteristics: type of foundation, installation tool or sling, installation and retrievable method.

5.2.4.2 Design documentation including the complete list of design documents with document number, title, revision, emission date and summary, covering, as a minimum:

- Design specification: including design datasheet, cathodic protection requirements, installation and intervention procedures.
- Design drawings: detailed, scaled mechanical drawings including weights, dimensions, cross sections and material and parts lists.
- Material specification: materials selection report including material list and properties. Compatibility details, test procedures and report.
- Design analysis report: containing mechanical, electrical, thermal and materials calculations and theoretical studies.
- Handling, transportation and storage: Document containing handling, transport and storage procedures.

5.2.4.3 Manufacture and Assemble main processes description.

5.2.4.4 Improvements arising from SLMS manufacture and assembly procedures, tools and facilities.

5.2.4.5 Improvements arising from system integration, installation and subsea operations.

5.2.4.6 Improvements in QC/QA procedures.

5.2.4.7 List of manufacturing, assembly, testing and QC/QA documents to assure TRC C with document number, title, revision and emission date.

5.2.4.8 Potential SLMS and component´s weaknesses, residual risks and uncertainties.

5.2.5 PETROBRAS, as its own discretion and during all project phases, may ask for a dataroom to verify any document listed in the TMA Report, Qualification Assurance Report and/or Track Record Report.

6 TECHNICAL REQUIREMENTS

6.1 SYSTEM OVERVIEW

6.1.1 Figure 2 presents a general diagram of the SLMS for subsea separation system.

6.1.2 The main system is composed of:

- Subsea density profiler solution (section 6.3);
- Subsea DP sensors solution (section 6.4);
- Subsea electrical cabling (section 6.5);
- SLMS topside processing system (sections 6.7 and 6.8).

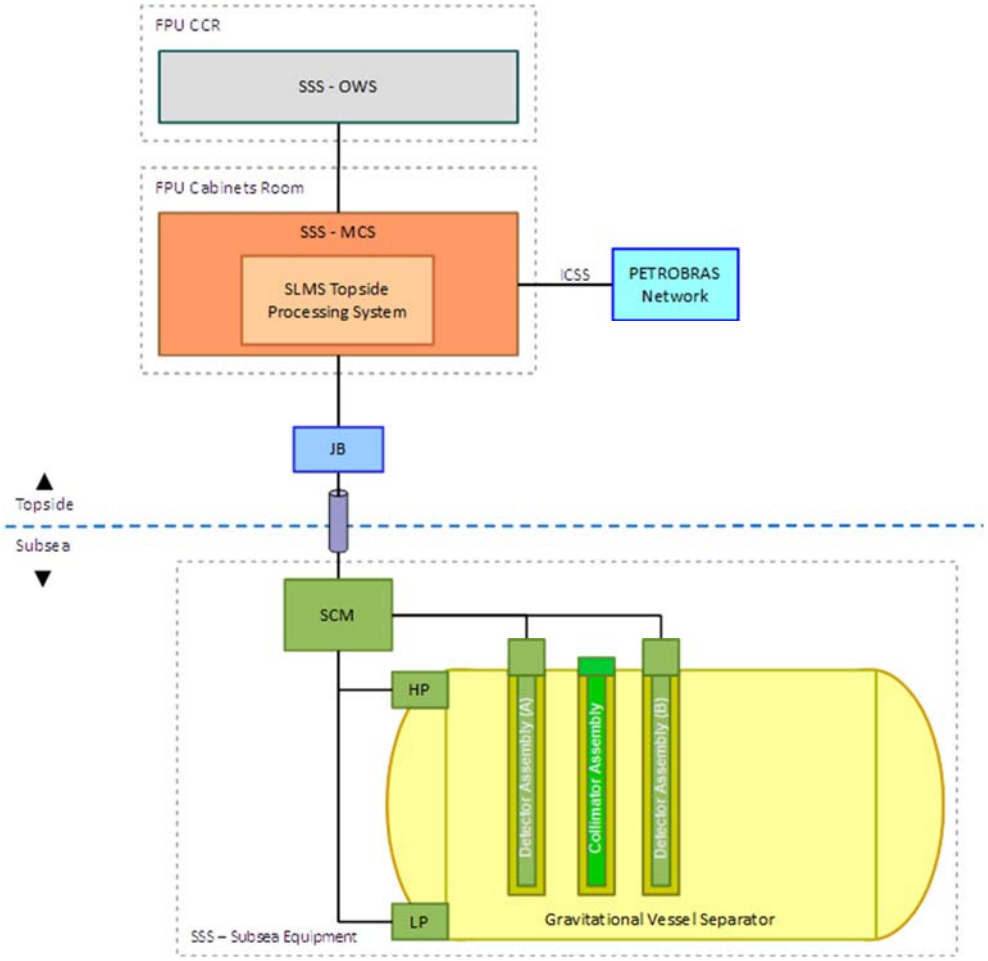

Figure 2 — SLMS General Arrangement

6.2 GENERAL REQUIREMENTS

6.2.1 Design life of the subsea components shall be the same of the subsea separation system.

6.2.2 All the subsea components shall be qualified for the project's subsea separation system water depth and under water pressure & temperature scenario.

