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**UMBILICAL TERMINATION ASSEMBLY (UTA) FOR SESDV  
(SUBSEA EMERGENCY SHUT-DOWN VALVE)****1 INTRODUCTION**

This document presents the Technical Specification and functional requirements for the electro-hydraulic control system of UTA for the subsea import/export system of PETROBRAS production fields (to connect to a SESDV).

**2 ABBREVIATIONS**

AC - Alternating Current;  
AFM - Material Supply Authorization;  
CD - Chromatic Dispersion;  
CLM - Material Release Communication;  
C-OTDR - Coherent OTDR;  
DC - Direct Current;  
DIO - Internal Optical Distributor;  
DIV - Diver;  
DUT - Device Under Test;  
EFL - Electrical Flying Lead;  
ET - Technical Specification;  
FAT - Factory Acceptance Test ;  
FLDF - Flying Leads Deployment Frame;  
FPU - Floating Production Unit;  
HCR - High Collapse Resistant;  
HDPE - High Density Polyethylene;  
HFL - Hydraulic Flying Lead;  
HPU - Hydraulic Power Unit;  
ICPC - International Cable Protection Committee;  
JB- Junction Box;  
JIC - Joint Industry Council;  
MTTF - Mean Time to Failure;  
MQC - Multi-Port Quick Connection;  
NC - Not Connected pin;  
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;  
PVT - Performance Verification Test;  
ROV - Remotely Operated Vehicle;  
RM - Material Requisition;  
RMS - Root Mean Square;  
SDU - Subsea Distribution Unit;  
SESDV - Subsea Emergency Shut-Down Valve;  
SIT - Site Integration Test;  
UEH - Electro-Hydraulic Umbilical;  
UEP - Stationary Production Unit;  
UJ - Universal Joint;  
UTA - Umbilical Termination Assembly;  
UTH - Umbilical Termination Head;  
WMC - Wet mate Connector.

### 3 REFERENCE DOCUMENTS, CODES AND STANDARDS

This section lists standards and documents applicable to the design of the control and monitoring system:

#### 3.1 International standards

- [1] API 6A: Specification for Wellhead and Christmas Tree Equipment;
- [2] API 17D: Specification for Subsea Wellhead and Tree Equipment;
- [3] API 17E: Specification for Subsea Umbilicals;
- [4] API 17F: Standard for Subsea Production Control Systems;
- [5] API 17Q: Recommended Practice on Subsea Equipment Qualification;
- [6] ASME B16.5: Standard Specification for Alloy-Steel and Stainless Steel Bolting for Low-Temperature Service;
- [7] ASME B16.5: Pipe Flanges and Flanged Fittings;
- [8] MIL-STD-217F: Reliability Prediction of Electronic Equipment;
- [9] DNVGL-RP-B401: Cathodic Protection Design;
- [10] IEC 60529: Degrees of Protection Provided by Enclosures (IP Code);
- [11] DNV-RP-H103: Modelling and Analysis of Marine Operations;
- [12] 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");
- [13] ISO 15156-3: Cracking resistant CRAs (corrosion Resistant Alloys) and other alloys;
- [14] IEC 60502-1: Cables for rated voltages of 1 kV ( $U_m = 1,2$  kV) and 3 kV ( $U_m = 3,6$  kV);
- [15] ITU-G.978: Characteristics of Optical Fiber Submarine Cables;
- [16] ITU-T G.652: Characteristics of a Single-mode Optical Fiber and Cable;
- [17] SEAFOM TSD-02: Functional Design and Test Specification for Subsea Electrical and Optical Connectors and Jumpers.

#### 3.2 PETROBRAS documents

- [18] I-ET-3000.00-1500-823-PEK-001: Qualification of Wet-Mate Electrical Connectors and Accessories;
- [19] I-ET-3000.00-1510-854-PEK-001: MONITORING SYSTEM FOR SUBSEA EMERGENCY SHUT-DOWN VALVE (SESDV);
- [20] ET-3000.00-1500-610-PEK-002: ESLINGAS, SKIDS, CAIXAS E BASE DE TESTES DE EQUIPAMENTOS SUBMARINOS;
- [21] I-ET-3000.00-1500-600-PEK-010: MECHANICAL REQUIREMENTS FOR UMBILICAL TERMINATION ASSEMBLIES – UTAs;
- [22] ET-3000.00-1500-600-PEK-006: REQUISITOS GERAIS DE EQUIPAMENTOS SUBMARINOS.

