

	TECHNICAL SPECIFICATION					No.: I-ET-3000.00-1500-276-PEK-003			
	CLIENT: E&P					SHEET: 1 of 23			
	JOB: MALHA ÓPTICA PROJECT					N/A			
	AREA: SANTOS BASIN					NO SCALE / A4			
SUB/ES	TITLE: SUBSEA UMBILICAL TERMINATION (SUT) FOR TELECOM MOP-BS					PUBLIC			
					EECE/ECE				
Microsoft Office Word 2010 / ENGLISH / I-ET-3000.00-1500-276-PEK-003_0									
REVISION INDEX									
REV.	DESCRIPTION AND/OR REVISED SHEET								
0	ORIGINAL ISSUE.								
	REV. 0	REV. A	REV. B	REV. C	REV. D	REV. E	REV. F	REV. G	REV. H
DATE	08/08/2023								
DESIGN	EECE/ECE								
EXECUTION	BYE8								
CHECK	DVHV / B8WL								
APPROVAL	CXF0								
INFORMATION IN THIS DOCUMENT IS PROPERTY OF PETROBRAS, BEING PROIHBITED OUTSIDE THEIR PURPOSE.									
FORM OWNED TO PETROBRAS N-381 REV. L.									

 PETROBRAS	TECHNICAL SPECIFICATION	No. I-ET-3000.00-1500-276-PEK-003	REV. 0
	E&P		SHEET: 2 of 23
	TITLE: SUBSEA UMBILICAL TERMINATION (SUT) FOR TELECOM MOP-BS		PUBLIC
			EECE/ECE
INDEX 1. INTRODUCTION.....3 1.1. PURPOSE3 1.2. SCOPE3 2. TERMS AND DEFINITIONS.....3 2.1. ABBREVIATIONS3 2.2. DEFINITIONS4 3. REFERENCE AND APPLICABLE DOCUMENTS.....4 3.1. PETROBRAS REFERENCE DOCUMENTS4 3.2. APPLICABLE REFERENCE STANDARDS AND CODES.....5 4. TECHNICAL CHARACTERISTICS.....6 4.1. DESIGN AND FABRICATION.....6 4.2. QUALIFICATION6 5. FUNCTIONAL REQUIREMENTS.....6 5.1. SYSTEM OVERVIEW6 5.2. GENERAL REQUIREMENTS7 5.3. WET MATE CONNECTORS AND FLYING LEADS9 5.4. TELECOM OPTICAL CABLE REQUIREMENTS11 5.5. OPTICAL FIBER REQUIREMENTS.....12 5.6. OPTICAL TESTS.....13 5.7. DIMENSIONAL AND WEIGHT LIMITS17 5.8. INSTALLATION AND HANDLING REQUIREMENTS17 5.9. PAINTING REQUIREMENTS18 5.10. CATHODIC PROTECTION REQUIREMENTS.....19 6. SYSTEM AVAILABILITY19 7. TECHNICAL DOCUMENTATION19 8. TESTS AND INSPECTIONS20 9. REQUIREMENTS FOR INSPECTION, PACKAGING, STORAGE, PRESERVATION AND TRANSPORTATION20 10. CONDITIONING21 11. TRAINING22 12. AFTERMARKET SUPPORT SERVICES22 13. SCOPES OF SUPPLY23			

	TECHNICAL SPECIFICATION	No. I-ET-3000.00-1500-276-PEK-003	REV. 0
	E&P		SHEET: 3 of 23
	TITLE: SUBSEA UMBILICAL TERMINATION (SUT) FOR TELECOM MOP-BS		PUBLIC EECE/ECE

1. INTRODUCTION

1.1. PURPOSE

1.1.1. The purpose of this Technical Specification is to define the minimum requirements for designing, procurement, manufacturing and installation of SUT (Subsea Umbilical Termination) to be installed in connection to the *Malha Óptica* Project – Santos Basin on EPCI SURF Projects for telecom purpose.

1.2. SCOPE

1.2.1. This Technical Specification defines the requirements of SUTs, to be installed on Santos Basin Projects.

1.2.2. Specific parameters related to optical components are included in the technical specifications of subsea optical system.

2. TERMS AND DEFINITIONS

2.1. ABBREVIATIONS

AFM	Material Supply Authorization
EPCI	Engineering, Procurement, Construction, and Installation
ET	Technical Specification
DUT	Device Under Test
FEA	Finite Element Analysis
FO	Fiber Optic
ITP	Inspection and Testing Plan
PLSV	Pipe Laying Support Vessel
RM	Material Requisition
NCR	Non-conformity Report
ROV	Remotely Operated Vehicle
SWL	Safety Working Load
SURF	Subsea Umbilicals, Risers and Flowlines
SUT	Subsea Umbilical Termination
SM FO	Single Mode Fiber Optic
VCI	Volatile Corrosion Inhibitor
OFL	Optical Flying Lead
PBOF	Pressure Balanced Oil Filled
PMD	Polarization Mode Dispersion
PRM	Permanent Reservoir Monitoring
PM	Magnetic Particle Testing
LP	Penetrating Liquid Testing
US	Ultrasonic Testing
WPS	Welding Procedure Specification
WPQR	Welding Procedure Qualification Record

	TECHNICAL SPECIFICATION	No. I-ET-3000.00-1500-276-PEK-003	REV. 0
	E&P		SHEET: 4 of 23
	TITLE: SUBSEA UMBILICAL TERMINATION (SUT) FOR TELECOM MOP-BS		PUBLIC EECE/ECE

2.2. DEFINITIONS

SUT CONTRACTOR	The company contracted by PETROBRAS to design, construct and supply the SUT and its accessories (e.g., OPTICAL SYSTEM)
UMBILICAL CONTRACTOR	The company contracted by PETROBRAS to design, construct, supply and install the umbilical line and its accessories.
FPU CONTRACTOR	The company contracted by PETROBRAS to design, construct and supply the FPU topside infrastructure of OPTICAL SYSTEM
MOP-BS CONTRACTOR	The company contracted by PETROBRAS to design, construct and supply the MOP-BS EPCI Project.
SUPPLIER	Company hired by SUT CONTRACTOR, to supply components from SUT OPTICAL SYSTEM.
MAY	It is used when alternatives are equally acceptable
SHOULD	It is used when a provision is not mandatory, but is recommended as a good practice
SHALL	It is used when a provision is mandatory
AVAILABILITY	Probability that the system will remain operating under the conditions specified in the project during its useful life.
EQUIPMENT	Set of components and parts composing an architecture to meet the requirements of this ET.
RECOMMENDED PRACTICE	Best Practice established in Technical Standard, but which admits the possibility of a more adequate alternative to the specific application.
TECHNICAL PROPOSAL	Set of technical premises that the SUT CONTRACTOR undertakes to follow in the design of the Equipment.
SYSTEM	Set of elementary systems, integrated within the premises and operational availability established in the RM to which this ET refers.
UTH	Sub-module of the UTA, in which all the components residing in the UTA of the OPTICAL SYSTEM are assembled.