6.2.3 The vessel subsea sensing components shall also be qualified and calibrated for the project's fluids process composition, density, pressure and temperature operational range.

6.2.4 To design, supply, test and commission the SLMS density profiler solution (subsea and topside scopes), SSS CONTRACTOR shall select a SLMS CONTRACTOR: with a previous experience (track record) in a subsea system supplied & installed worldwide and operating continually without failure for a period of 2 years in water depths for at least 500 meters.

6.2.5 During the executive design SSS CONTRACTOR shall submit to PETROBRAS approval a Technical Proposal of the SLMS for SSS, including the evidence of attending item 6.2.4 for the SLMS density profiler solution.

6.2.6 The half-life of all gamma radioactive sources shall be dimensioned to be bigger than half of project's subsea separation system design life (but not smaller than 10 years).

6.2.7 For components with gamma radioactive sources, it is SSS CONTRACTOR's responsibility to fully comply with the provisions of CNEN NN 3.01 standard for handling, storing, manufacturing and assembling activities carried out in Brazil at its facilities. SSS CONTRACTOR shall comply with the HSE requirements related to radioactive sources from ANNEX A.

6.2.8 The components with gamma radioactive sources shall be manufactured in such a way that during the operation, maintenance and storage of these components and its parts, workers are not exposed to radiation above the limit defined at item 5.4.2 of CNEN NN 3.01 standard.

6.2.9 The purpose of level monitoring is to accurately detect the water, oil and gas levels in the vessel during operational life in order to support the SSS control system.

6.2.10 The Figure 2 presents a general overview of level monitoring installation schematic including other components from SSS control system, i.e. SCM.

6.3 SUBSEA DENSITY PROFILER SOLUTION

6.3.1 The Subsea Density Profiler Solution shall comprises the two main components:

- Subsea collimator radiation source assembly rod;
- Subsea radiation detector assembly rods (A & B).

6.3.2 The subsea collimator assembly shall hold a source-arming rod that contains a series of radioactive sources along its length. The rod shall be surrounded by a tube called as collimator which shall have small holes drilled in it at each source level as shown in Figure 3.

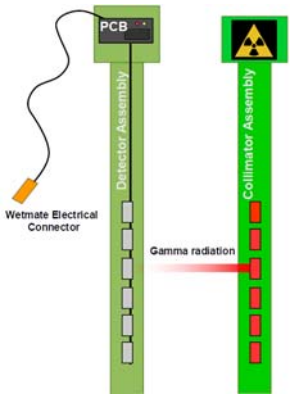

Figure 3 — Typical probe collimator and detector arrangement.

6.3.3 These holes direct a narrow beam of radiation towards an adjacent radiation detector sensor element (e.g. Geiger Muller tube) in the probes, which are mounted inside the detector assemblies. Fluid material between the two vessel dip pipes will attenuate the radiation and so the intensity of radiation seen by the sensor element is related to the density of the intervening material. The distance between all sets of sources/detector sensing element shall be the same along the assemblies. All sources shall have the same standard radiation beam angle.

6.3.4 The arming rod shall be attached to the arming mechanism on the top of the collimator. This operation shall only be operated in dry conditions. When the arming mechanism shall be locked in the shut position the alignment of the sources and the collimator shall be such that the sources are isolated and the radiation from the Profiler shall be at a significantly reduced level.

6.3.5 The resolution desired for level measurement with subsea density profiler solution should be around 1 cm. If SLMS CONTRACTOR solution could not achieve this requirement, SLMS CONTRACTOR shall present from profiler solution design the minimum level measurement resolution (shall be smaller than 5 cm) for PETROBRAS approval during project's detailing phase.

6.3.6 Each detector sensing element output shall gather radiation raw data by a signal processing PCB mounted in the top canister of the detector assembly. The raw data shall be digitalized by the Signal Processing PCB and are relayed topside for engineering processing data by the SLMS Data Collector System.

