PETROBRAS	**TECHNICAL SPECIFICATION**	**Nº** I-ET-3000.00-1500-276-PX9-001	
	CLIENT PETROBRAS		**SHEET** 1 of 25
	JOB		
	AREA –		
SUB	**TITLE** **UMBILICAL TERMINATION ASSEMBLY (UTA) FOR SUBSEA TELECOM SYSTEM**		***PUBLIC*** SUB/ES/EDA/EAI

REVISION INDEX

REV.	DESCRIPTION AND/OR REVISED SHEETS
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	REV. 0	REV. A	REV. B	REV. C	REV. D	REV. E	REV. F	REV. G	REV. H
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INTRODUCTION

1.1. This document presents the Technical Specification and functional requirements for design, procurement, manufacture and installation of UTA (Umbilical Termination Assembly) to be installed in the seabed to connect with the *Malha Óptica* Project – Santos Basin for telecom purpose.

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

1.3. The UTA (Umbilical Termination Assembly) for subsea telecom system is called SUT (Subsea Umbilical Termination).

1 ABBREVIATIONS

AFM - Material Supply Authorization;
CD – Chromatic Dispersion;
CLM - Material Release Communication;
C-OTDR – Coherent OTDR;
DIO - Internal Optical Distributor;
DIV – Diver;
DUT – Device Under Test;
EPCI – Engineering, Procurement, Construction and Installation;
ET - Technical Specification;
FAT - Factory Acceptance Test;
FLDF - Flying Leads Deployment Frame;
FPU – Floating Production Unit;
ICPC – International Cable Protection Committee;
ITU – International Telecommunication Union;
JB – Junction Box;
MOP – Malha Óptica Project;
MTTF - Mean Time to Failure;
NC – Not Connected pin;
NCR - Non-conformity Report;
OFL - Optical Flying Lead;
OIL – Optical Insertion Loss;
OTDR – Optical Time Domain Reflectometer;
ORL – Optical Return Loss;
PBOF – Pressure Balanced Oil Filled;
PLSV – Pipe Lay Support Vessel;
PMD - Polarization Mode Dispersion;
ROV - Remotely Operated Vehicle;
RM - Material Requisition;
SIT - Site Integration Test;
SUT – Subsea Umbilical Termination;
UEP - Stationary Production Unit;
UJ – Universal Joint;
UTA - Umbilical Termination Assembly;
UTH - Umbilical Termination Head;
WMC – Wet mate Connector.

2 REFERENCE DOCUMMENTS, CODES AND STANDARDS

This section lists standards and documents applicable to the design of the optical UTA system:

2.1 International standards

[1] API 6A: Specification for Wellhead and Christmas Tree Equipment;

[2] AWS D1.1: Structural Welding Code – Steel;

[3] API RP 2A: Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms;

[4] API 17D: Specification for Subsea Wellhead and Tree Equipment;

[5] API 17E: Specification for Subsea Umbilicals;

[6] API 17F: Standard for Subsea Production Control Systems;

[7] API 17H: Remotely Operated Tools and Interfaces on Subsea Production Systems;

[8] API 17P: Subsea structures and manifolds;

[9] API 17Q: Recommended Practice on Subsea Equipment Qualification;

[10] API 17TR9: Subsea Umbilical Termination (SUT) Selection and Sizing Recommendations;

[11] API 17TR10: Subsea Umbilical Termination (SUT) Design Recommendations;

[12] ASME B16.5: Standard Specification for Alloy-Steel and Stainless Steel Bolting for Low-Temperature Service;

[13] ASME B16.5: Pipe Flanges and Flanged Fittings;

[14] MIL-STD-217F: Reliability Prediction of Electronic Equipment;

[15] DNVGL-RP-B401: Cathodic Protection Design;

[16] IEC 60529: Degrees of Protection Provided by Enclosures (IP Code);

[17] DNV-RP-H103: Modelling and Analysis of Marine Operations;

[18] ISO 13628-6: Subsea Production Control System (**Note:** The cleaning classification for hydraulic fluids of the old NAS 1638 standard (“Cleanliness Requirements used in Hydraulic Systems”) is cited in this specification as a reference best known by the Industry. The most current standard is SAE AS 4059 (“Cleanliness Classification for Hydraulic Fluids”);

[19] ISO 15156-3: Cracking resistant CRAs (corrosion Resistant Alloys) and other alloys;

[20] IEC 60502-1: Cables for rated voltages of 1 kV (Um = 1,2 kV) and 3 kV (Um = 3,6 kV);

[21] ITU-G.978: Characteristics of Optical Fiber Submarine Cables;

[22] ITU-T G.652: Characteristics of a Single-mode Optical Fiber and Cable;

[23] SEAFOM TSD-02: Functional Design and Test Specification for Subsea Electrical and Optical Connectors and Jumpers.

2.2 PETROBRAS documents

[24] N-0133: *Soldagem* (Welding Requirements);

[25] ET-3000.00-1500-610-PEK-002: ESLINGAS, SKIDS, CAIXAS E BASE DE TESTES DE EQUIPAMENTOS SUBMARINOS;

[26] I-ET-3000.00-1500-600-PEK-010: MECHANICAL REQUIREMENTS FOR UMBILICAL TERMINATION ASSEMBLIES – UTAs;

[27] ET-3000.00-1500-600-PEK-006: REQUISITOS GERAIS DE EQUIPAMENTOS SUBMARINOS;

[28] I-ET-3000.00-1500-251-PEK-001: High-strength Low-alloy Steel Fasteners for Subsea Applications;

[29] ET-3000.00-1500-251-PEK-002: *Rastreabilidade para Fixadores em Aço de Alta Resistência para Utilização Submarina;*

[30] ET-3000.00-1500-940-PEK-001: *Projeto de Proteção Catódica para Equipamentos Submarinos;*

[31] ET-3000.00-1521-600-PEK-001: *Projeto de Interfaces para Operações com ROV;*

[32] ET-3000.00-1500-600-PEK-005: *Requisitos de Estruturas de Equipamentos Submarinos;*