3. REFERENCE AND APPLICABLE DOCUMENTS

3.1. PETROBRAS REFERENCE DOCUMENTS

Ref.	Document identification	Title
1	N-2037	<i>Pintura de Equipamentos Submersos em Água do Mar</i> (Painting for Subsea Equipment)
2	N-0133	<i>Soldagem</i> (Welding Requirements)
3	I-ET-3000.00-1500-251-PEK-001	High-strength Low-alloy Steel Fasteners for Subsea Applications

	TECHNICAL SPECIFICATION	No. I-ET-3000.00-1500-276-PEK-003	REV. 0
	E&P		SHEET: 5 of 23
	TITLE: SUBSEA UMBILICAL TERMINATION (SUT) FOR TELECOM MOP-BS		PUBLIC EECE/ECE

Ref.	Document identification	Title
4	ET-3000.00-1500-251-PEK-002	<i>Rastreabilidade para Fixadores em Aço de Alta Resistência para Utilização Submarina</i>
5	ET-3000.00-1500-940-PEK-001	<i>Projeto de Proteção Catódica para Equipamentos Submarinos</i>
6	ET-3000.00-1521-600-PEK-001	<i>Projeto de Interfaces para Operações com ROV</i>
7	ET-3000.00-1500-600-PEK-006	<i>Requisitos Gerais de Equipamentos Submarinos</i>
8	ET-3000.00-1500-600-PEK-005	<i>Requisitos de Estruturas de Equipamentos Submarinos</i>
9	I-ET-3000.00-1500-29B-PAZ-006	<i>QUALIFICATION FOR POWER, CONTROL AND INJECTION UMBILICALS</i>
10	I-ET-3000.00-1500-29B-PAZ-008	<i>QUALIFICATION TESTS FOR OPTICAL UMBILICALS – OPTICAL MESH NETWORK PROJECT</i>
11	I-ET-3A36.00-1519-29B-PAZ-001	<i>SUBSEA UMBILICAL SYSTEMS TO CONNECT PRODUCTION UNITS TO THE OPTICAL MESH NETWORK</i>
12	I-ET-3000.00-1500-29B-PAZ-010	<i>GENERAL REQUIREMENTS OF OPTICAL RISERS FOR THE SUBSEA OPTICAL NETWORK</i>
13	ET-3000.00-1500-600-PEK-006	<i>REQUISITOS GERAIS DE EQUIPAMENTOS SUBMARINOS</i>

When not mentioned, the revision of the applicable document that shall be considered is the current revision referred to the date of signature of the contract.

3.2. APPLICABLE REFERENCE STANDARDS AND CODES

Ref.	Standard/Code	Title
14	AWS D1.1	Structural Welding Code – Steel
15	API RP 2A	Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms
16	API 17TR9	Subsea Umbilical Termination (SUT) Selection and Sizing Recommendations
17	API 17TR10	Subsea Umbilical Termination (SUT) Design Recommendations
18	API Spec 17D / ISO 13628-4	Petroleum and natural gas industries – Design and operation of subsea production systems – Part 4: Subsea wellhead and tree equipment
19	API Spec 17E / ISO 13628-5	Petroleum and natural gas industries – Design and operation of subsea production systems – Part 5: Subsea umbilicals
20	API RP 17H	Remotely Operated Tools and Interfaces on Subsea Production Systems
21	ISO 13628-8	Petroleum and natural gas industries – Design and operation of subsea production systems – Part 8: Remotely Operated Vehicle (ROV) interfaces on subsea production systems

	TECHNICAL SPECIFICATION		No. I-ET-3000.00-1500-276-PEK-003	REV. 0
	E&P			SHEET: 6 of 23
	TITLE: SUBSEA UMBILICAL TERMINATION (SUT) FOR TELECOM MOP-BS			PUBLIC
			EECE/ECE	

Ref.	Standard/Code	Title
22	API RP 17P / ISO 13628-15	Petroleum and natural gas industries - Design and operation of subsea production systems Part 15: Subsea structures and manifolds
23	NORSOK M-501	Surface Preparation and Protective Coating
24	API STD 17F	Standard for Subsea Production OPTICAL SYSTEMs
25	IEC-60529	Degrees of Protection provided by enclosures (IP codes)

When not mentioned, the revision of the applicable Standard/Code that shall be considered is the current revision referred to the date of signature of the contract.

4. TECHNICAL CHARACTERISTICS

4.1. DESIGN AND FABRICATION

4.1.1. All subsea optical components shall be designed in accordance with API 17E and API 17F.

4.1.2. 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 OPTICAL SYSTEM.

4.1.3. All enclosures with a required degree of ingress protection shall comply with IEC 60529 (latest revision).

4.2. QUALIFICATION

4.2.1. All subsea equipment shall be qualified in accordance with API 17Q or ISO 13628-6:2006.

4.2.2. SUT CONTRACTOR shall consider SUPPLIERS with experience in subsea umbilical lines and OPTICAL SYSTEMs.

5. FUNCTIONAL REQUIREMENTS

5.1. SYSTEM OVERVIEW

5.1.1. The OPTICAL SYSTEM shall be compatible with the following environmental conditions:

- Operating water depth: up to 3,000 m;
- Maximum storage temperature: 50°C;
- Submarine average temperature: 4°C;
- Maximum environmental temperature during tests: 45°C;
- Maximum relative air humidity: 85%;
- Design life: 25 years.

 PETROBRAS	TECHNICAL SPECIFICATION	No. I-ET-3000.00-1500-276-PEK-003	REV. 0
	E&P		SHEET: 7 of 23
	TITLE: SUBSEA UMBILICAL TERMINATION (SUT) FOR TELECOM MOP-BS		PUBLIC
			EECE/ECE

5.2. GENERAL REQUIREMENTS

5.2.1. This section describes the common requirements for SUT.

5.2.2. SUT shall comprise 02 (two) independent structural elements: the connection body and the base. The connection body is the structural element where the pigtails of the optical will be interconnected/terminated within. The base is the structural element that will support the connection body and that shall be designed accordingly to withstand all loads foreseen during the SUTs lifetime.

5.2.3. The design of SUT shall allow the assembling (base and connection body) both onshore and even on-board of an installation ship. To comply with this purpose, guides shall be foreseen to promote the alignment and final assembling between the connection body element and the base element.

5.2.4. The connection body element shall be designed aiming to protect all internal components, including the optical bulkhead wet mate connectors, against impacts and damage during SUTs handling and installation.

5.2.5. The umbilical optical cable (including accessories) shall be terminated inside the SUT connection body. These terminations shall:

- Be made previously onshore, but may be executed on-board of the installation ship after PETROBRAS approval;
- Guarantee the mechanical protection of internal fibers, considering the water depth, umbilical handling and mechanical efforts during installation of the umbilical lines.

5.2.6. SUT’s structure shall be designed and manufactured to keep the equipment stable on the seabed soil, according to criteria established on subsea project from RM. Calculations and other analysis documents, including FEA, shall be submitted to PETROBRAS for prior evaluation.

5.2.7. SUT’s structure shall be designed to withstand loads due to operating and environmental conditions, installation and uninstallation, and even occasional conditions foreseen during the equipment lifetime, as in accordance with subsea project from RM.