6.3.7 The collimator assembly shall not be subsea retrievable during SSS operational life. However, SSS CONTRACTOR shall design a solution for retrieving in a safe way during decommissioning phase with ROV operations before removing the subsea vessel.

6.3.8 The detector assemblies (A and B) shall be redundant and both shall be separated subsea retrievable units during SSS operational life using ROV operations.

6.3.9 Both detector assemblies' (A and B) data shall be electrically connected to the SSS-CS SCM for power and communication purposes interfaced by a retrievable ROV panel and the SSS-CS electrical distribution. The connection between each SLMS detector and the ROV panel shall be performed by the correspondent EFL with a single wet-mate connector (represented in Figure 3). The connection between ROV panel and the SSS-CS electrical distribution shall be performed by 2 (two) EFLs, each one corresponding to one SLMS detector.

6.3.10 Both detector assemblies' (A and B) data should communicate using SIIS level 2 (CANopen CiA-443). Other communication protocol shall be presented to PETROBRAS approval during project's detailing phase.

6.3.11 It shall be presented a report regarding the density measurement expected deviations, and therefore level measurement, along the system lifetime based on the expected marine growth, any other solid built up, dip pipes wall thickness, or any other built-in system particularities, like source rod cells decay or aged sensors that could lead to deviations in the sensors readings:

a) This report shall present to each of them the way to recalibrate to achieve good readings again from the sensors;

b) This report shall indicate the expected frequency of recalibration that should be required by what have been assessed;

c) This report shall present what are the design mitigation actions that will be taken in the source rod / sensors / geometry / dip pipe surface treatment / or any other identified ways to keep the readings from the profilers as long as possible without the need of recalibration.

6.4 SUBSEA DP SENSORS SOLUTION

6.4.1 The subsea DP sensors solution shall be a backup level measurement solution for the SSS.

6.4.2 The SSS CONTRACTOR shall design the subsea DP sensors solution for at least two main pressure sensors sockets (at the top and the bottom of the separator vessel).

6.4.3 For the subsea DP sensors level measurement, the calculation shall be based in different constants densities of the process fluid's phases.

6.4.4 This constants shall be configurable during pre-commissioning phase and during SSS project's operational life whenever required.

6.4.5 The SSS CONTRACTOR shall present the strategy to configure this constants during pre-commissioning phase and also during the SSS project's operational life of the system whenever required.

6.4.6 The subsea pressure sensors shall be intrusive ("flush" type), not retrievable and with full redundancy (i.e. redundant sensing element and internal electrical components).

6.4.7 The connection with the separator vessel shall be made with API 6BX flange 1.13/16" – 10K psi. The thickness of the pressure sensors flange shall match a 92 mm long screw. The material hardness of the pressure sensors flange shall be compatible with the material hardness of the type BX seal ring. The pressure sensors shall have hole(s) to allow hydrostatic testing to be performed on the BX ring after installing the pressure sensors in the separator vessel from outside to inside, meaning the need for o-rings on the flange.

6.4.8 The subsea pressure sensors shall be qualified and tested in order to confirm its resistance for installation conditions (shock and vibration) and storing (open-air area) of the separator vessel before offshore installation.

6.4.9 If absolute pressure readings sensors (with DP calculation) are applied to be considered for DP measurement use, the following list present some of metrology specifications (according to VIM 2012) of the pressure sensors shall comply:

- Calibration range: 0 to 10k psi;
- Maximum admissible pressure: 15k psi;
- Rupture pressure: 20k psi;
- Calibration temperature: 0º a +120 ºC;
- Operational temperature: - 20º a +120 ºC;
- Stability: +/- 0.1 % full-scale/year;
- Accuracy: +/- 0.2 % full-scale ("zero/span setting and temperature effects" – TOTAL ERROR BAND);
- Repeatability: 0.06 % full-scale;
- Resolution: 0.03 % full-scale.
- Level Accuracy: +/- 5 cm or better (**Note 1**);

If differential pressure technology sensors are applied for conventional DP measurement, the following list present some of metrology specifications (according to VIM 2012) of the pressure sensors shall comply:

- DP calibration range: 0 to 3 psi;
- Calibration temperature: 0º a +120 ºC;
- Operational temperature: - 20º a +120 ºC;
- Stability: +/- 0.1 % full-scale/year;

- DP pressure accuracy: +/- 0.2 % full-scale ("zero/span setting and temperature effects" – TOTAL ERROR BAND);
- Repeatability: 0.06 % full-scale;
- DP resolution: 0.03 % full-scale.
- Level Accuracy: +/- 5 cm or better (**Note 1**);

Note 1: The level accuracy shall be demonstrated by SSS CONTRACTOR by submitting a complete report for PETROBRAS approval on how this accuracy will be achieved by the selected DP measurement technology that will be applied and also by the expected fluid behavior and separation pressures during the system operational lifetime.