[33] I-ET-3000.00-1500-29B-PAZ-006: *QUALIFICATION FOR POWER, CONTROL AND INJECTION UMBILICALS;*

[34] I-ET-3000.00-1500-29B-PAZ-008: *QUALIFICATION TESTS FOR OPTICAL UMBILICALS – OPTICAL MESH NETWORK PROJECT;*

[35] I-ET-3A36.00-1519-29B-PAZ-001: *SUBSEA UMBILICAL SYSTEMS TO CONNECT PRODUCTION UNITS TO THE OPTICAL MESH NETWORK;*

[36] I-ET-3000.00-1500-29B-PAZ-010: *GENERAL REQUIREMENTS OF OPTICAL RISERS FOR THE SUBSEA OPTICAL NETWORK.*

3 DEFINITIONS

UTA CONTRACTOR	The company contracted by PETROBRAS to design, construct and supply the UTA 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.
MOP-BS CONTRACTOR	The company contracted by PETROBRAS to design, construct, supply and install the MOP-BS EPCI Project.
FPU CONTRACTOR	The company contracted by PETROBRAS to design, construct and supply the FPU topside infrastructure of OPTICAL SYSTEM.
OPTICAL SYSTEM	All accessories for the functional main operation from the UTA (i.e., optical components).
SUPPLIER	Company hired by UTA CONTRACTOR, to supply components from 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	The 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 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 UTA 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 with umbilical pigtails.
MALE CONNECTOR	Optical wet mate connector solution with the mechanical plug interface.
FEMALE CONNECTOR	Optical wet mate connector solution with the mechanical receptacle interface.

4 TECHNICAL CARACTERISTICS

4.1 Design and fabrication

4.1.1 All subsea optical components shall be designed in accordance with [5], [6] and [23].

4.1.2 Selection of materials for all subsea structures shall be in accordance with [15] 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 [16].

4.2 Qualification

4.2.1 All subsea equipment shall be qualified in accordance with [9] or [18].

4.2.2 All optical components and accessories (e.g., subsea JBs) shall be qualified as per [6], [23], [33], and [34].

4.2.3 UTA CONTRACTOR shall consider SUPPLIERS with experience in subsea optical systems.

4.2.4 SUPPLIERS shall demonstrate prior experience in delivering integrated optical systems (UTA + optical connectors) with full qualification of the assembly, including cable-to-connector interface and sealing mechanisms. Evidence must be based on proven filed performance and/or recognized qualification tests. The supply of individual components will not be accepted as evidence. The following criteria shall be used to demonstrate compliance:

- Evidence of functional and mechanical tests (locking, sealing, resistance to pressure and vibration)
- Operational history without critical failures in similar projects (minimum 2 years)
- Certifications or qualification reports issued by independent entities or the operator
- The minimum quantity requirement shall consider 8 complete units of UTAs, not just optical connectors, to ensure representativeness of the integrated system’s performance

5 GENERAL TECHNICAL REQUIREMENTS

5.1 System overview

5.1.1 SUT design shall be in accordance with the general requirements from the technical specification [10], [11] and [27].

5.1.2 UTA CONTRACTOR shall design and build the SUT mechanical structure according to the technical specification [26].

5.1.3 UTA CONTRACTOR shall design the SUT and FLDF structures considering metallic structures to protect sensible components like flying leads hoses and connectors. The protection of those components is very important during offshore activities like umbilical handling and laying with the PLSV.

5.1.4 SUT design shall consider maximization of the SUT component's integration onshore to facilitate PLSV offshore activities. Any technical solution different from this technical specification may be proposed by UTA CONTRACTOR and presented for PETROBRAS technical team during SUT detailing design for approval before implementation.

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

5.1.5.1 Operating water depth: up to 2500 meters

5.1.5.2 Maximum storage temperature: 50ºC

5.1.5.3 Submarine average temperature: 4ºC

5.1.5.4 Maximum environmental temperature during tests: 45ºC

5.1.5.5 Maximum relative air humidity: 85%

5.1.5.6 OPTICAL SYSTEM design life: 30 years

5.1.6 UTA CONTRACTOR shall previously identify, in the phase of submission of the TECHNICAL PROPOSAL, all subsea equipment that needs maintenance during the lifetime of the OPTICAL SYSTEM's operation, as well as presenting a list of recommended additional spare parts in the RM document. If it is not listed in the RM, the number of spare parts in the present document shall be considered.

5.1.7 SUT design shall include in all the ROV Pannels grab bars for ROV operations interface according to [27] .

5.1.8 SUT shall include in all the ROV Pannels a subsea QR Code as described in [27].

5.1.9 The cathodic protection system shall be designed in accordance with the requirements and specifications presented in [26] and [30] and shall consider protection for all equipment internal elements and connected parts to the SUT's 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. The UTA's cathodic protection system does not include the umbilical line. All equipment of the OPTICAL SYSTEM shall be protected against crevice corrosion [19].

5.1.10 The SUT Base and SUT Connection Body shall be designed to have their own cathodic protection systems. Both SUT Base and SUT Connection Body shall be outfitted with a separate cathodic protection inspection point. The SUT Base and SUT Connection Body shall be designed based on [7] and such that a ROV grab handle is near each inspection point to allow the ROV to stay stationary while using a cathodic protection Probe.

5.1.11 All SUT's structure shall be painted in accordance with the painting requirements presented in the [26]. The Equipment Painting Plan shall be submitted to PETROBRAS for approval. Equipment painting scheme shall be duly qualified by a painting certified inspector.

5.1.12 All subsea components from OPTICAL SYSTEM shall be designed, manufactured, and tested according to [1], [4], [6] and [18].

5.1.13 UTA CONTRACTOR shall present a reliability study based on standard [14] for the OPTICAL SYSTEM components. If any critical components should be found during the reliability study, technical solutions shall be pointed out to satisfy the equipment's operational design life.

5.1.14 All recoverable subsea components shall be able to withstand the inherent impacts from subsea installation and recovery operations. SUPPLIER shall present in the TECHNICAL PROPOSAL the parameters of maximum acceleration in all axes and allowable vibrations of each subsea equipment to be installed and/or recovered.