**UMBILICAL TERMINATION ASSEMBLY (UTA) FOR SESDV  
(SUBSEA EMERGENCY SHUT-DOWN VALVE)**
**4 DEFINITIONS**

<b>UTA CONTRACTOR</b>	The company contracted by PETROBRAS to design, construct and supply the UTA and its accessories (e.g., CONTROL SYSTEM).
<b>UMBILICAL CONTRACTOR</b>	The company contracted by PETROBRAS to design, construct, supply and install the umbilical line and its accessories.
<b>SESDV CONTRACTOR</b>	The company contracted by PETROBRAS to design, construct, supply and install the SESDV and its accessories.
<b>FPU CONTRACTOR</b>	The company contracted by PETROBRAS to design, construct and supply the FPU topside infrastructure of SESDV SYSTEM.
<b>CONTROL SYSTEM</b>	All accessories for the functional main operation from the UTA (i.e., ELECTRICAL, HYDRAULIC and/or OPTICAL SYSTEMS).
<b>SUPPLIER</b>	Company hired by UTA CONTRACTOR, to supply components from CONTROL SYSTEM.
<b>MAY</b>	It is used when alternatives are equally acceptable.
<b>SHOULD</b>	It is used when a provision is not mandatory but is recommended as a good practice.
<b>SHALL</b>	It is used when a provision is mandatory.
<b>AVAILABILITY</b>	The probability that the system will remain operating under the conditions specified in the project during its useful life.
<b>EQUIPMENT</b>	Set of components and parts composing architecture to meet the requirements of this ET.
<b>RECOMMENDED PRACTICE</b>	Best Practice established in Technical Standard, but which admits the possibility of a more adequate alternative to the specific application.
<b>TECHNICAL PROPOSAL</b>	Set of technical premises that the UTA CONTRACTOR undertakes to follow in the design of the Equipment.
<b>SYSTEM</b>	Set of elementary systems, integrated within the premises and operational availability established in the RM to which this ET refers.
<b>UTH</b>	Sub-module of the UTA, in which all the components residing in the UTA of the CONTROL SYSTEM are assembled with umbilical pigtailed.
<b>MALE CONNECTOR</b>	Electrical wet mate connector solution with the electrical pins non-exposed to sea water.
<b>FEMALE CONNECTOR</b>	Electrical wet mate connector solution with the electrical pins exposed to sea water.

**5 TECHNICAL CHARACTERISTICS**
**5.1 Design and fabrication**

- 5.1.1 All subsea control components shall be designed in accordance with [3] and [4].
- 5.1.2 Selection of materials for all subsea structures shall be in accordance with [9] item 5.5 and be designed for the same design life as the CONTROL SYSTEM.
- 5.1.3 All enclosures with a required degree of ingress protection shall comply with [10].

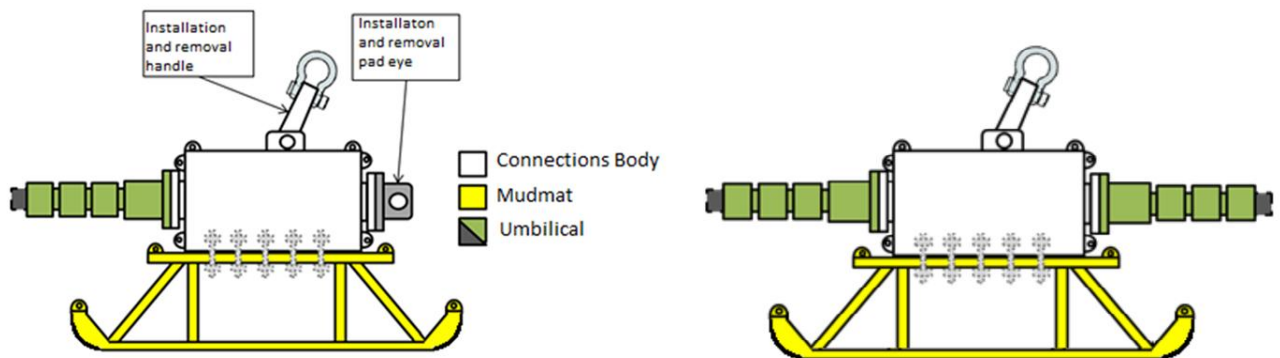
**5.2 Qualification**

- 5.2.1 All subsea equipment shall be qualified in accordance with [5] and/or [12].
- 5.2.2 All wet mate optical connectors and accessories shall be qualified as per [17].
- 5.2.3 All wet mate electrical connectors and accessories shall be qualified as per [18].
- 5.2.4 UTA CONTRACTOR shall consider SUPPLIERS with experience in subsea electric, hydraulic and/or optical control systems.