6.4.10 The characteristics on § 6.4.9 are minimum and shall be replaced and complemented by adequate parameters in case of process fluid having more stringent requirements.

6.4.11 All subsea pressure sensors data shall be electrically connected with EFLs to the SCM for power and communication purposes.

6.4.12 All subsea pressure sensors data should communicate using SIIS level 2 (CANopen CiA-443). Other communication protocol shall be presented to PETROBRAS approval during project's detailing phase.

6.5 SUBSEA CABLING

6.5.1 The SLMS subsea components units shall be connected to SCM through electrical cables installed at ROV interface panel in order to power supply and communicate with these components.

6.5.2 The ROV interface panel design for interconnection with SLMS detectors shall be a retrievable solution and wet mate connectors parking places shall be supplied as well.

6.5.3 SSS CONTRACTOR shall propose the pinout of this cabling in its design and submit a proposal for PETROBRAS approval.

6.5.4 Subsea cabling shall be qualified and tested for SSS project's environment.

6.5.5 The EFLs shall be terminated in a wet-mate connectors with the following requirements:

- Be ROV operated;
- Be dual barriers oil filled solution, pressure compensated design;
- Be housing made with a corrosion resistant solution without cathodic protection necessity;
- Be qualified according to API 17F;
- Be suitable for operation in the foreseen environment, able to operate in a depth of at least 3000 m;
- Be able to withstand at least 100 connection/disconnection cycles;
- Have a design life as per SLMS project and not less than 25 years
- Have a qualified PBOF hose solution for mounting the internal cabling.

6.6 SYSTEM TOPOLOGY

6.6.1 Figure 4 shows the connection topology of SLMS. Marked in red, the scope of supply of this technical specification. The other components shall be specified in SSS documents, however some additional requirements are herein presented.

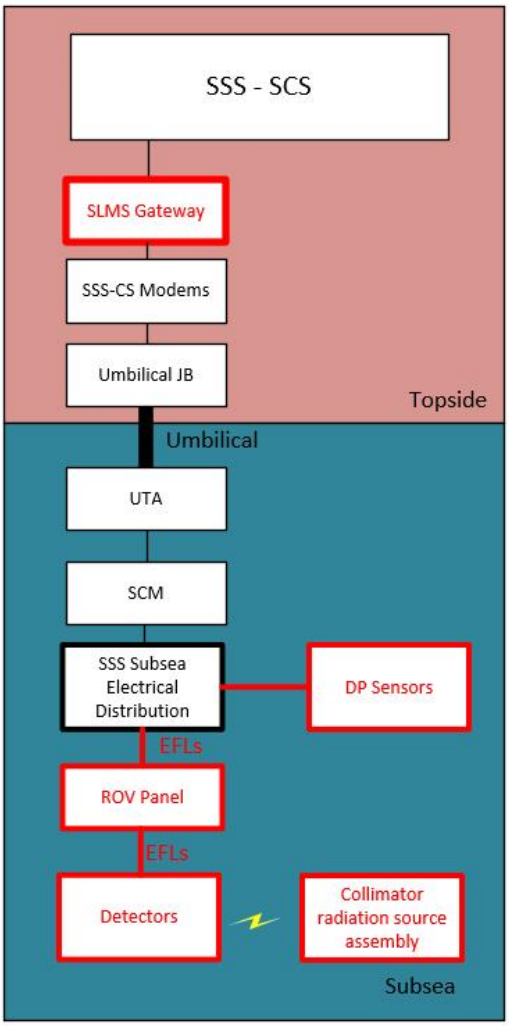

Figure 4 — SLMS Scope of supply.

6.7 SLMS GATEWAY

6.7.1 The SLMS Gateway shall have the function to receive data from SLMS subsea sensors, process and provide it to SSS-SCS. Data from SLMS subsea sensors are collected by the SSS-CS equipment (including SCMs and surface modems) and then provided to the SLMS Gateway.

6.7.2 The SLMS Gateway should run with a PLC redundant solution. Other automation redundant solution may be presented to PETROBRAS approval during project's detailing phase.

6.7.3 The SLMS Gateway shall collect data from all the various specified sources (from section 6.3 and 6.4) and therefore act as a hub for processed data distribution. It shall operate autonomously without any need for operator intervention. It shall operate automatically with initialization by SSS-SCS.