5.1.15 The design of the OPTICAL SYSTEM shall ensure that its components are prepared to resist efforts during subsea offshore installations and recovery of SUT structure or flying lead jumpers set.

5.1.16 The minimum length of each flying lead (OFL) of the flying lead jumpers set shall be 50 meters long.

5.1.17 The maximum distance between SUT and SESDV structures shall be 30 meters.

5.1.18 UTA CONTRACTOR shall submit a ROV accessibility report study for interconnection between UTA and MOP-BS optical HUB to demonstrate compliance with such premises.

5.2 General Design Requirements

5.2.1 This section describes the common requirements for SUT design.

5.2.2 SUT shall comprise 02 (two) independent structural elements: the Connection Body and the Base.

5.2.3 A basic schematic arrangement for SUTs is shown in Figure 1 and Figure 2 below. However, UTA CONTRACTOR may suggest a different equipment arrangement and submit to PETROBRAS for approval.

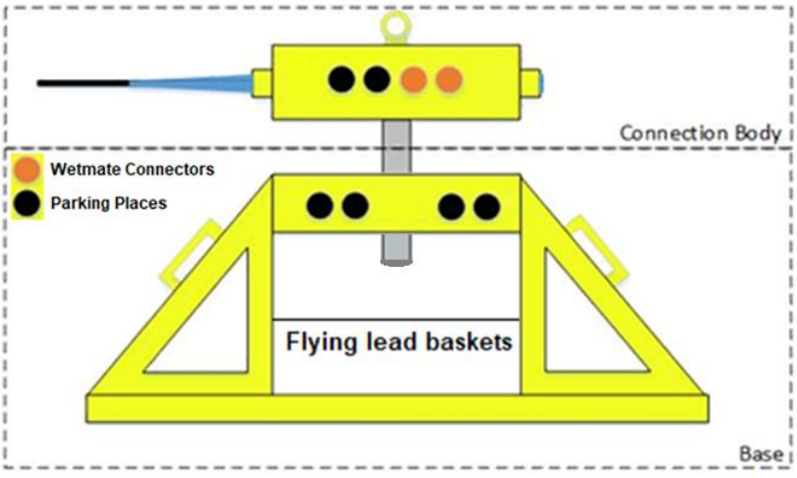

Figure 1 – SUTs basic general schematic arrangement

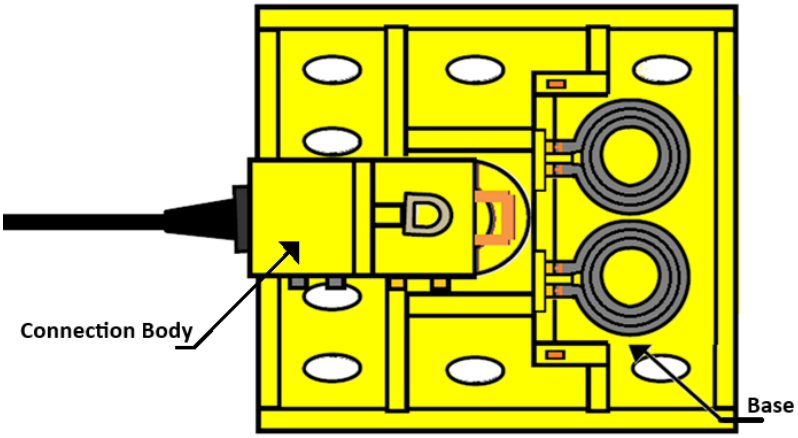

Figure 2 – SUT's general arrangement from top view

5.2.4 SUT Connection Body is the structural element where the pigtails of the optical cabling will be interconnected/terminated within.

5.2.5 SUT Base is the structural element that will support the connection body and that shall be designed accordingly to withstand all loads foreseen during the UTA's lifetime.

5.2.6 SUT Base (see Figure 3) comprises two main components:

5.2.6.1 *Connection Body Mounting Base*: that includes a guidance system to mitigate the risk of the SUT Connection Body impacting the SUT Base structure during installation and a ROV manual locking mechanism.

5.2.6.2 *OFLs Deployment Frame (FLDF)*: that includes two OFLs parked at basket inside for ROV installation.

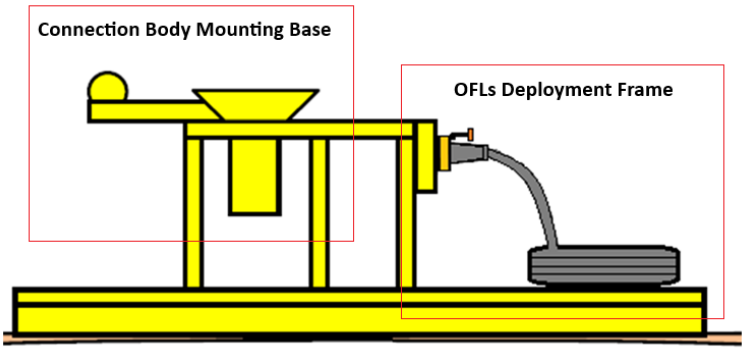

Figure 3 – SUT base schematic arrangement

5.2.7 The design of SUT shall allow the assembling (Base and Connection Body) both onshore and even offshore installation. 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. SUT Connection Body Mounting Case Mounting base shall be designed such that the final SUT assembly is supported a minimum of 2000 mm higher than the base of the subsea host structure.

5.2.8 SUT Connection Body shall be designed to protect all internal components, including the optical bulkhead wet mate connectors, against impacts and damage during SUTs handling and offshore installation.

5.2.9 SUT Connection Body shall be handled as a separate unit as illustrated on Figure 4 with the guide pin parked in horizontal position for transport.