## 6 GENERAL TECHNICAL REQUIREMENTS

### 6.1 System overview

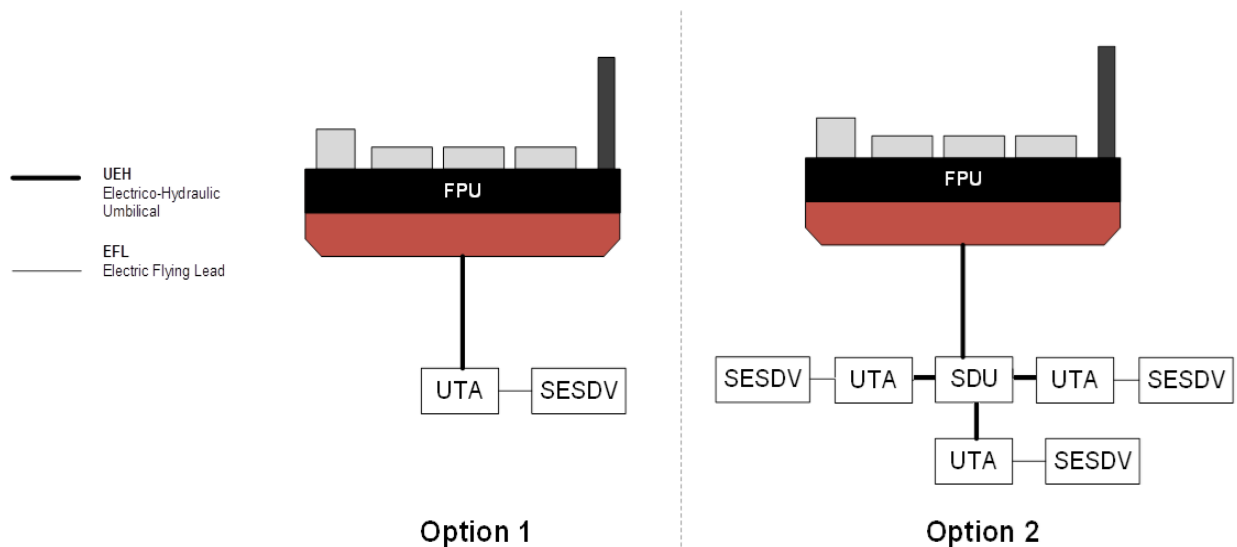
- 6.1.1** UTA design shall be in accordance with the general requirements from the technical specification [22].
- 6.1.2** UTA CONTRACTOR shall design and build the UTA mechanical structure according to the technical specification [21] (see Figure 1).
- 6.1.3** UTA CONTRACTOR shall design the UTA and FLDF structure considering metallic structures to protect sensible components like flying leads and connectors. The protection of those components is very important during offshore activities like umbilical handling and laying at the PLSV.
- 6.1.4** UTA design shall consider maximization of the UTA 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 UTA detailing design for approval before implementation.



**Figure 1** - Example of UTAs configuration: End-line and In-line installation

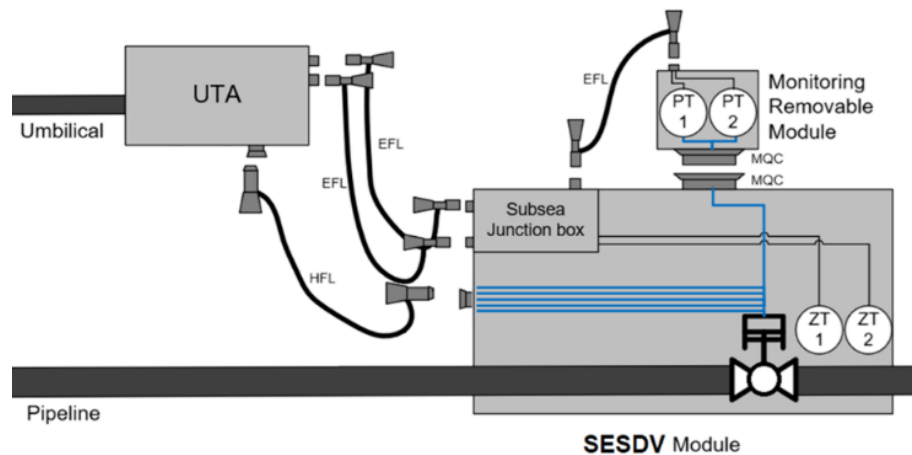
- 6.1.5** The CONTROL SYSTEM shall be compatible with the following environmental conditions:
- 6.1.5.1 Operating water depth: up to 2500 m
  - 6.1.5.2 Maximum storage temperature: 50°C
  - 6.1.5.3 Submarine average temperature: 4°C
  - 6.1.5.4 Maximum environmental temperature during tests: 45°C
  - 6.1.5.5 Maximum relative air humidity: 85%
  - 6.1.5.6 CONTROL SYSTEM design life: 30 years
- 6.1.6** 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 CONTROL SYSTEM's operation, as well as presenting a list of recommended 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.
- 6.1.7** UTA design shall include in the ROV Pannels from UTA and FLDF grab bars for ROV operations interface according to [22].

- 6.1.8 UTA shall include in the ROV Pannels from UTA and FLDF a subsea QR Code as described in [22].
- 6.1.9 All components from CONTROL SYSTEM (except FLDF) shall be protected by the cathodic protection from UTA as per ref. [9]. If a component cannot be protected, the equipment shall be made of corrosion resistant material and submitted for PETROBRAS technical approval.
- 6.1.10 All equipment of the CONTROL SYSTEM shall be protected against crevice corrosion.
- 6.1.11 All subsea components from CONTROL SYSTEM shall be designed, manufactured, and tested according to [1], [2], [4] and [12].
- 6.1.12 UTA CONTRACTOR shall present a reliability study based on standard [8] for the CONTROL 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.
- 6.1.13 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.
- 6.1.14 The design of the CONTROL SYSTEM shall ensure that its components are prepared to resist efforts during subsea offshore installations and recovery of UTA structure or flying lead jumpers set.
- 6.1.15 The CONTROL SYSTEM project, including the UTA mechanical structure, shall be compatible with a subsea layout according to Figure 1.
- 6.1.16 The monitoring and hydraulic actuation systems can follow two arrangement options:
  - One umbilical connects FPU to just one SESDV (Option 1 – Figure 2).
  - One umbilical connects FPU to more than one SESDV, through a SDU (Option 2 - Figure 2).