5.2.8. A bullseye-type circular level, compatible with ROV visualization, shall be provided in the SUTs structure to be permit checking the final equipment leveling after its installation. Manufacturer shall control the maximum deviation in the equipment level relating to seabed soil in order to not affect the equipment functionality and allowing operations with ROV.

5.2.9. For SUT’s base design, the soil data reported in the soil characterization reports shall be considered.

5.2.10. SUT shall be operated by single ROV. SUTs design shall meet the requirements for operating interfaces with ROV, as specified on [6], [20] and [21], and docking stations (grab bars) shall be provided for the ROV operations. ROV accessibility studies shall be performed to demonstrate the attendance of this requirement.

5.2.11. SUT and SUT’s deployment frame shall include in the ROV Pannels a subsea QR Code as described in [13].

5.2.12. Equipment identification plates shall be embossed type (engraved in high or low relief), with the characters painted in black color. The identification plates shall be welded to the SUTs structure. It is not allowed to punch the equipment plates to execute the identification characters.

	TECHNICAL SPECIFICATION	No. I-ET-3000.00-1500-276-PEK-003	REV. 0
	E&P		SHEET: 8 of 23
	TITLE: SUBSEA UMBILICAL TERMINATION (SUT) FOR TELECOM MOP-BS		PUBLIC EECE/ECE

5.2.13. All equipment pad eyes shall be embossed with the respective SWL values and they shall be submitted to load tests considering 1.5 times the SWL value, and at 90-degree, 60-degree and 45-degree angles.

5.2.14. A basic schematic arrangement for SUTs is shown in the Figure 1 below. SUT CONTRACTOR however may suggest a different equipment arrangement and submit to PETROBRAS for approval.

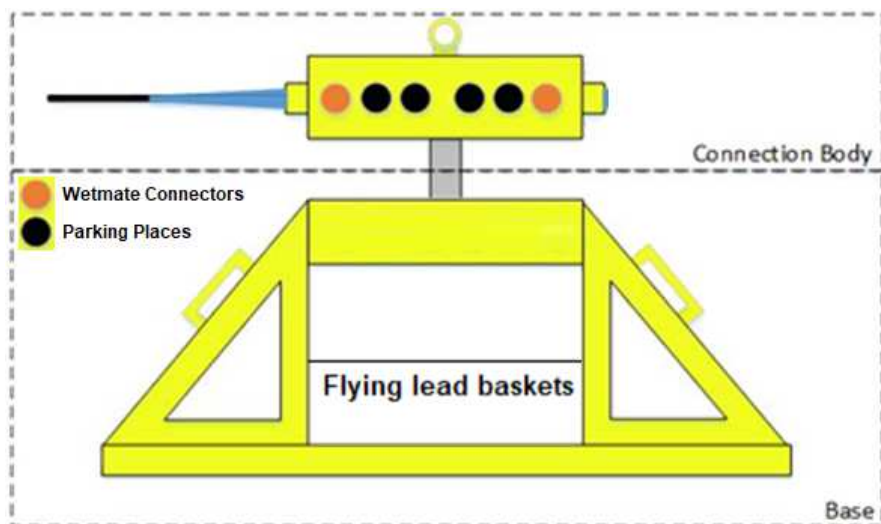


Figure 1 – SUTs basic schematic arrangement.

5.2.15. The lowest plates of the SUTs base may be perforated to facilitate its laying and settlement on the seabed soil.

5.2.16. Connection body shall be certified to be installed in water depths at least 3,000-meters (three-thousand meters).

5.2.17. SUTs design life shall be considered as 25 (twenty-five) years.

5.2.18. SUTs shall be designed with 2 (two) wet mate optical bulkhead connectors (mounted with 8 single mode FO cores from the riser umbilical line [11]).

5.2.19. The connection/splices inside SUTs between wet mate optical connectors' pigtails and umbilical cable pigtails shall be done with subsea junction boxes. Other type of connection between pigtails can be presented for PETROBRAS approval during executive project design.

	TECHNICAL SPECIFICATION	No. I-ET-3000.00-1500-276-PEK-003	REV. 0
	E&P		SHEET: 9 of 23
	TITLE: SUBSEA UMBILICAL TERMINATION (SUT) FOR TELECOM MOP-BS		PUBLIC
			EECE/ECE
5.3. WET MATE CONNECTORS AND FLYING LEADS			
5.3.1. The wet mate optical connectors’ model shall be chosen during the construction phase in formal consultation with PETROBRAS.			
5.3.2. The wet mate optical connector model shall conform to the following requirements: • be 8 (eight) or more-ways optical fiber cores, with fibers end face Angled Physical Contact (APC); • be ROV-mate; • be able to withstand at least 100 mates/demates cycles; • be qualified according to [24] (shall present evidences); • have a track record of at least 30 units installed worldwide and operating continually without failure for a period of 02 years.			
5.3.3. The wet mate optical bulkhead connectors’ pigtails shall be designed/supplied with same specification of the fibers from umbilical cables.			
5.3.4. The mechanical/optical interface mounting assembly between the wet mate bulkhead connectors’ pigtails and the umbilical lines’ pigtails inside SUTs shall be qualified according to [24].			
5.3.5. For all SUTs, all the wet mate bulkhead connectors shall be supplied with dummy connectors to protect the connectors’ integrity during operations offshore.			
5.3.6. Some of the dummy connectors shall be designed to have some closed looped pins to check the fibers integrity during and after installation. SUT CONTRACTOR shall select the dummy connectors during the construction phase in formal consultation with PETROBRAS.			
5.3.7. For all SUTs, SUT CONTRACTOR shall supply parking places for all wet mate bulkhead connectors. Parking places shall be designed in SUTs structure.			
5.3.8. SUT CONTRACTOR shall supply OFLs to connect with single ROV operations.			
5.3.9. The OFLs shall be designed with PBOF hoses of 50-meters length and both ends mounted with wet mate connectors compatible with wet mate bulkhead connectors from SUTs.			
5.3.10. The OFLs shall be designed/supplied with same specification of the fibers from umbilical cables.			
5.3.11. The structure of the SUT base shall have baskets to accommodate 2 (two) OFLs. The placement of baskets in the structure shall make it possible the offshore installation of SUT, with the flying leads being simultaneously accommodated in the structure. Parking places for OFL connectors shall be designed in SUTs structure.			