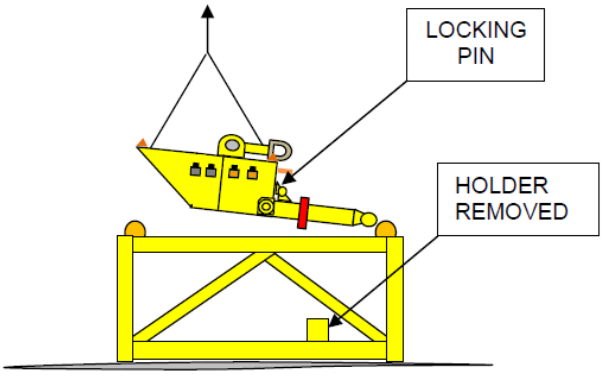

Figure 4 - SUT Connection body at transportation skid schematic

5.2.10 After connection of the umbilical line and make-up of the optical connections the SUT Connection Body being lifted from deck to allow vertical positioning of the stabbing /guide pin and over-boarding the vessel.

6 OPTICAL SYSTEM COMPONENTS

6.1 WET MATE CONNECTORS AND FLYING LEADS requirements

6.1.1 The wet mate optical connectors' model shall be chosen during the construction phase in formal consultation with PETROBRAS.

6.1.2 All optical connectors shall be supplied with interconnection of PBOF hoses.

6.1.3 The optical distribution shall be made with ½" hoses, filled with silicone oil.

6.1.4 PBOF hoses shall be supplied with internal pressure as specified by the manufacturer. PBOF hoses shall be qualified for projects subsea application. The results of the qualification tests shall be submitted for PETROBRAS approval.

6.1.5 Bend stiffeners shall be provided at the interface between the PBOF hoses with the wet mate connectors or the subsea junction box. These bend stiffeners shall ensure that the PBOF hose shall not exceed the minimum radius of curvature and minimize the possibility of crevice corrosion.

6.1.6 During the project detailing phase, UTA CONTRACTOR shall present to PETROBRAS evaluation and approval the angle of the orientation keys of all the ROV-operable optical connectors of the OPTICAL SYSTEM.

6.1.7 The wet-mate optical connector model shall conform to the following requirements:

6.1.7.1 Be 8 (eight) or more-ways optical fiber cores, with fibers end face Angled Physical Contact (APC).

6.1.7.2 be ROV-mate.

6.1.7.3 be able to remain firm after mating another connector.

6.1.7.4 be able to be connected and disconnected in sea water at the required depth.

6.1.7.5 be able to withstand at least 100 mate/demate cycles.

6.1.7.6 be qualified according to [6] & [23] (shall present evidences).

6.1.7.7 have a double barrier against the sea water ingress to the contacts, both for the part of the connection, and for the cable-connector interface at its rear.

6.1.7.8 have a track record of at least 30 units installed worldwide and operating continually without failure for a period of 2 years.

6.1.8 The wet mate optical bulkhead connectors' pigtails shall be designed/supplied with same specification of the fibers from umbilical cables.

6.1.9 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 [6] & [23].

6.1.10 UTA CONTRACTOR shall supply all dummy connectors to protect the connectors' integrity during operations offshore as presented at Figure 5.

6.1.11 The dummy connectors shall be designed to have some closed looped pins to check the fibers' integrity during and after installation. UTA CONTRACTOR shall select the dummy connectors detailing during the construction phase in formal consultation with PETROBRAS.

6.1.12 UTA CONTRACTOR shall supply parking places for all wet mate bulkhead connectors as presented in Figure 5. Parking places shall be designed in SUT Connection Body and SUT Base FLDF ROV Pannels.

6.1.13 UTA CONTRACTOR shall supply OFLs to connect with single ROV operations.

6.1.14 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 SUT Base FLDF.

6.1.15 The OFLs shall be designed/supplied with same specification of the fibers from umbilical cables.

6.1.16 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 for the offshore installation of SUT Base, with the flying leads being simultaneously accommodated in the structure. Parking places for OFL connectors shall be designed in SUT's structure.