**Figure 2** – General schematic of the subsea layout with SESDV Monitoring System (two options)

- 6.1.17** The minimum length of each flying lead (EFL and HFL) of the flying lead jumpers set shall be 50 meters long.
- 6.1.18** The maximum distance between UTA and SESDV structures shall be 30 meters.
- 6.1.19** UTA CONTRACTOR and SESDV CONTRACTOR shall both submit a ROV accessibility report study for interconnection between UTA and SESDV to demonstrate compliance with such premises. A general schematic of the UTA and SESDV interconnected is illustrated in the Figure 3. SESDV requirements is fully demonstrated on [19].



**Figure 3 – SESDV MONITORING SYSTEM subsea general schematic**

## 6.2 Electrical components requirements

- 6.2.1** The requirements from Section 6.2 (and its sub-items) shall be applicable to all electrical components from CONTROL SYSTEM, including the UTA's resident ELECTRICAL SYSTEM, the EFLs set and the FLDF.
- 6.2.2** The following requirements are valid for all electrical components of the CONTROL SYSTEM:
- 6.2.2.1 Nominal voltage (as defined in standard [14]): 0.6 / 1 (1.2) kV
  - 6.2.2.2 Rated current: 10A RMS AC
- 6.2.3** All PBOF hoses used in electrical distribution from CONTROL SYSTEM shall be provided terminated with connector assembly JIC 37° male ¾" - 16UNF (SIZE 8) for electrical connectors.
- 6.2.4** All electrical connectors shall be supplied with JIC 37° male ¾" - 16UNF (SIZE 8) for interconnection of PBOF hoses.
- 6.2.5** The electrical distribution shall be made with ½" hoses, filled with silicone oil.
- 6.2.6** All the electrical conductors shall be arranged with twisted shielded pairs.
- 6.2.7** 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.
- 6.2.8** 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

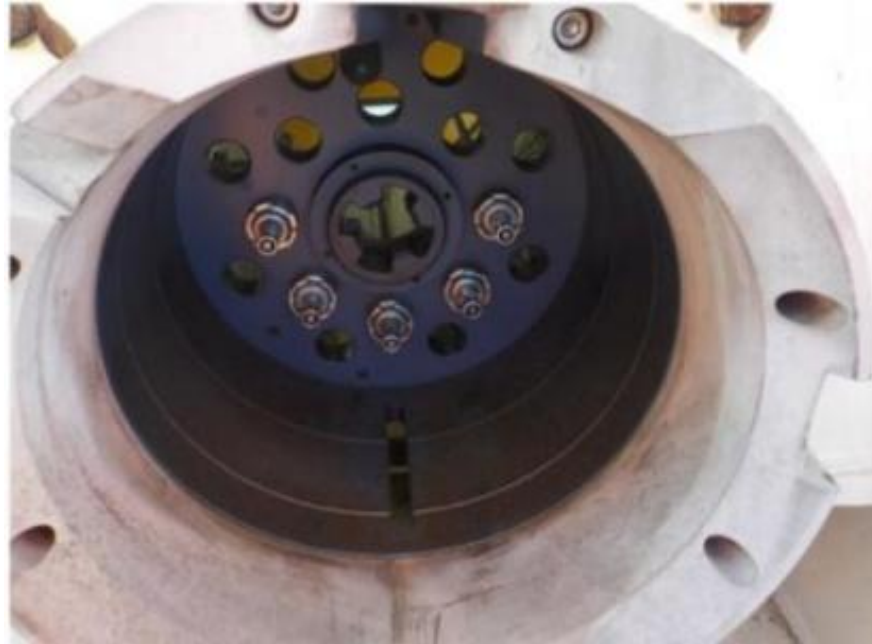
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the possibility of crevice corrosion.

- 6.2.9** During the project detailing phase, CONTRACTOR shall present to PETROBRAS evaluation and approval the angle of the orientation keys of all the ROV-operable electrical connectors of the CONTROL SYSTEM.
- 6.2.10** The electrical wet mate connectors (ROV-mate & diver-mate) shall have the following characteristics:
- 6.2.10.1 It shall be able to remain firm after mating with another connector.
  - 6.2.10.2 It shall be able to be connected and disconnected in sea water at the required depth.
  - 6.2.10.3 It shall have electrical contacts protected from sea water during the mating. The contacts shall be designed in a controlled environmental compartment, pressure compensated and filled with oil or dielectric gel during mating and demating.
  - 6.2.10.4 It shall 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.
  - 6.2.10.5 It shall be able to maintain its mechanical and electrical integrity after 100 (one hundred) operations (mate/demate).
  - 6.2.10.6 It shall have a reduced body, allowing easy handling by the ROV manipulator.
  - 6.2.10.7 It shall have an insulation resistance (after 100 operations) greater than  $1G\Omega$  @500VDC at environmental temperature.
  - 6.2.10.8 It shall allow the MALE CONNECTOR to be kept energized even when disconnected.
- 6.2.11** Each electrical connector shall have a respective complete protective dummy connector to prevent the pins (MALE and FEMALE) from being exposed to sea water.
- 6.2.12** All subsea electrical ROV connectors shall be suitable for single ROV operation.
- 6.2.13** The subsea junction box inside UTA shall be made of corrosion resistant material and shall also be equipped with a double barrier against the penetration of sea water.
- 6.2.14** All types of subsea electrical connectors of the CONTROL SYSTEM shall be subjected to PVT-type tests, including connection cycling and disconnection in a hyperbaric chamber, according to test procedures approved by PETROBRAS. The samples used in these tests shall be chosen randomly from those manufactured for the CONTROL SYSTEM.
- 6.2.15** All subsea electrical hoses, including flying leads, shall have at least two barriers against seawater penetration in electrical contacts.
- 6.2.16** The flying leads shall be of the type where the electrical wires are wrapped inside a hose filled with dielectric oil as a barrier for pressure compensation (PBOF).
- 6.2.17** The route of all electrical hoses shall be submitted to PETROBRAS in the project detailing phase.
- 6.2.18** All electrical components that are subject to fungal attacks and humidity shall be tropicalized to inhibit these issues.
- 6.2.19** UTA CONTRACTOR shall use EFLs with electrical connectors from the same SUPPLIER model, except in cases indicated at project's RM. During the UTA detailing design phase, UTA CONTRACTOR shall make a formal consultation to PETROBRAS for the definition of ROV CONNECTOR SESDV MODEL before placement of the AFM.