6.7.4 The SLMS Gateway shall be installed and integrated inside SSS-MCS.

6.7.5 All raw data (from subsea detector assemblies and pressure sensors) shall be collected at SCM and then be routed to topside until reaches SLMS Gateway by SSS-CS LAN.

6.7.6 The SSS-SCS shall provide time reference to synchronize all gathered data from SLMS.

6.7.7 Data shall be continuously retrieved from the subsea instrumentation. The sampling period shall be 1 second or less and a timeout event shall be understood as the unsuccessful retrieval of 3 consecutive samples.

6.8 SSS SUPERVISORY AND CONTROL REQUIREMENTS

6.8.1 The SSS-SCS shall have a dynamic mode which shall be activated automatically when the level changes outside of a predetermined rate of change envelope or level goes beyond a configurable threshold. The purpose of the dynamic mode shall be to enable a global fast response from the control system, based in a level measurement with a lower time constant response. Once the system level has stabilized to a predetermined level it shall return automatically to its longer/normal time constant.

6.8.2 SLMS processed data shall present at dashboard screens for data visualization from SSS-OWS at CCR.

6.8.3 The SSS-SCS shall have a dedicated screen to configure the density ranges for each phase in the vessel, at supervisory level access.

6.8.4 All data collected (raw and processed data) by SLMS shall be available via standardized OPC UA (Unified Architecture) interfaces as follows:

- OPC UA Data Access (DA) for real-time data.
- OPC UA Historical Access (HA) for historical data.
- OPC UA Alarms & Conditions (AC) for alarms.

6.8.5 SSS-SCS shall provide access to all configuration and maintenance interfaces of the various sensors and equipment.

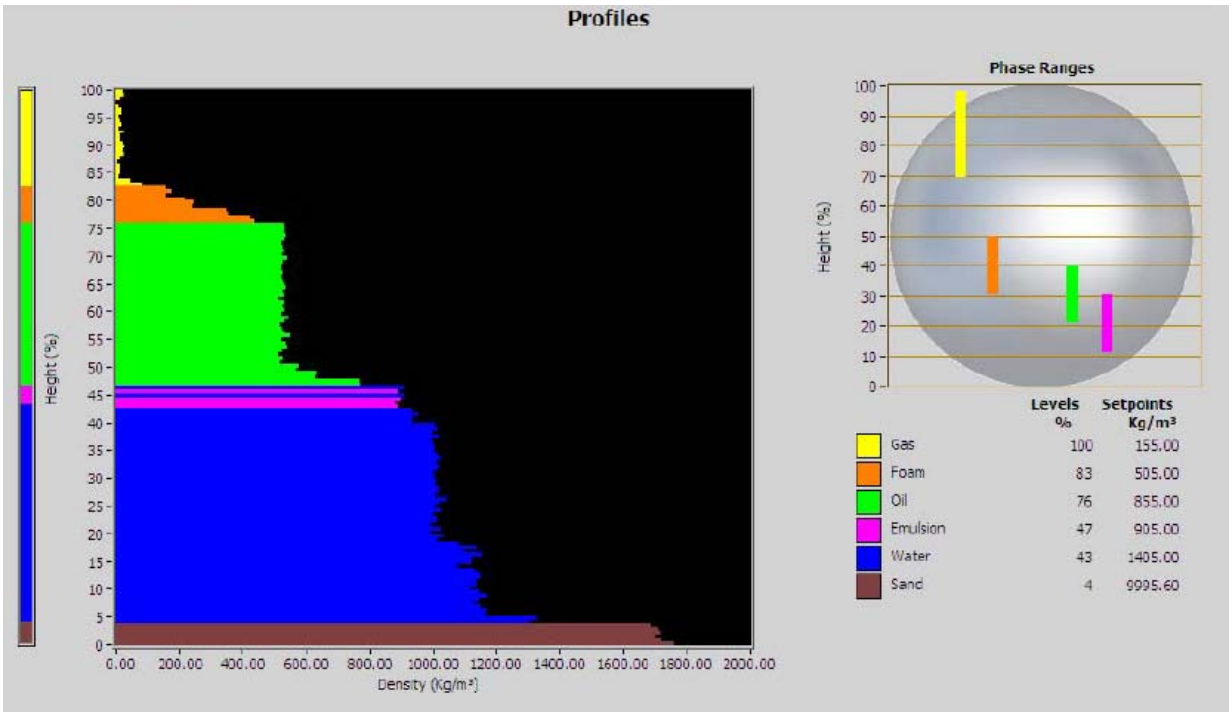

Figure 5 — HMI screenshot example

6.8.6 Dedicated supervisory screens shall report the value of every monitored variable as they are acquired, along with the status of communication channels.