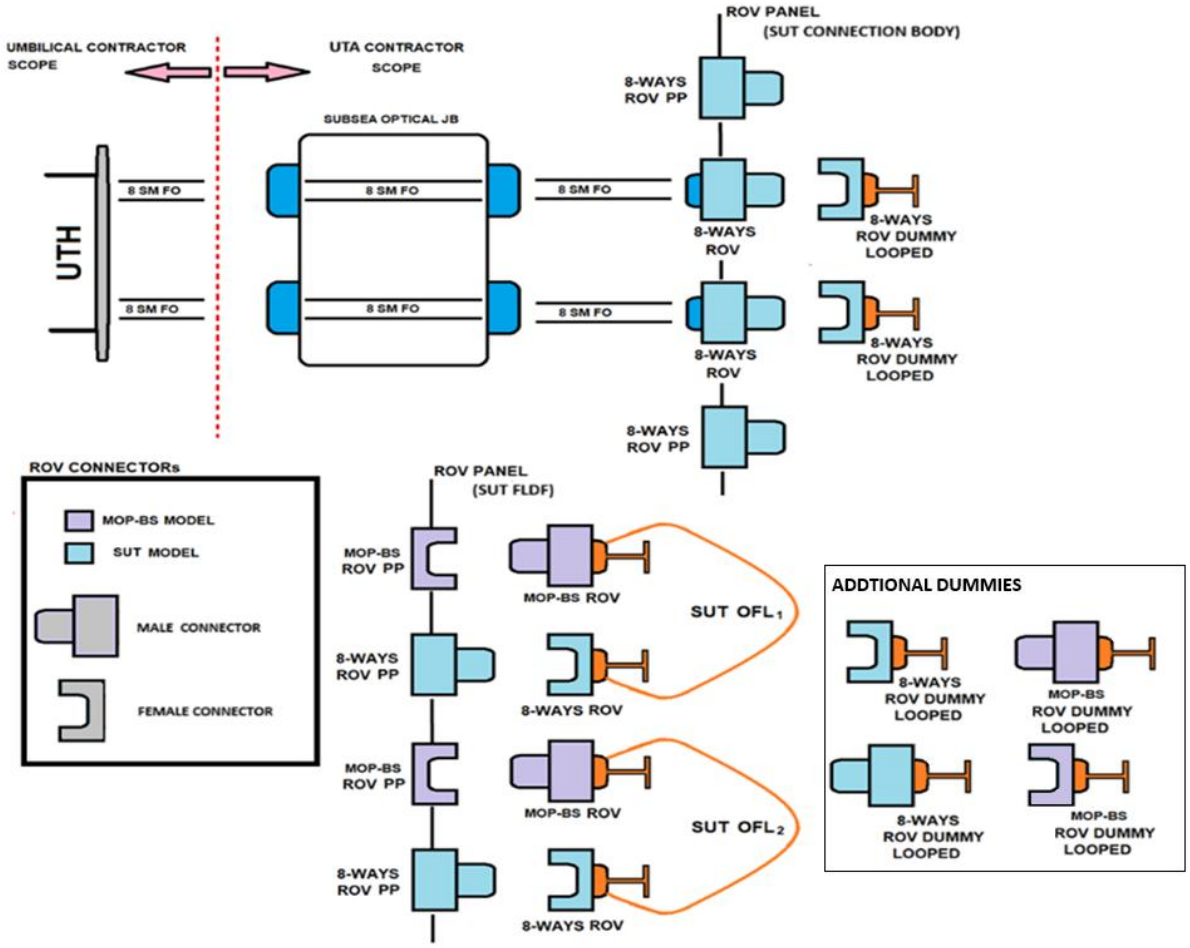

Figure 5 - SUT's optical wiring diagram schematic

6.1.17 UTA CONTRACTOR shall supply FLDF (with all flying leads installation accessories) where the OFLs shall be patched for offshore installation, it shall be provided with protective surfaces to prevent any damage to the OFLs and parking places for both wet mate connectors.

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

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

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

6.1.21 UMBILICAL CONTRACTOR shall commission the SUT installed offshore before connection to the *Malha Óptica* Project equipment. UMBILICAL CONTRACTOR and UTA CONTRACTOR shall inform the tests and commissioning procedures according to section 10 during the construction phase in a formal consultation with PETROBRAS telecom team. UMBILICAL CONTRACTOR and UTA CONTRACTOR shall submit the procedures to PETROBRAS for approval.

6.2 TELECOM OPTICAL CABLE REQUIREMENTS

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

6.2.1.1 Have 16 (sixteen) or more optical single mode fiber cores meeting the requirements on item 6.3.

6.2.1.2 Certification and qualification by UJ CONSORTIUM.

6.2.1.3 SUPPLIER shall inform all optical and mechanical characteristics of the cable provided.

6.2.1.4 Cable shall be qualified to ensure fiber protection against water depth pressure, longitudinal water ingression in case of rupture, chemical aggression, and hydrogen darkening during lifetime.

6.2.1.5 Considering a period of 14 days after rupture, the longitudinal water ingression shall respect the maximum allowed ingression of 1 km.

6.2.1.6 Cable structure shall ensure that there will be no performance degradation on fiber during deployment, burial, and recovery, considering industry best practices.

6.2.1.7 Cable structure shall ensure that there will be no additional attenuation on fibers during lifetime due to hydrogen molecules ingression due to metallic structure corrosion

6.2.1.8 The acceptable cable to be used is Single Armoured Cable.

6.2.1.9 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 launch and maintenance operations.
- Not damage the environment.

6.2.1.10 Cable application shall comply with [21] – Characteristics of optical fiber submarine cables.

6.2.1.11 PETROBRAS shall approve the cable application.

6.2.1.12 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.

6.2.2 Cable marks and identification:

6.2.2.1 Cable shall be identified and marked in accordance to recommendation 16, emission 1 from ICPC.

6.2.2.2 The physical structure, colors and fonts from labels and markings shall be proposed by supplier and approved by PETROBRAS.

6.2.2.3 IDs shall be visible considering a 0,5m distance.

6.2.2.4 Cable shall have an alphanumeric ID printed on cable. This code shall be enough to identify number and type of fibers and other cable specifications.

6.2.2.5 ID shall be repeated every 5 meters.

6.2.2.6 IDs and markings shall remain intact during loading, unloading, deployment, recovery, and repair.

6.2.2.7 A numeric length scale shall be printed on cover.

6.2.2.8 Cable shall present distance markings on every one kilometer.

6.2.2.9 Cable shall have labels that define the marking of all junctions.

6.2.2.10 Besides junctions, every cable transition shall be marked and identified.

6.3 OPTICAL FIBER REQUIREMENTS

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

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

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

6.3.3.1 Attenuation shorter than or equal to 0.18 dB/km

6.3.3.2 Dispersion shorter than or equal to 18.00 ps/nm.km

6.3.3.3 Dispersion Slope shorter than or equal to 0.088 ps/nm².km

6.3.3.4 PMD shorter than or equal to 0.20 ps/√km

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

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

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

6.3.7 Once covered by the primary coating, the optical fiber when submitted to a curvature radius equal to or greater than 37.5 mm, shall not present a variation of attenuation for wavelengths between 1300 and 1625 nm, in accordance with [22].

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

6.3.9 UTA CONTRACTOR shall inform PETROBRAS of the following characteristics of the optical fibers used to manufacture the optical fiber cable:

6.3.9.1 Refractive index profile.

6.3.9.2 Maximum attenuation coefficient at the 1310 nm transmission window.

6.3.9.3 Minimum attenuation coefficient at the 1310 nm transmission window.

6.3.9.4 Maximum attenuation coefficient at the 1550 nm transmission window.

6.3.9.5 Minimum attenuation coefficient at the 1550 nm transmission window.

6.3.9.6 Maximum chromatic dispersion (ps/nm.Km) at the 1300 nm transmission window.

6.3.9.7 Maximum chromatic dispersion (ps/nm.Km) at the 1550 nm transmission window.

6.3.9.8 Cut-off wavelength.

6.3.9.9 Detailing of Hydrogen impermeabilization.

6.3.9.10 Modal field diameter.

6.3.9.11 Core / cladding concentricity error.

6.3.9.12 Core non circularity.

6.3.9.13 PMD - Polarization Mode Dispersion.

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

7 INSTALLATION AND INTERVENTION REQUIREMENTS

7.1.1 The SUT Connection Body and Base shall be designed and prepared for subsea installation, preferably installed separately. An integrated assembly may be proposed but is subjected to PETROBRAS approval. In both scenarios, the integrity of the equipment - including sealing, structural stability, and functional interfaces - shall be preserved throughout handling, deployment, and operational life. All subsea operations shall consider the use of a single ROV.