### 6.3 Hydraulic components requirements

**6.3.1** The requirements of Section 6.3 (and its sub-items) are applicable to all hydraulic components of the CONTROL SYSTEM, which covers the UTA resident HYDRAULIC SYSTEM, the JUMPERS ASSEMBLY HFLs and the FLDF.



**Figure 4** - Hydraulic multi-connector example (MQC)

**6.3.2** Working pressure of the hydraulic components of the CONTROL SYSTEM: 5.000 psi.

**6.3.3** Internal diameter of the hydraulic control lines of the CONTROL SYSTEM: ½ inches.

**6.3.4** The hydraulic components of the control system shall comply with the cleaning class standard SAE AS4059 [12]: 6B to 6F classes.

**6.3.5** The CONTROL SYSTEM shall be compatible with the following hydraulic control fluids standardized by PETROBRAS: *MacDermid HW443*, *MacDermid HW525P* and *Castrol Transaqua DW*.

**6.3.6** After placement of the AFM, the UTA CONTRACTOR shall provide compatibility analysis showing that the hydraulic control fluid adopted in the project is compatible with all materials used in the CONTROL SYSTEM that will be in contact with such control fluid.

**6.3.7** All HYDRAULIC SYSTEM piping shall be stainless steel and welded and in accordance with [6] and [7].

**6.3.8** For the delivery of the equipment to PETROBRAS, all hydraulic control circuits of the CONTROL SYSTEM shall be filled with the control fluid with corrosion protection in the vapor phase, standardized by the COMPANY.

**6.3.9** UTA CONTRACTOR shall fill and flush all hydraulic circuits with HPU water-glycol based hydraulic control fluid with cleanliness class according to Norm ISO 4406 CLASS 17/15/12. (Equivalent to class 6 from the old Norm NAS1638 [12] Cleanliness Requirements used in Hydraulic Systems) and ensure no air bubbles inside.

**6.3.10** The hydraulic fluid shall be defined by PETROBRAS by a formal consultation during detailing phase based on 6.3.5. The hydraulic fluid shall be the same as SESDV, UTA

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and topside HPU.

- 6.3.11** The hydraulic couplers (couplings) shall have metal to metal primary seal type and resilient secondary seal. The part of the connector that contains the seals shall be located on the equipment that is easiest to install and recover to the surface.
- 6.3.12** The hydraulic couplers shall allow at least ten (10) connecting subsea complete cycles and disconnection, without the need to replace the seals. SUPPLIER shall inform in the details of the project before the placement of AFM by PETROBRAS the maximum number of connection and disconnection cycles after which the seals shall be replaced.
- 6.3.13** The hydraulic couplers shall be connected and disconnected normally (without damage or degradation), even when subjected to maximum operating pressure.
- 6.3.14** Each hydraulic couplers connection pair shall have a check valve to minimize the ingress of seawater during connection and disconnection operations. The maximum ingress of seawater during a connection shall not exceed 5 ml.
- 6.3.15** The check valve of the hydraulic coupler shall be suitable for operating at water depth of the CONTROL SYSTEM and shall not open unduly in case the external pressure to the coupler is equal to or lower than the operating water depth.
- 6.3.16** There shall not be any fluid leakage when the connection and the disconnection of the couplers hydraulic even at maximum pressure test.
- 6.3.17** All types of hydraulic couplers and hydraulic multi-connectors (as per Figure 4) of the monitoring system equipment shall be subjected to PVT type tests after placing the SUPPLIER AFM, including cycling connection and disconnection in a hyperbaric chamber according to procedures approved by PETROBRAS.
- 6.3.17.1 As an alternative to meet the requirement of previous item, SUPPLIER shall be allowed to present PETROBRAS approval, in the project detailing phase, the qualification history of the couplers from a previous supply, in PETROBRAS projects. History shall comprise couplers with successful performance in the field, as well as understanding the fulfillment of the same or more demanding requirements in relation to this ET. Copper alloys such as "Hiduron 130" and "Nibron" are historically incompatible with hydraulic fluid MacDermid HW443, so these materials are not allowed the use of such materials in hydraulic couplers for Monitoring System at the regions of the couplers in which there is contact with hydraulic control fluid.
- 6.3.18** The hydraulic multi-connectors of the CONTROL SYSTEM shall have a locking mechanism with rotational type for ROV actuation. The design of the hydraulic multi-connector shall be such that, in the event of receiving over torque, the locking mechanism shall have a failure mode that allows the unlocking of the hydraulic multi-connector.
- 6.3.19** Hydraulic internal jumpers shall be supplied for the interconnection of UTA internal tubing and UTH hydraulic pigtails. All Hydraulic internal jumpers shall be HCR-type thermoplastic hoses with a minimum of 1 meter length each and shall have internal diameter of ½ inches. All Hydraulic internal jumpers shall be supplied filled with hydraulic control fluids as per item 6.3.10 and with cleanliness level as per item 6.3.4.
- 6.3.20** Thermoplastic hoses used in HFLs shall be designed and shall have the respective operational procedures developed by the SUPPLIER in such a way as to ensure the