6.8.7 Supervisory system shall have specific screens that permit recalibration of all SLMS sensors individually during any time during SSS operation life. After recalibration, Gateway shall update to use the new calibration parameters.

6.8.8 The supervisory shall allow for the querying and plotting of historical data for user-selectable intervals. Users shall be able to export data sets to files compatible with Microsoft Excel 2003 or newer.

7 SERVICE REQUIREMENTS

7.1 QUALIFICATION TESTING

7.1.1 All subsea equipment shall be qualified in accordance with API 17Q and API 17F.

7.1.2 Previously qualified equipment may be presented to PETROBRAS approval and, if necessary, SSS CONTRACTOR shall provide the qualification program to be witnessed/certified by an accredited independent party or by a PETROBRAS representative.

7.2 FACTORY ACCEPTANCE TESTING

7.2.1 All subsea equipment (including deliverable spares) shall undergo FATs in accordance with API 17F.

7.2.2 All subsea measurement sensors sets shall be calibrated after installed at separator vessel. Calibration reports shall be presented to demonstrate performance requirements are met.

7.2.3 All sensor units shall undergo a full functional test. These tests shall demonstrate correct and stable long-term operation in all possible modes.

7.2.4 Dimensional and electrical checks shall be performed on all sensor units.

7.3 SYSTEM INTEGRATION TESTING

7.3.1 SIT shall be performed with the purpose of verifying interfaces between components and proper operation of the system as a whole.

7.3.2 All mechanical, electrical, instrumentation and automation interfaces shall be functionally tested.

7.3.3 All system operation modes (and combinations thereof, when multiple components are involved) shall be tested with the aim of ensuring proper long-term, stable operation.

7.3.4 The system integration test shall be performed with the actual components of the system.

7.3.5 The proper operation of external data interfaces (OPC UA) shall be attested with a connection to a test computer running client data acquisition software.

7.4 INSTALLATION AND COMMISSIONING REQUIREMENTS

7.4.1 The requirements presented in this section shall be met regarding commissioning activities. Planning of installation and commissioning activities shall be developed and submitted for PETROBRAS approval.

7.4.2 Commissioning is understood, in this context, as the process of placing the system (or parts thereof related to a particular monitored structure) in a fully functional state, without any pending issues.

7.4.3 SSS CONTRACTOR shall install and commissioning all equipment and cables included in its scope (including redundancies). PETROBRAS shall inform about requirements to onboard activities.

7.4.4 SSS CONTRACTOR shall provide all tools, accessories and consumables required for these activities.

7.4.5 All equipment shall be tested onshore before deployment at sea. Testing and interventions on equipment shall not be planned or performed during offshore deployment (on deck), save for emergency occasions, in which case approval shall be explicitly given by PETROBRAS.

7.4.6 The system shall be delivered with all configurable parameters (such as alarms, safe limits and calibration coefficients) preset to correspond to the SLMS design data.

7.4.7 FPU components shall be installed and commissioned prior to installation of SSS, in order to be ready to receive monitoring data as soon as it becomes available.

7.4.8 The commissioning schedule of monitoring system shall be agreed with PETROBRAS.

8 SCOPE OF SUPPLY

8.1.1 SSS CONTRACTOR shall design, supply and install the topside equipment for SLMS as described in item 6.

8.1.2 SSS CONTRACTOR shall design, supply and install SLMS subsea sensors, and all needed structure for separator vessel as section 6.

8.1.3 Supply the minimum spare units of subsea system to each separator vessel related to SLMS:

- 1 x Detector assembly (from section 6.3);
- 1 x ROV Interface panel with all necessary EFLs (from section 6.5).

8.1.4 Spare units shall be identical to the items they replace and undergo the same fabrication, calibration and testing. Spares shall be supplied in packaging proper for long-term storage.

9 SCOPE OF WORK

9.1.1 Before the SLMS executive design, SSS CONTRACTOR shall submit to PETROBRAS approval a Technical Proposal of the SLMS, including the design basis of technical solution, presenting evidences of attending main points of item 6.2.

9.1.2 SSS CONTRACTOR shall design the entire SLMS system as described in section 6.

9.1.3 SLMS CONTRACTOR shall provide all qualification needed to attend this technical specification for density profiler solution (see item 7.1).

9.1.4 SSS CONTRACTOR shall design, configure and supply the SCM for gathering the raw data from subsea and interface with the topside processing system.