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

7.1.3 In case the subsea installation is performed separately, SUT Base installation preparation shall have FLDF baskets at mud mat structure to accommodate 2 (two) OFLs, from the JUMPERS SET. The placement of baskets in the structure shall make it possible to:

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

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

7.1.4 SUT Base shall be initially installed offshore in the seabed. SUT Base shall be designed for both vertical (with 2-point lift) and horizontal (with 4-point lift) installation offshore. All related accessories shall be new and dully certificated. Refurbished or reused slings/accessories shall not be accepted.

7.1.5 SUT Base handling/lifting design shall consider both transport handling, installation and uninstallation operations. The slings and all accessories (e.g., shackles, sling yokes, master links, etc.) shall be part of the scope of supply of the UTA CONTRACTOR and shall be in accordance with [25].

7.1.6 The position and orientation of SUT Base shall be monitored via transponders and gyroscopic compass during the installation (during descent and deployment). SUT Base shall equipped with transponder buckets and inclinometer (subsea bullseye) to verify that the SUT base shall be installed within the tolerances specified.

7.1.7 A bullseye-type circular level, compatible with ROV visualization, shall be provided in the SUT Base to be permitted to check the final equipment leveling after its installation.

7.1.8 The SUT Base shall be designed to be installed withing the following tolerances:

7.1.8.1 Center of the SUT base within 5 meters (radius) from target box;

7.1.8.2 Orientation within +/- 5 degrees from the target indication;

7.1.8.3 Unevenness (out of level): maximum 2 degrees.

7.1.9 After SUT Base shall be successfully installed, SUT Connection Body will start the procedures for offshore installation.

7.1.10 The structure of the SUT Connection Body shall be attached with the support flange termination to mechanically connect with the umbilical line structures.

7.1.11 SUT Connection Body shall be designed to allow both first and second end installation methods, that contain and support a flange termination to mechanical connect to the umbilical line. See an example of second end installation sequence in Figure 6, Figure 7, Figure 8 and Figure 9.

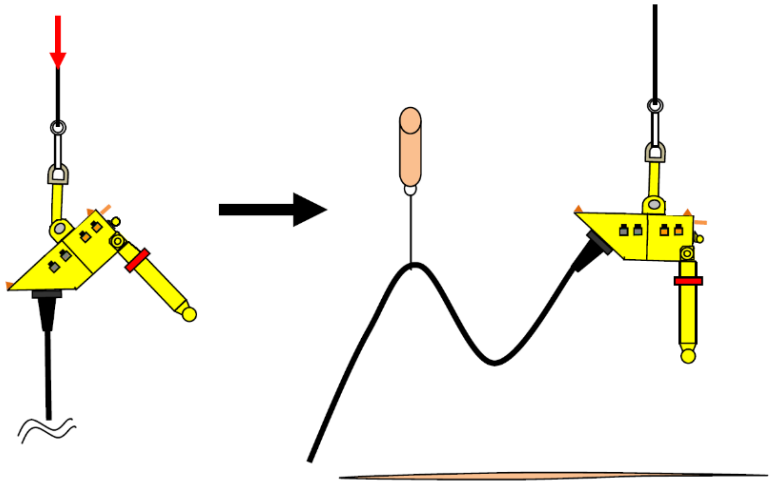

Figure 6 – Example installation sequence (step 1: SUT Connection body descending)

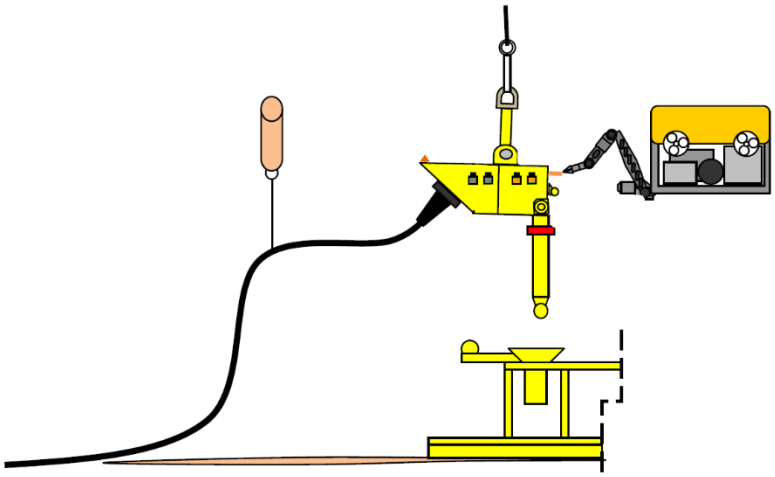

Figure 7– Example installation sequence (step 2: SUT Connection body with ROV assistance)

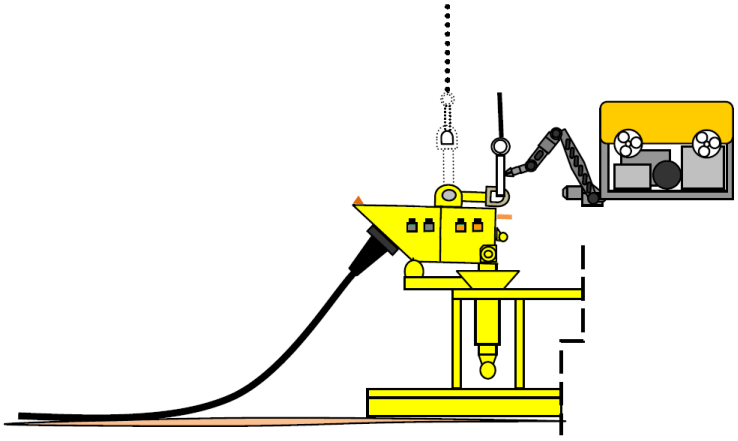

Figure 8 - Example installation sequence (step 3: ROV removing installation sling)