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integrity of its components during its underwater installation, including to ensure that they do not collapse. The use of HCR-type thermoplastic hoses shall not be permitted. Thermoplastic hoses interface between HFL MQC outboard plates shall be with a JIC standard. All Thermoplastic hoses shall be protected together with a HDPE heavy duty hose spiral wrap guard protector.

- 6.3.21** Thermoplastic hoses used in HFLs shall be designed and shall have the respective operational procedures developed by the SUPPLIER in such a way as to ensure the integrity of its components during its underwater installation, including to ensure that they do not collapse. The use of HCR-type thermoplastic hoses shall not be permitted for HFL hoses.

## 7 CONTROL SYSTEM COMPONENTS

### 7.1 ELECTRICAL SYSTEM

- 7.1.1** ELECTRICAL SYSTEM shall comprise the supply from UTA internal electrical components for the UEH with 4 pairs except in cases indicated at project's RM. All ELECTRICAL SYSTEM (except parking places) shall be supplied in dedicated transportation "IP-65" boxes for the offshore installation.
- 7.1.2** The default case, all channels shall be terminated in the electrical ROV wet mate bulkhead connectors mounted at ROV panel from UTA to interface with the EFLs JUMPER SET.
- 7.1.3** The ROV wet mate connectors shall be a MALE CONNECTOR, with 7-ways electrical connector compatible with the EFLs of the JUMPERS SET.
- 7.1.4** The pairs of UTH electrical cables shall be terminated: pair ID-1 (Connector 1: pins #1 and #2), pair ID-2 (Connector 1: pins #3 and #4) and pair ID-3 (Connector 2: pins #1 and #2) and pair ID-4 (Connector 2: pins #3 and #4) of the electrical connectors of the ROV panel (see Figure 5).
- 7.1.5** The subsea cables to connect the subsea junction box shall be PBOF hoses with JIC8 interface for mounting with the FEMALE diver connectors supplied from UMBILICAL CONTRACTOR.
- 7.1.6** UMBILICAL CONTRACTOR shall be responsible for the supply of diver wet mate connectors with male JIC-8 interface (including all mounting accessories) and UTA CONTRACTOR shall be responsible for the PBOF hoses with electrical cables terminated in a female JIC-8 interface (see Figure 5).
- 7.1.7** UTA CONTRACTOR shall supply the required silicon oil for this cable mounting. These subsea cable mountings shall be executed by UMBILICAL CONTRACTOR and/or UTA CONTRACTOR.