9.1.5 SSS CONTRACTOR shall provide FATs to SLMS (see item 7.2).

9.1.6 SSS CONTRACTOR shall provide SIT (see item 7.3);

9.1.7 SSS CONTRACTOR shall commission the entire SLMS (see item 7.4).

9.1.8 SSS CONTRACTOR shall provide documentation and training as defined at sections 10 and 11.

10 DOCUMENTATION REQUIREMENTS

10.1.1 Documentation shall be issued in compliance with agreed standards and formal processes.

10.1.2 All documentation delivered to PETROBRAS shall conform to the following PETROBRAS standards:

- N-0381 – format and execution
- N-1710 – identification/coding

10.1.3 Safe operation limits of monitored structures shall also be delivered to PETROBRAS in the form of a document.

10.1.4 The SLMS documentation shall include at least the following:

- Design basis;
- Detailed design documentation covering, among others, equipment, software, cabling and general accessories;
- Mechanical drawings for all individually delivered assemblies;
- Basic design for decommissioning procedures of radioactive elements at the end of project's life;
- Datasheets, manuals and certificates for every equipment/instrument when applicable, covering operation, maintenance and installation guidelines;
- Calibration procedures, reports and certificates for every sensor;
- Equations and calibration curves used for converting raw sensor data into engineering values, along with all coefficients used in conversion, for all sensors;
- Detailed system arrangement, including but not limited to, electrical diagrams, cable layout and equipment interconnection diagrams;
- LAN diagram and complete descriptions of all communication protocols used between equipment;
- Detailed definition and specification of the alarm system designed for the supervisory system;
- Complete OPC I/O list with all implemented tags;
- As-built drawings, when applicable;
- Detailed installation procedures;
- Detailed procedures maintenance operations to be performed by third parties, including ROV operations to be executed by the maintenance team;
- Detailed test and commissioning procedures and reports;
- System operation and maintenance manuals;
- Training plan.

11 TRAINING REQUIREMENTS

11.1.1 Training shall be provided to qualify personnel appointed by PETROBRAS to operate and maintain (install, dismantle, replace parts and make adjustments) each system component.

11.1.2 Training shall be performed at PETROBRAS facilities in Rio de Janeiro, Brazil (on-shore). Training courses shall be given for two classes of 10 students (total of 20 students). The two classes shall be scheduled at least 1 month apart, to accommodate for PETROBRAS offshore labor regime. Training course shall be sized for 3 days as a minimum. Lessons shall be taught in Portuguese.

11.1.3 The training program shall cover basic system operation and maintenance aspects. A detailed training program shall be submitted for PETROBRAS approval.

11.1.4 The training program shall cover, at least, the following items:

- Complete description of equipment and system;
- Technical and operational characteristics;
- Operating principles;
- Operational cautions and warnings;
- Operational procedures and routines;
- Preventive maintenance routines (e.g. recalibration procedures);
- ROV operations (detector assembly rod retrieval and replacement);
- Supervisory system operation;
- Storage and conservation of spare equipment.

ANNEX A: ADDITIONAL REQUIREMENTS FOR RADIOACTIVE SOURCES

A.1 Obligations for SSS CONTRACTOR:

A.1.1 Provide the manufacturer's name, date of fabrication, all activities and serial number of the source(s).

A.1.2 Provide the certificate of the source(s).

A.1.3 Provide the technical data, manufacturer's name, model and serial number of the Nucleonic Meter or Ionizing Radiation Generating Equipment, as per ANNEX "A".

A.1.4 Provide, in Portuguese, the operation and maintenance manual for the Nucleonic Meter, Radioactive Source or Ionizing Radiation Generating Equipment, detailing the safety procedures that may be necessary.

A.1.5 Provide, in Portuguese, the technical manual for the Nucleonic Meter or Ionizing Radiation Generating Equipment and the necessary guidelines for the elaboration of procedures for installation, operation, intervention in the equipment and its removal.

A.2 Documentation required for supply:

A.2.1 Certificate of the source(s), with indication of the serial number, activity, date of manufacture and name of the manufacturer;

A.2.2 Leak test report (wipe test) for possible radioactive contamination from sources;

A.2.3 Document stating the serial number of the Nucleonic Meter(s), radioactive source(s), ionizing radiation generating equipment, model, manufacturer's name;

A.2.4 Radiometric survey of the package in the different modes of transportation;

A.2.5 Reports of radiometric surveys of the temporary storage area (awaiting installation):

- Before the installation;
- During installation, defining isolation area and signaling of free zone;
- After installation, to check the same levels identified before installation.