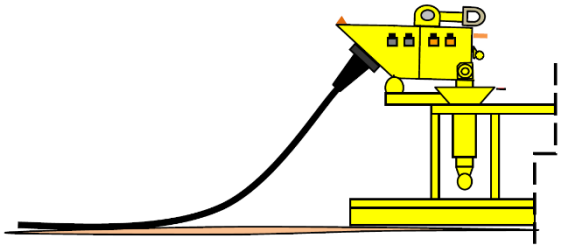

Figure 9 - Example installation sequence (step 4: SUT Connection Body installed in SUT Base)

7.1.12 For a first end lay, the provisions will be optical dummy connectors with looped pins to allow for OTDR and optical continuity measurements on the optical fibers from umbilical cable. For a second end lay scenario, the optical dummy connectors will need to be removed, and optical test connectors shall be installed to facilitate OTDR and optical continuity measurements.

7.1.13 After the SUT Connection Body has been successfully installed on the SUT Base, it shall be securely locked with the ROV Locking Pins at SUT Connection Body Mounting Base.

7.1.14 Design of SUT Connection Body 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 related accessories shall be new and dully certificated. Refurbished or reused slings will not be accepted.

7.1.15 UTA CONTRACTOR shall evaluate and define the most appropriate location for the installation of yoke on the SUT Connection Body and shall consider aspects such as load capacity, interferences, and the equipment orientation required for its installation and/or uninstallation.

7.1.16 Yoke shall be designed so that, after SUT Connection Body 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.

7.1.17 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.

7.1.18 During the SUT Connection Body designing, UTA 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's 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.

7.1.19 SUT Connection Body 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. UTA 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.

7.1.20 SUT Connection Body structure shall consider, at minimum, the material properties of group II class B of [3]. For those parts of the structural frames that will not be subjected to primary mechanical loads, material properties of group II class C of [3] may be used. Use of materials of group I class C of [3], such as Steel A-36, will not be accepted.

7.1.21 For equipment welding works, UTA CONTRACTOR shall meet the requirements of PETROBRAS N-133 Standard [24], 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).

7.1.22 SUT Connection Body and SUT Base shall be robust enough and structurally prepared to withstand the mechanical launching loading, both vertically and horizontally, and without suffering displacement of its components. UTA CONTRACTOR shall submit the structural analysis of the UTA for prior analysis of PETROBRAS.

7.1.23 UTA 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.

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

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

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

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

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

7.1.29 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.

8 SYSTEM AVAILABILITY

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

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

8.1.3 UTA CONTRACTOR shall clearly inform PETROBRAS which methods are used to calculate availability, as well as the assumptions adopted.

9 TECHNICAL DOCUMENTATION

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

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

9.1.3 UTA CONTRACTOR shall present in the project detailing phase, with approval by PETROBRAS, the procedure for assembling the OPTICAL SYSTEM at UTH.

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

9.1.5 The technical documentation shall include at least the following:

- Block diagram;
- Piping and Instrumentation Diagram (P&ID);
- General arrangement drawings of UTA with flying leads;
- General arrangement drawings of FLDF with flying leads;
- Optical connectors drawings and datasheet;
- Factory Acceptance Test Procedure/Reports;
- Acceptance and Performance test (TAP) Procedure/Reports;
- Operational procedures for SUT Connection Body and SUT Base;
- SUT Connection Body and SUT Base ROV accessibilities report.

10 TESTS AND INSPECTION

10.1 OPTICAL CONNECTORS, OFLs and SUBSEA JBs TESTS

10.1.1 Regarding the qualification tests:

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

10.1.2 With respect to FATs:

10.1.2.1 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.

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

10.1.2.3 Optical tests (see sections 10.2 and 10.3);

10.1.2.4 Helium or nitrogen leak test as specified by the manufacturer and previously approved;

10.1.2.5 Visual and dimensional inspection test;

10.1.2.6 Mechanical tests: hydrostatic test, visual and dimensional inspection.

10.1.3 The SIT shall be performed by UTA CONTRACTOR before the CLM, with at least 1 (one) full UTA set (i.e. SUT Connection Body + SUT Base), 1 (one) JUMPERS SET and, if it is the scope of supply. SIT shall include the mechanical installation test from SUT Connection Body at mounting base structure of SUT Base.

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

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

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

10.2 OPTICAL TESTS

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

10.2.2 The tests shall be performed according to Table 1:

Table 1 – List of tests

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

10.2.3 UMBILICAL CONTRACTOR shall perform optical attenuation tests from the DIO 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.

10.2.4 UTA / UMBILICAL CONTRACTOR shall use appropriate instruments and with valid calibration certificates, to perform these factory and offshore tests.

10.2.5 It shall be UTA/UMBILICAL CONTRACTOR's responsibility to supply all the accessory

materials necessary for the perfect execution of all tests factory and offshore.

10.3 OPTICAL TESTS TECHNICAL DESCRIPTION

10.3.1 Total optical attenuation.

10.3.2 This test shall be performed using a power meter and light source to measure the total attenuation / insertion loss of the DUT.

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

10.3.4 The results shall preferably be presented according to Table 2:

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

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]		

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

10.3.6 Optical attenuation – OTDR

10.3.7 The optical attenuation tests shall be performed with OTDR in both directions, whenever possible to be performed.

10.3.8 For the commissioning tests, the 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.

10.3.9 To perform measurements on the commissioned system, CONTRACTOR shall evaluate the need for the application of optical filters or C-OTDR type instruments.