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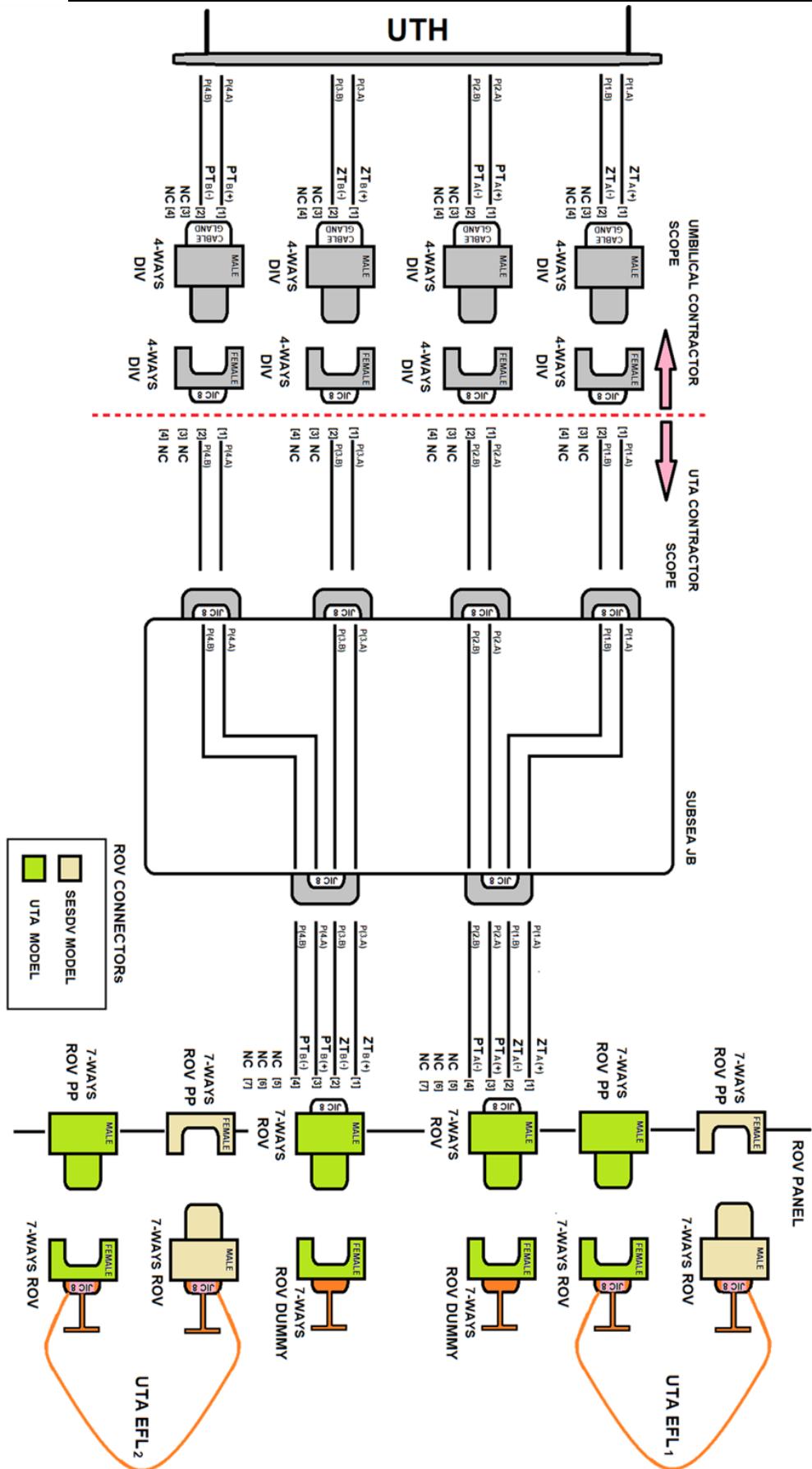
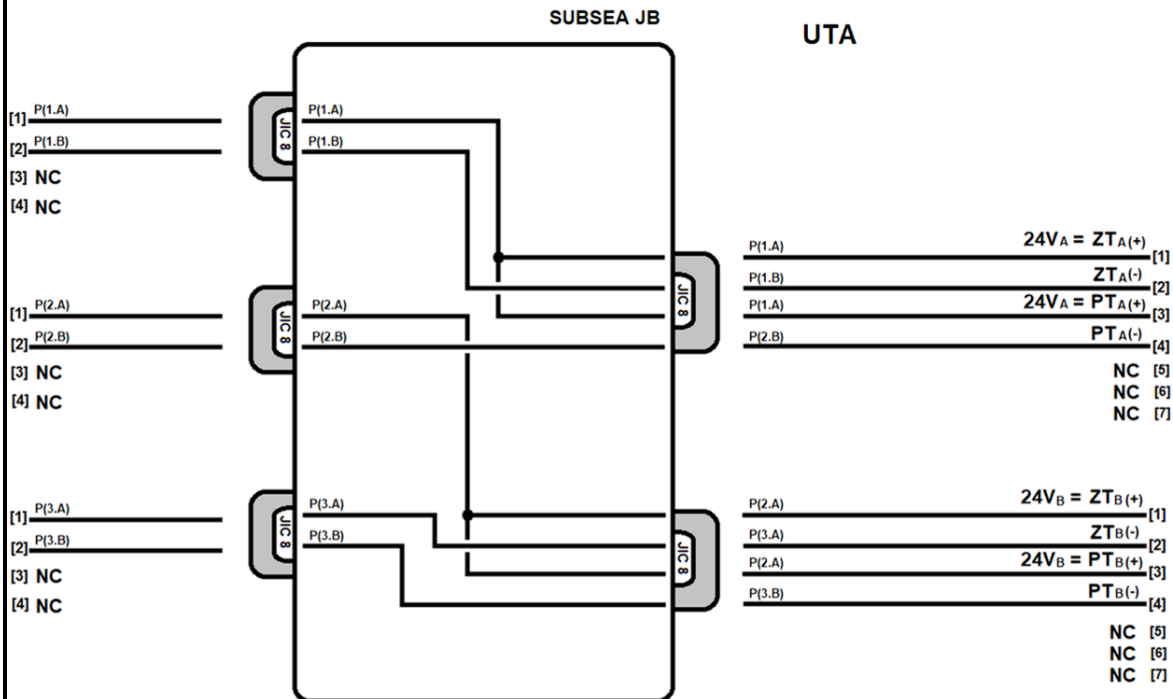


Figure 5 – ELECTRICAL SYSTEM wiring diagram from standard UTA

**7.1.8** If UEH is supplied with only 3 pairs indicated in the project's RM, UTA CONTRACTOR shall supply a subsea junction in the electrical arrangement as indicated in Figure 6.



**Figure 6** – Subsea junction box wiring diagram from UEH with 3 pairs

**7.1.9** UTA CONTRACTOR shall provide 2 (two) protective ROV dummy connectors (FEMALE – UTA MODEL), operated by ROV to protect wet mate bulkhead connectors and/or EFL connector to be mounted in the ROV panel for offshore operation. Both shall be looped, i.e., have the pairs of pins short circuited, to support the umbilical line integrity monitoring during pipelay installation.