	TECHNICAL SPECIFICATION	No. I-ET-3000.00-1500-276-PEK-003	REV. 0
	E&P	SHEET: 10 of 23	
	TITLE: SUBSEA UMBILICAL TERMINATION (SUT) FOR TELECOM MOP-BS	PUBLIC	
		EECE/ECE	

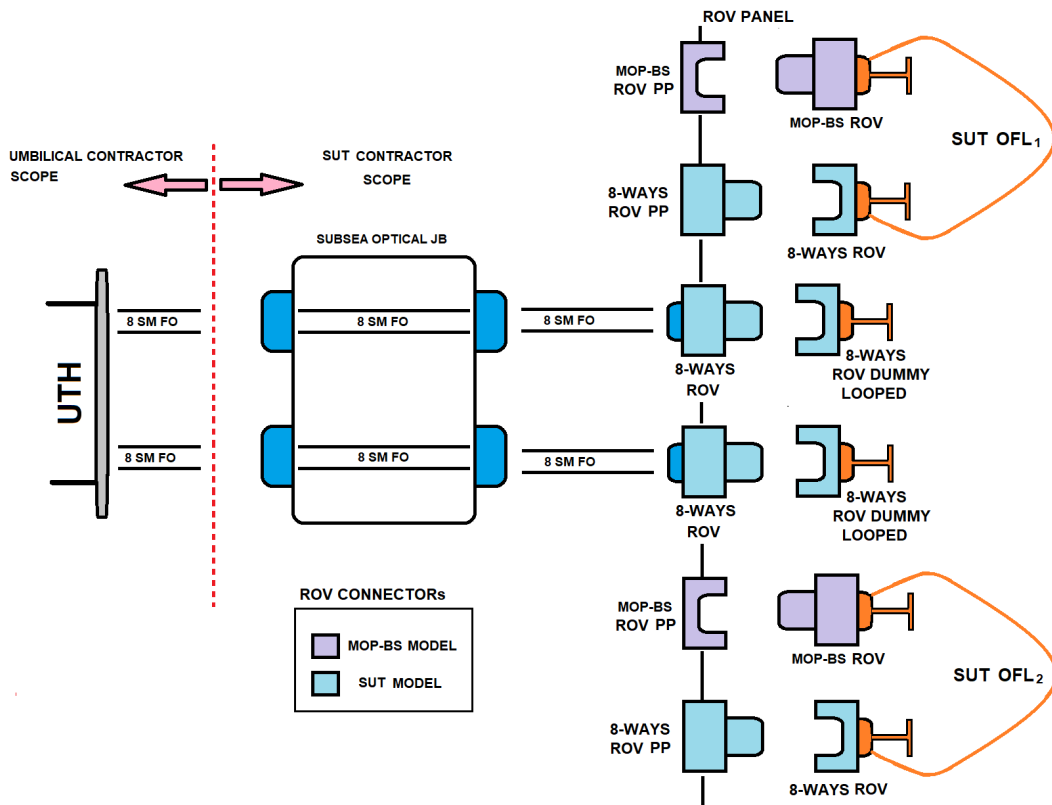


Figure 2– SUT's optical wiring diagram schematic.

5.3.12. SUT CONTRACTOR shall supply deployment frames (with all flying leads installation accessories) where the OFLs shall be patched for offshore installation (typically in a figure 8 shape), it shall be provided with protective surfaces to prevent any damage to the OFLs and parking places for both wet mate connectors.

5.3.13. The deployment frame's sling design shall consider both transport handling, installation and uninstallation operations. The slings and all accessories (e.g., shackles, sling yokes etc) shall be part of the scope of supply of the SUT CONTRACTOR.

5.3.14. The OFLs shall be designed with one termination with wet mate connectors' model defined by MOP-BS EPCI Project. SUT CONTRACTOR shall make a formal consultation to PETROBRAS for the definition of MOP-BS MODEL before placement of the AFM.

5.3.15. SUT CONTRACTOR shall supply as a minimum of 1 (one) spare OFL in dedicated transportation "IP-65" boxes.

5.3.16. SUT CONTRACTOR shall provide 2 (two) test connectors kit for ROV wet mate connectors (MOP-BS MODEL and SUT MODEL) for supporting SUT OPTICAL SYSTEM mounting/testing. All SUT OPTICAL SYSTEM (including test connectors) shall be supplied in dedicated transportation "IP-65" boxes.

5.3.17. UMBILICAL CONTRACTOR shall commission the SUT installed offshore before connection to the *Malha Óptica* Project equipment. UMBILICAL CONTRACTOR and SUT CONTRACTOR shall inform the tests and commissioning procedures according to section 4.5 during the construction phase in a formal consultation with PETROBRAS telecom team. UMBILICAL CONTRACTOR and SUT CONTRACTOR shall submit the procedures to PETROBRAS for approval.

	TECHNICAL SPECIFICATION	No.	I-ET-3000.00-1500-276-PEK-003	REV.	0
	E&P			SHEET:	11 of 23
	TITLE:	SUBSEA UMBILICAL TERMINATION (SUT) FOR TELECOM MOP-BS			PUBLIC
				EECE/ECE	

5.4. TELECOM OPTICAL CABLE REQUIREMENTS

5.4.1. The Telecommunication Optical Cable from umbilical line shall comply with the following requirements:

- have 16 (sixteen) or more optical single mode fiber cores meeting the requirements on item 4.2;
- certification and qualification by UJ CONSORTIUM.
- Supplier shall inform all optical and mechanical characteristics of the provided cable.
- Cable shall be qualified to ensure fiber protection against water depth pressure, longitudinal water ingress in case of rupture, chemical aggression, and hydrogen darkening during lifetime.
- Considering a period of 14 days after rupture, the longitudinal water ingress shall respect the maximum allowed ingress of 1km.
- Cable structure shall ensure that there will be no performance degradation on fiber during deployment, burial, and recovery, considering industry best practices.
- Cable structure shall ensure that there will be no additional attenuation on fibers during lifetime due to hydrogen molecules ingress due to metallic structure corrosion.
- The acceptable cable to be used is Single Armoured Cable.
- Fiber optic coating shall:
 - Inhibit armature corrosion.
 - Resist to marine life and rodents.
 - Be flexible enough to allow the cable to follow seabed detours.
 - Not be toxic or flammable.
 - Have properties that ensure handling, settling and recovery during launching and maintenance operations.
 - Not damage the environment.
- Cable application shall comply ITU-G.978 – Characteristics of optical fiber submarine cables.
- PETROBRAS shall approve the cable application.
- Cables in discordance with ITU shall be evaluated and authorized by PETROBRAS if it is necessary due to environmental variables to be mapped during the protect stage.

5.4.2. Cable marks and identification:

- Cable shall be identified and marked in accordance to recommendation 16, emission 1 from ICPC.
- The physical structure, colors and fonts from labels and markings shall be proposed by supplier and approved by PETROBRAS.
- IDs shall be visible considering a 0,5m distance.
- Cable shall have an alphanumeric ID printed on cable. This code shall be enough to identify number and type of fibers and other cable specification.
- ID shall be repeated every 5m.
- IDs and markings shall remain intact during loading, unloading, deployment, recovery, and repair.
- A numeric length scale shall be printed on cover.
- Cable shall present distance markings on every one kilometer.
- Cables shall have labels that define the marking of all junctions.
- Beside junctions, every cable transition shall be marked and identified.

	TECHNICAL SPECIFICATION	No. I-ET-3000.00-1500-276-PEK-003	REV. 0
	E&P		SHEET: 12 of 23
	TITLE: SUBSEA UMBILICAL TERMINATION (SUT) FOR TELECOM MOP-BS		PUBLIC
			EECE/ECE

5.5. OPTICAL FIBER REQUIREMENTS

5.5.1. The following requirements shall be applied to the optical fibers of the umbilical, subsea optical cable, SUT, flying leads and optical connectors.