10.3.10 In addition to the events throughout the DUT, the OTDR tests shall evaluate the ORL per event.

10.3.11 The results shall preferably be presented according to Table 3:

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

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					

10.3.12 Chromatic Dispersion.

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

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

10.3.15 The results shall preferably be presented according to Table 4:

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

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/(nm^2.km)]		Sellmeier Coeficients		
A	B		1310nm	1550nm	1625nm		Lambda Zero	1550nm	A	B	C

10.3.16 Dispersion by Polarization Mode.

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

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

10.3.19 The results shall preferably be presented according to Table 5:

Table 5 – Suggested format for presenting PMD results

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

10.3.20 Acceptance Criteria

10.3.21 The acceptance criteria shall be as described at Table 6:

Table 6 – Tests acceptance criteria

TESTS	FACTORY (UTA CONTRACTOR scope)	VESSEL / COMMISSIONING (UMBILICAL CONTRACTOR scope)
Total optical attenuation	Attenuation per kilometer less than or equal to 0.20 dB/km @1550 nm.	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 0.20 dB/km @1550 nm; • Optical splices with OIL less than 0.2 dB; • 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 0.20 dB/km @1550 nm. • Optical splices with insertion loss <0.2 dB. ○ Connections to wet mate connectors with OIL and ORL better or equal to that specified in the element datasheet.
Chromatic Dispersion	CD < 18 ps/nm^2*km	N/A
PMD	PMD < 0,2 ps/km^{0,5}	N/A

11 REQUIREMENTS FOR INSPECTION, PACKAGING, STORAGE, PRESERVATION AND TRANSPORTATION

11.1.1 SUT's inspection requirements shall be in accordance with [27] and [32].

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

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

11.1.4 UTA 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.

11.1.5 UTA 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.

11.1.6 The packaging methods shall be designed to completely protect all the equipment and parts of OPTICAL SYSTEM against possible damage during transport, loading and unloading.

11.1.7 UTA CONTRACTOR shall submit for approval of PETROBRAS, the procedures for handling the OPTICAL SYSTEM equipment, depending on the specified means of transport.

11.1.8 OPTICAL SYSTEM shall be delivered to PETROBRAS disassembled from SUT Connection Body, packed by UTA 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.

11.1.9 The spare OPTICAL SYSTEM from SUT Connection Body, shall be delivered by UTA 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.

11.1.10 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.

11.1.11 The two main OFL jumpers shall be delivered to PETROBRAS accommodated in existing basket in the SUT FLDF (at SUT base), respecting the total quantity according to RM in which this ET is referenced.

11.1.12 SUT Base shall be delivered to PETROBRAS covered in canvas to protect against ultraviolet rays, so that the OPTICAL SYSTEM, components located in the SUT FLDF structure, shall be protected from the weather.

11.1.13 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.

12 CONDITIONING

12.1.1 UTA CONTRACTOR shall be responsible for the conditioning of OPTICAL SYSTEM equipment from the beginning of the manufacture until delivery to the PETROBRAS staff for which it is intended, including the period of transportation.

12.1.2 When required in RM, UTA CONTRACTOR shall submit for approval of PETROBRAS, the procedures for the implementation of the conditioning of OPTICAL SYSTEM equipment.

13 AFTERMARKET SUPPORT SERVICES

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

13.1.2 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.

14 SCOPES OF SUPPLY

14.1.1 The scope of supply is illustrated on **Figure 10**.

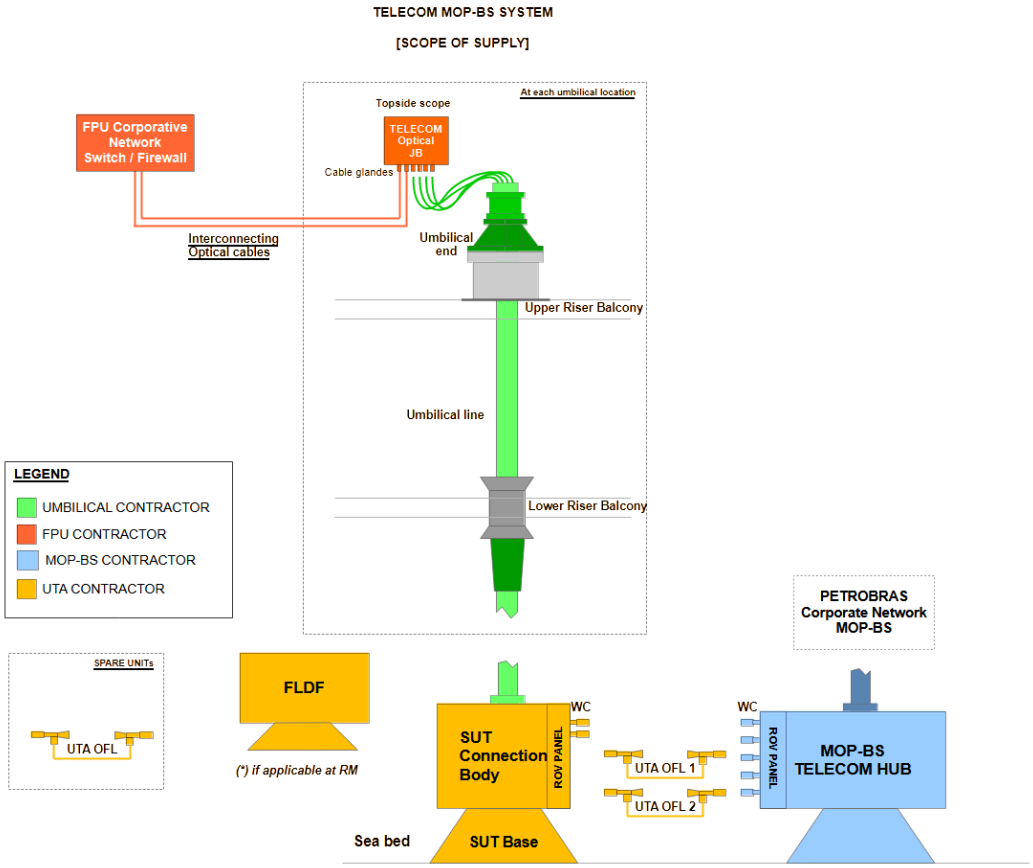

Figure 10 - Diagram of UTA for Telecom system main components standard scope of supplies