A.2.6 Leak test report (wipe test) of the nucleonic meter(s) performed during the installation;

A.2.7 Operation and Maintenance Manual, in Portuguese;

A.2.8 Operation and Maintenance Manual, in Portuguese;

A.2.9 Technical Specification of the Equipment, in Portuguese;

A.2.10 "LI" or "RTR" form, at least 120 days before the scheduled date for installation;

Notes:

1. The radiometric survey reports shall be accompanied by:
   - Responsible for the survey including: name, registration and signature;
   - Date of the radiometric survey;
   - Identification of the Radiation Meter (brand, model, serial number) used in the execution of radiometric surveys;
   - Identification of the Probe or Detector (brand, model, serial number) used in the execution of radiometric surveys;
   - Indication of the Calibration Certificate (laboratory, certificate number and calibration date) of the Radiation Meter used in the execution of radiometric surveys;

- Identification of the micro source (activity, radioisotope and serial number) used to carry out the measurement or operational control of the radiation meter.

2. Radiation meters shall be properly calibrated and within the validity period of the calibration. Remembering that they must be calibrated in laboratories accredited by CNEN.

3. The leak test (wipe test) shall be prepared by the manufacturer, in Portuguese, and carried out by the same. The collected material shall be inserted in a plastic bag and sent to a specific laboratory accredited by CNEN for analysis of the level of contamination.

A.3 Requirements for transportation:

A.3.1 In the event of movement of the radioactive sources / Nucleonic Meters under the SSS CONTRACTOR's custody and within PETROBRAS facilities (whether for testing, acquisition, transfers or installation), the PETROBRAS HSE team shall be communicated, together with a copy of all relevant documentation (Radiometric Surveys of the radioactive sources / Nucleonic Meters and Cargo, Transportation Plan registered with Brazilian CNEN, if necessary, and Transport Envelope), with a minimum of 30 days in advance, so that they shall be informed of the necessary conditions for boarding / disembarking, without prejudice of the Permit Authorizations.

Notes:

1. The transfer of custody of the radioactive source (from the SSS CONTRACTOR to PETROBRAS) with CNEN shall occur upon acceptance by PETROBRAS after the installation of the equipment on the seabed and confirmation of the operation of the Nucleonic Meter.

2. The Transport Envelope shall contain:

   - Emergency form;
   - Declaration by the Dispatcher of radioactive materials;
   - Maritime and road vehicle monitoring form;
   - Transport envelope with standard labels on the front and back.

A.3.2 Transportation procedures:

1) Follow the requirements of the CNEN / NE-5.01 Standard - Transport of radioactive materials and ANTT Resolution No. 420/2004;
2) Use, depending on the radioactive element(s) and activity(ies), of an Accredited Carrier for the Transport of Dangerous Products;
3) File the Transport Plan with CNEN, if necessary;
4) Use of individual dosimeter, if necessary;
5) Check the calibration of the meter and if the battery is charged;
6) Perform the Operational Control of the meter;
7) Proceed with radiometric survey of the Nucleonic Meter or the container of the radioactive source and pack the cargo, fixing it to the packaging;
8) Proceed with radiometric survey of the package, defining the “IT” and the transport category, if applicable;
9) Fill the packaging labels, according to the established category;
10) Place the shipping labels on opposite sides of the package, if applicable;
11) Fix the package to the vehicle;
12) Monitor the vehicle, including the driver's cabin;
13) Sign the vehicle with the radioactive material transport signaling label on the sides, front and rear, if applicable;
14) Sign the vehicle with the United Nations number tag (3332) on the sides, front and rear, if applicable;
15) Fill in transport documents (transport envelope);
16) Carry the transport documents.

A.3.3 The transport envelope shall accompany the cargo to the final recipient.

Notes:

1. The radiometric survey and vehicle monitoring reports shall be accompanied by:

   - Responsible for the survey: name, registration and signature;
   - Identification of the Radiation Meter (brand, model, serial number) used in the execution of radiometric surveys;
   - Probe or Detector identification (brand, model, serial number) used in the execution of radiometric surveys;
   - Indication of the Calibration Certificate (laboratory, certificate number and calibration date) of the Radiation Meter used in the execution of radiometric surveys;
   - Identification of the micro source (activity, radioisotope and serial number) used to measure or operationally control the radiation meter.

2. Radiation meters shall be properly calibrated and within the validity period of the calibration. Remembering that they shall be calibrated in laboratories accredited by CNEN.

A.4 Requirements for skilled labor:

A.4.1 All services with Nucleonic Meter or Ionizing Radiation Generating Equipment shall be performed by qualified, trained and authorized workers.