5.5.2. The optical fibers shall be according to ITU-T G series recommendations and the technical characteristics of G.652D recommendation.

5.5.3. On the 1550nm window, the optical fiber shall have the following characteristics:

- 1) Attenuation shorter than or equal to 0.18 dB/km
- 2) Dispersion shorter than or equal to 18.00 ps/nm.km
- 3) Dispersion Slope shorter than or equal to 0.088 ps/nm².km
- 4) PMD shorter than or equal to 0.20 ps/√km

5.5.4. The optical fibers shall not present any variation of attenuation greater than 0.01 dB/km throughout its length.

5.5.5. The cladding diameter shall be 125 μm with a maximum tolerance of ± 2 μm.

5.5.6. The cladding circularity error must be shorter than 1%.

5.5.7. Once covered by the primary coating, the optical fiber when submitted to a curvature radius equal to or greater than 37.5mm, shall not present a variation of attenuation for wavelengths between 1300 and 1625nm, in accordance with ITU-T G-652.

5.5.8. Optical fibers when submitted to 30 nm curvature radius by 100 turns, the increase of attenuation for the wavelengths between 1300 and 1625nm shall be smaller than 0.1 dB, in accordance with ITU-T G.652 recommendation.

5.5.9. The optical fiber that will compound the optical fiber cable shall endure a minimum stretching tension of 0.69 Gpa (~7000 Kgf/cm2) without affect its physical and optical characteristics.

5.5.10.CONTRACTOR shall inform the following characteristics of the optical fibers used to manufacture the optical fiber cable:

- a) Refractive index profile;
- b) Maximum attenuation coefficient at the 1310nm transmission window;
- c) Minimum attenuation coefficient at the 1310nm transmission window;
- d) Maximum attenuation coefficient at the 1550nm transmission window;
- e) Minimum attenuation coefficient at the 1550nm transmission window;
- f) Maximum chromatic dispersion (ps/nm.Km) at the 1300nm transmission window;
- g) Maximum chromatic dispersion (ps/nm.Km) at the 1550nm transmission window;
- h) Cut-off wavelength;
- i) Detailing of Hydrogen impermeabilization;
- j) Modal field diameter;
- k) Core / cladding concentricity error;
- l) Core non circularity;
- m) PMD - Polarization Mode Dispersion.

	TECHNICAL SPECIFICATION	No. I-ET-3000.00-1500-276-PEK-003	REV. 0
	E&P		SHEET: 13 of 23
	TITLE: SUBSEA UMBILICAL TERMINATION (SUT) FOR TELECOM MOP-BS		PUBLIC EECE/ECE

5.5.11. For acceptance, the optical fibers shall be followed by the characterization reports issued by the manufacturers.

5.6. OPTICAL TESTS

5.6.1. All subsea optical devices (i.e. umbilical lines, SUTs, wet mate connectors, OFLs), shall be tested at the factory, on the installation vessel prior to launch and post launching at the commissioning stage.

5.6.2. The tests shall be performed according to Table 1:

TESTS	FACTORY	VESSEL	COMMISSIONING
Total optical attenuation	x	x	
Optical attenuation - OTDR	x	x	x
Chromatic Dispersion	x		
PMD	x		

Table 1 – List of tests

5.6.3. UMBILICAL CONTRACTOR shall perform optical attenuation tests from the DIO (Internal Optical Distributor) installed at the telecommunications room connected to the submarine optical telecom HUB after installing the umbilical line including fusions at the riser balcony and subsea connection in the optical telecom HUB.

5.6.4. SUT CONTRACTOR and UMBILICAL CONTRACTOR shall use appropriate instruments and with valid calibration certificates, in order to perform these factory and offshore tests.

5.6.5. It shall be SUT CONTRACTOR and UMBILICAL CONTRACTOR's responsibility to supply all the accessory materials necessary for the perfect execution of all tests factory and offshore.

5.6.6. Tests technical description

5.6.6.1. Total optical attenuation

5.6.6.1.1. This test shall be performed using a power meter and light source in order to measure the total attenuation / insertion loss of the DUT (Device Under Test).

5.6.6.1.2. The tests shall be carried out on the 1550nm optical window in both directions (A-B and B-A).

	TECHNICAL SPECIFICATION		No. I-ET-3000.00-1500-276-PEK-003		REV. 0		
	E&P					SHEET: 14 of 23	
	TITLE: SUBSEA UMBILICAL TERMINATION (SUT) FOR TELECOM MOP-BS					PUBLIC	
							EECE/ECE

5.6.6.1.3. The results shall preferably be presented according to Table 2:

Coil ID/ Loop:	Date:	Technical resp.:
Equipment:	S/N:	
Equipment:	S/N:	
Wave length (λ):	Fiber length:	

Fibers		A-B			B-A			Mean [dB]	Att. Coef. [dB/km]
A	B	P _A [dBm]	P _B [dBm]	Att[dB]	P _B [dBm]	P _A [dBm]	Att[dB]		

Table 2 – Suggested format for presenting results of total optical attenuation

5.6.6.1.4. In addition to the results table, all measurement traces with identification of the respective events shall be presented.

5.6.6.2. **Optical attenuation – OTDR**

5.6.6.2.1. The optical attenuation tests shall be performed with OTDR (Optical Time Domain Reflectometer) in both directions, whenever possible to be performed.

5.6.6.2.2. For the commissioning tests, CONTRACTOR shall consider that the corresponding optical system is a repeated type and then in the fibers tested there shall be presence of wavelengths in the C band.

5.6.6.2.3. In order to perform measurements on the commissioned system, CONTRACTOR shall evaluate the need for the application of optical filters or C-OTDR type instruments (Coherent Optical Time Domain Reflectometer).

5.6.6.2.4. In addition to the events throughout the DUT, the OTDR tests shall evaluate the ORL (Optical Return Loss) per event.

	TECHNICAL SPECIFICATION	No. I-ET-3000.00-1500-276-PEK-003	REV. 0
	E&P		SHEET: 15 of 23
	TITLE: SUBSEA UMBILICAL TERMINATION (SUT) FOR TELECOM MOP-BS		PUBLIC EECE/ECE

5.6.6.2.5. The results shall preferably be presented according to Table 3:

Coil ID/ Loop:		Date:		Technical resp.:		
Equipment:		S/N:				
Equipment:		S/N:				
Wave length (λ):						
Fibers		Distributed loss [dBm/km] (A-B)	Distributed loss [dBm/km] (B-A)	Mean [dB/km]	Lenght [km]	Mean loss [dB]
A	B					

Table 3 – Suggested format for presenting optical attenuation results - OTDR.

5.6.6.3. Chromatic dispersion

5.6.6.3.1. Chromatic dispersion tests shall be performed at wavelengths 1310nm, 1550nm and 1625nm.

5.6.6.3.2. The measurement technique to be applied in these tests shall be decided by the CONTRACTOR.

5.6.6.3.3. The results shall preferably be presented according to Table 4:

Coil ID/ Loop:		Date:		Technical resp.:							
Equipment:		S/N:									
Equipment:		S/N:									
Fibers		Lambda Zero[nm]	Dispersion [ps/(nm.km)]			Total disp. @1550nm [ps/nm]	Inclination [ps/(nm².km)]		Sellmeier Coeficients		
A	B		1310nm	1550nm	1625nm		Lambda Zero	1550nm	A	B	C

Table 4 – Suggested format for presenting the results of the chromatic dispersion.

	TECHNICAL SPECIFICATION	No. I-ET-3000.00-1500-276-PEK-003	REV. 0
	E&P		SHEET: 16 of 23
	TITLE: SUBSEA UMBILICAL TERMINATION (SUT) FOR TELECOM MOP-BS		PUBLIC EECE/ECE

5.6.6.4. Dispersion by polarization mode

5.6.6.4.1. The measurement technique to be applied in these tests shall be decided by CONTRACTOR.

5.6.6.4.2. Measurements shall be performed at intervals greater than 60 minutes.

5.6.6.4.3. The results shall preferably be presented according to Table 5:

Coil ID/ Loop:					Date:					Technical resp.:				
Equipment:					S/N:									
Equipment:					S/N:									
Fiber length:														
Fibers		M 1M 2M 3			M 4M 5M 6			M 7M 8M 9			PMD Delay [ps]	PMD Coef. [ps/√km]		
A	B													

Table 5 – Suggested format for presenting PMD results.

5.6.6.5. Acceptance criteria

5.6.6.5.1. The acceptance criteria shall be as described at Table 6:

TESTS	FACTORY (SUT CONTRACTOR scope)	VESSEL / COMMISSIONING (UMBILICAL CONTRACTOR scope)
Total optical attenuation	Attenuation per kilometer less than or equal to 0.20dB/km @1550nm.	Attenuation per kilometer less than or equal to 0.20 dB/km @1550 nm ±10%
Optical attenuation - OTDR	- Attenuation per kilometer less than or equal to 0.20dB/km @1550 nm; - Optical splices with OIL less than 0.2dB; - Connections to wetmate connectors with OIL and ORL better or equal to that specified in the element datasheet.	- Attenuation per kilometer less than or equal to 0.20dB/km @1550nm. - Optical splices with insertion loss <0.2dB. - Connections to wet mate connectors with OIL and ORL better or equal to that specified in the element datasheet.
Chromatic Dispersion	DC < 18 ps/nm ² *km	N/A
PMD	PMD < 0,2 ps/km ^{0.5}	N/A

Table 6 – Tests acceptance criteria.

 PETROBRAS	TECHNICAL SPECIFICATION	No. I-ET-3000.00-1500-276-PEK-003	REV. 0
	E&P		SHEET: 17 of 23
	TITLE: SUBSEA UMBILICAL TERMINATION (SUT) FOR TELECOM MOP-BS		PUBLIC
			EECE/ECE

5.7. DIMENSIONAL AND WEIGHT LIMITS

5.7.1. Dimensions of SUTs connection body shall be priorly limited to 3-meters maximum length and 1.4-meters maximum diameter. If final dimensions of designed equipment exceed dimensional limits, SUT CONTRACTOR shall submit the equipment configuration to PETROBRAS for approval.

5.7.2. After the connection body be assembled with the equipment base, SUTs maximum dimensions shall be limited to 3-meters height, 3.5-meters width and 3.5-meters length. If final dimensions of designed equipment exceed dimensional limits, SUT CONTRACTOR shall submit the equipment configuration to PETROBRAS for approval.

5.7.3. SUTs total dry weight shall not exceed 20 tons (20,000 kg). If designed equipment exceeds weight limit, SUT CONTRACTOR shall submit final dry weight to PETROBRAS for approval.

5.8. INSTALLATION AND HANDLING REQUIREMENTS

5.8.1. SUT shall be designed to allow both first and second end installation methods, that contains and support a flange termination to mechanical connect to the umbilical line.

5.8.2. Design of SUT shall include a yoke with curved shackle with pin, nut and safety lock, and a master link required for the equipment installation and uninstallation. All relating accessories shall be new and dully certificated. Refurbished or reused slings will not be accepted.

5.8.3. SUT CONTRACTOR shall evaluate and define the most appropriate location for the installation of yoke on the SUT’s structure and shall consider aspects such as load capacity, interferences, and the equipment orientation required for its installation and/or uninstallation.

5.8.4. Yoke shall be designed so that, after SUT be installed and slings or installation cables be disconnected, yoke remains in an appropriate position to permit a future connection for an eventual uninstallation of the SUTs. The yoke shall be submitted to load test considering 1.0 times the maximum component allowable load, and at 90-degree, 60-degree and 45-degree angle directions.

5.8.5. Yoke shall be disassembled after the load test be performed and the pin shall be inspected using Penetrating Liquid (LP), and Magnetic Particle (PM), and Ultrasonic Testing. Yoke shall be free from any kind of defects such as cracking, kneading, warping, diameter reduction and material tearing. Pad eyes and reinforcement welds in the vicinity of the pad eyes shall be inspected by Penetrating Liquid (LP), and Magnetic Particle (PM), and Ultrasonic Testing (US), when applicable.

5.8.6. During the SUT designing, SUT CONTRACTOR shall evaluate if any additional pad eyes are required to be installed on the equipment structure aiming to execute its installation and/or uninstallation, or even to achieve the equipment final position. The SLW of pad eyes shall be compatible with the condition that induces the higher installation or uninstallation loads on the equipment structure. Pad eyes calculation sheet shall be submitted to PETROBRAS for approval.

5.8.7. SUT’s structure shall have, at minimum, one pad eye to be installed on each equipment vertex for handling and transportation purpose. The SWL of pad eyes shall be compatible with the loads due to equipment handling and transportation conditions. SUT CONTRACTOR shall guarantee that quantity and distribution of pad eyes is adequate to not cause excessive deflections on the equipment structure. Pad eyes calculation sheet shall be submitted to PETROBRAS for approval.

 PETROBRAS	TECHNICAL SPECIFICATION	No. I-ET-3000.00-1500-276-PEK-003	REV. 0
	E&P		SHEET: 18 of 23
	TITLE: SUBSEA UMBILICAL TERMINATION (SUT) FOR TELECOM MOP-BS		PUBLIC
			EECE/ECE

5.8.8. SUT's structure shall consider, at minimum, the material properties of group II class B of API RP 2A WSD. For those parts of the structural frames that will not be subjected to primary mechanical loads, material properties of group II class C of API RP 2A WSD may be used. Use of materials of group I class C of API RP 2A WSD, such as Steel A-36, will not be accepted.

5.8.9. For equipment welding works, SUT CONTRACTOR shall meet the requirements of PETROBRAS N-133 Standard [2], including welding consumables qualification. All welds shall be inspected by Visual method, and by Magnetic Particle (PM) and Penetrating Liquid (LP), and the welds of the pad eyes shall be fully-inspected (100%) by Ultrasonic Testing (US).

5.8.10. SUT's base shall be robust enough and structurally prepared to withstand the mechanical launching loadings, both vertically and horizontally, and without suffering displacement of its components. SUT CONTRACTOR shall submit the structural analysis of the SUTs for prior analysis of PETROBRAS.

5.8.11. SUT CONTRACTOR shall submit to PETROBRAS the Equipment Construction and Assembly Plan that shall indicate how the manufacturing and assembling sequence will be executed. The Welding Plan and Welding Maps shall also be submitted to PETROBRAS, as well as the Welding Procedures Qualification Records (WPQR) and Welding Procedures Specification (WPS), before the equipment assembling works have been started.

5.8.12. The structure of the SUT shall contains and support flange terminations to mechanical connect to the umbilical line structures and shall have baskets in order to accommodate 2 (two) OFLs, from the JUMPERS SET. The placement of baskets in the structure shall make it possible to:

5.8.12.1. The offshore installation of SUT, with the flying leads being simultaneously accommodated in the structure;

5.8.12.2. The handling by the ROV manipulator of the flying leads accommodated in SUT.

5.8.13. All subsea operations shall consider the use of a single ROV.

5.8.14. All ROV interfaces shall be in accordance with documentation specified in the respective RM to which this ET is attached.

5.8.15. All installation and recovery operations shall have their basic procedures submitted for PETROBRAS approval during the project detailing phase and provided as part of OPTICAL SYSTEM.

5.9. PAINTING REQUIREMENTS

5.9.1. SUT's structure shall be painted in accordance with the painting requirements presented in the [1] and [20].

5.9.2. The Equipment Painting Plan shall be submitted to PETROBRAS for approval. Equipment painting scheme shall be duly qualified by a painting certified inspector.

	TECHNICAL SPECIFICATION	No. I-ET-3000.00-1500-276-PEK-003	REV. 0
	E&P		SHEET: 19 of 23
	TITLE: SUBSEA UMBILICAL TERMINATION (SUT) FOR TELECOM MOP-BS		PUBLIC EECE/ECE

5.10. CATHODIC PROTECTION REQUIREMENTS

5.10.1. The cathodic protection system shall be designed in accordance with the requirements and specifications presented in [5] and shall consider protection for all equipment internal elements and connected parts to the SUTs structure, such as, connectors, crossovers, optical junction boxes and plates of the connection parts. The cathodic protection system shall also consider the protection for the flying leads cables/connectors.

5.10.2. The SUT's cathodic protection system does not include the umbilical.

6. SYSTEM AVAILABILITY

6.1. The availability of OPTICAL SYSTEM shall be guaranteed by adequate MTTF values.

6.2. The MTTF of the entire OPTICAL SYSTEM shall also be informed, calculated for the operating conditions indicated in this ET.

6.3. SUT CONTRACTOR shall clearly inform which methods are used to calculate availability, as well as the assumptions adopted.

7. TECHNICAL DOCUMENTATION

7.1. The documentation shall be in accordance with the requirements from the RM of which it is attached ET.

7.2. SUT CONTRACTOR shall present in the project detailing phase, for approval by PETROBRAS, the operational procedures applicable with respect to the OPTICAL SYSTEM.

7.3. SUT CONTRACTOR shall present, in the project detailing phase, for PETROBRAS approval, the procedure for the storage and preservation of the OPTICAL SYSTEM.

7.4. The technical documentation shall include at least the following:

- Block diagram;
- Piping and Instrumentation Diagram (P&ID);
- General arrangement drawings of SUT with flying leads;
- General arrangement drawings of deployment frame with flying leads;
- General arrangement with routing of optical system including OFLs;
- Optical connectors drawings and datasheet;
- Factory Acceptance Test Procedure/Reports;
- Acceptance and Performance test (TAP) Procedure/Reports;
- Operational procedure for SUT and deployment frame.

 PETROBRAS	TECHNICAL SPECIFICATION	No. I-ET-3000.00-1500-276-PEK-003	REV. 0
	E&P		SHEET: 20 of 23
	TITLE: SUBSEA UMBILICAL TERMINATION (SUT) FOR TELECOM MOP-BS		PUBLIC
			EECE/ECE

8. TESTS AND INSPECTIONS

8.1. Regarding the qualification tests:

8.1.1. All components of OPTICAL SYSTEM shall be subjected to qualification tests in order to confirm that these components shall comply with the design requirements. Qualification tests shall be reported to PETROBRAS.

8.2. With respect to FATs:

8.2.1. The list of FATs of OPTICAL SYSTEM, in addition to the FAT procedures themselves, shall be submitted for approval by PETROBRAS during the project detailing phase.

8.2.2. For hoses and optical cables, the FAT shall have at least:

- Optical tests (see section 5.6);
- Helium or nitrogen leak test as specified by the manufacturer and previously approved;
- Visual and dimensional inspection test.

8.2.3. For optical connectors, the FAT shall have at least:

- Optical tests (see section 5.6);
- Mechanical tests: hydrostatic test, visual and dimensional inspection.

8.3. The SIT shall be performed by SUT CONTRACTOR before the CLM, with at least 1 (one) SUT, 1 (one) OFL and 1 (one) deployment frame.

8.4. SUT CONTRACTOR shall supply all the manufacturing facilities for any repairs and alterations that are necessary to the optical components in an emergency, including services in marine units.

8.5. SUT CONTRACTOR shall provide proof of supply of all items to be purchased from sub-suppliers, which are an integral part of OPTICAL SYSTEM, through a letter of purchase intention, supply request or other supporting document.

8.6. The tests program shall demonstrate that all components of OPTICAL SYSTEM have been successfully installed and connected and that OPTICAL SYSTEM is fully operational.

9. REQUIREMENTS FOR INSPECTION, PACKAGING, STORAGE, PRESERVATION AND TRANSPORTATION

9.1. SUT’s inspection requirements shall be in accordance with [7] and [8].

9.2. SUTs base shall be designed assuming it is self-protected for transportation and not require one specific skid for this purpose. SUT CONTRACTOR, however, may suggest a proposal for SUT’s base transportation and shall submitted it to PETROBRAS for approval.

9.3. For transportation of SUTs connection body, SUT CONTRACTOR shall provide one specific and suitable skid for this purpose.

9.4. SUT CONTRACTOR shall submit a Preservation Plan to PETROBRAS, including all possible environments and conditions which the SUTs will be exposed to before its installation and shall provide all the materials required for its preservation.

 PETROBRAS	TECHNICAL SPECIFICATION	No. I-ET-3000.00-1500-276-PEK-003	REV. 0
	E&P		SHEET: 21 of 23
	TITLE: SUBSEA UMBILICAL TERMINATION (SUT) FOR TELECOM MOP-BS		PUBLIC
			EECE/ECE
9.5. SUT CONTRACTOR shall supply the equipment properly packaged and preserved to withstand weathering for a minimum period equal to 2 (two) years, using VCI (Volatile Corrosion Inhibitors) preservation philosophy, both for its external and internal areas. The Equipment Preservation Scheme shall be submitted to PETROBRAS for approval. 9.6. The packaging methods shall be designed in order to completely protect all the equipment and parts of OPTICAL SYSTEM against possible damage during transport, loading and unloading. 9.7. SUT CONTRACTOR shall submit for approval of PETROBRAS, the procedures for handling the OPTICAL SYSTEM equipment, depending on the means of transport specified. 9.8. OPTICAL SYSTEM shall be delivered to PETROBRAS disassembled from SUT, packed by SUT CONTRACTOR in a dedicated (separated from other project's supplies) IP-65 box that protects it from the weather, suitable for sea shipment. The use of wooden boxes shall not be allowed. 9.9. The spare OFL jumper set shall be delivered to PETROBRAS packed in boxes IP65 which are protect from weather, suitable for sea shipment. The use of wooden boxes shall not be allowed. 9.10. The SUT OFLs jumpers set shall be delivered to PETROBRAS accommodated in existing basket in the SUT structure (SUT body), respecting the total quantity according to RM in which this ET is referenced. 9.11. The deployment frame shall be delivered to PETROBRAS covered in canvas to protect against ultraviolet rays and other weather conditions. 9.12. The SUT structure shall be delivered to PETROBRAS covered in canvas to protect against ultraviolet rays, so that the OPTICAL SYSTEM, components located in the SUT structure, shall be protected from the weather. 9.13. The description of the packaging of OPTICAL SYSTEM components shall be included in the Technical Documentation and shall be submitted for approval by PETROBRAS during the project detailing phase. 10. CONDITIONING 10.1. SUT CONTRACTOR shall be responsible for the conditioning of OPTICAL SYSTEM equipment from the beginning of manufacture until delivery to the PETROBRAS staff for which it is intended, including the period of transportation. 10.2. When required in RM, SUT CONTRACTOR shall submit for approval of PETROBRAS, the procedures for the implementation of the conditioning of OPTICAL SYSTEM equipment, according even to the PETROBRAS standard N-858.			

	TECHNICAL SPECIFICATION	No.	I-ET-3000.00-1500-276-PEK-003	REV.	0	
	E&P			SHEET:	22 of 23	
	TITLE:	SUBSEA UMBILICAL TERMINATION (SUT) FOR TELECOM MOP-BS			PUBLIC	
					EECE/ECE	

11. TRAINING

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

11.2. Training shall be performed at PETROBRAS facilities in Rio de Janeiro, Brazil (on-shore). Training courses shall be given for two classes of 6 students (total of 12 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.

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

11.4. 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;
- ROV operations (subsea equipment retrieval and installation);
- Storage and conservation of equipment.

12. AFTERMARKET SUPPORT SERVICES

12.1. SUT CONTRACTOR shall commit to deploy in Brazil infrastructure and support for maintenance and aftermarket services, which shall be part of the Technical Proposal.

12.2. The effective implantation of this aftermarket infrastructure and support shall occur until the delivery date of the equipment of the scope of supply to PETROBRAS and shall be a condition for the CLM by PETROBRAS.

	TECHNICAL SPECIFICATION	No. I-ET-3000.00-1500-276-PEK-003	REV. 0
	E&P		SHEET: 23 of 23
	TITLE: SUBSEA UMBILICAL TERMINATION (SUT) FOR TELECOM MOP-BS		PUBLIC EECE/ECE

13. SCOPES OF SUPPLY

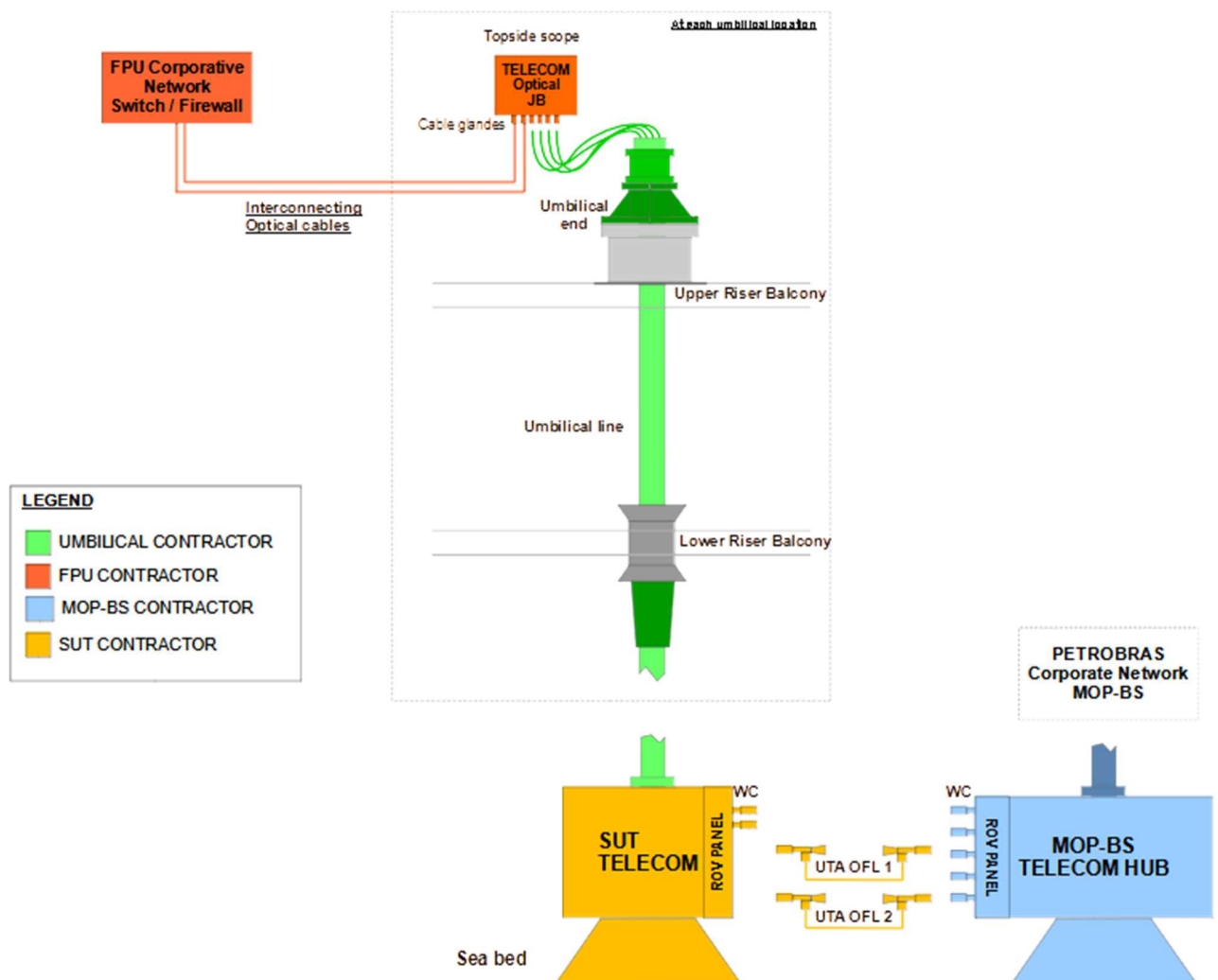


Figure 3 – Diagram of Telecom SUT system main components standard scope of supplies