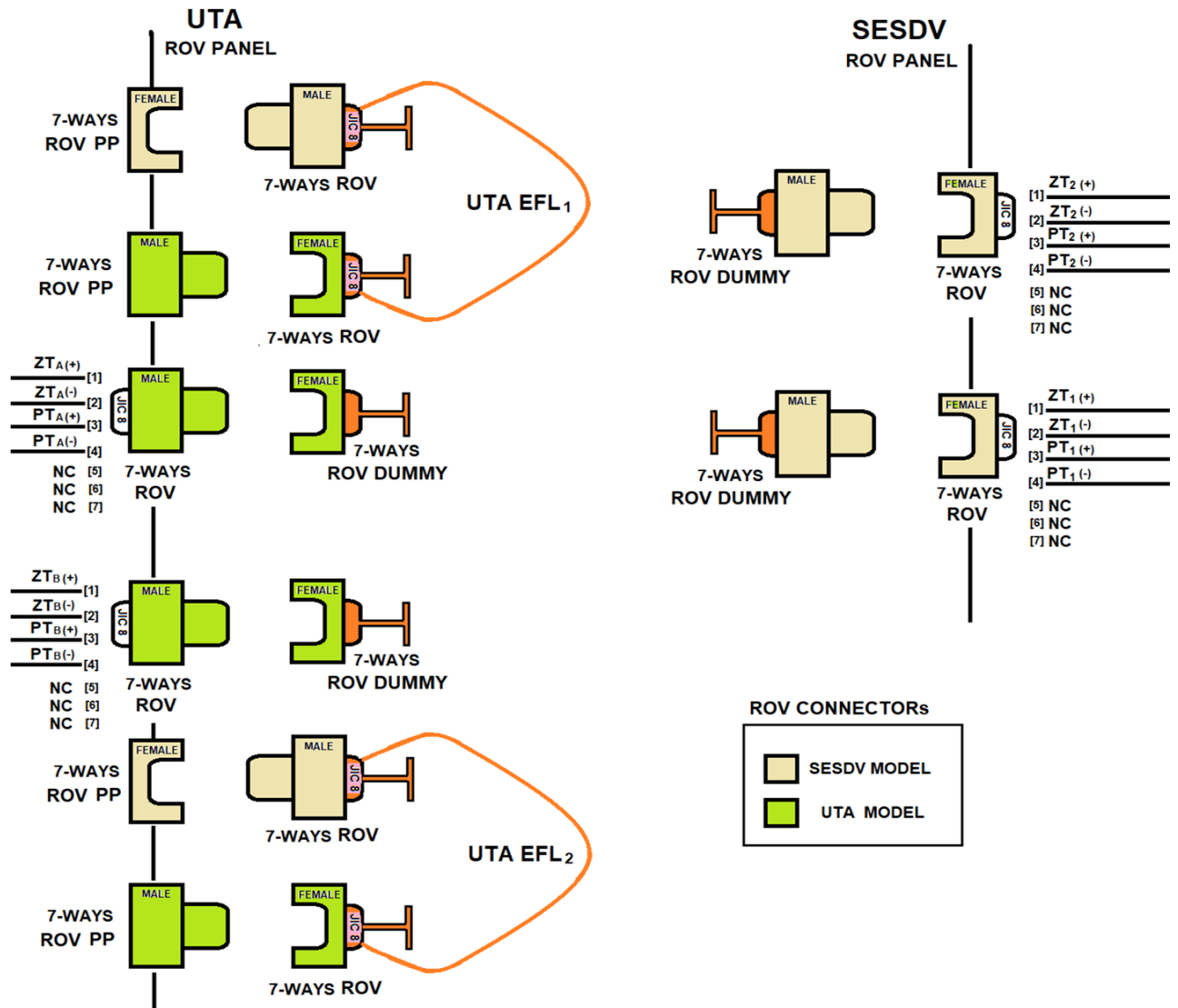
**7.1.10** UTA CONTRACTOR shall provide 4 (four) connectors parking places (2 FEMALE – SESDV MODEL and 2 MALE– UTA MODEL), mounted on ROV panel compatible with the EFL JUMPER SET terminations.

**7.1.11** All the electrical connectors (including parking places) shall be identified in the ROV panel by TAGs, for viewing by ROV. The identification shall adopt abbreviations that shall be defined by PETROBRAS during the detailing phase of the project.

**7.1.12** UTA CONTRACTOR shall provide 2 (two) test connectors kit for ROV wet mate connectors (SESDV MODEL and UTA MODEL) for supporting UTA ELECTRICAL SYSTEM mounting/testing.

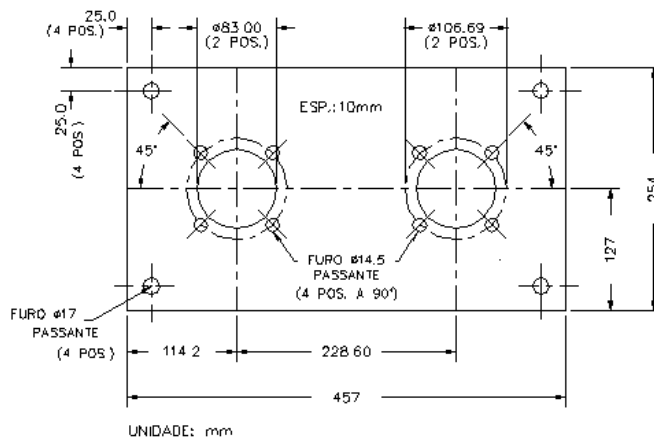
**7.1.13** The electrical crossover (diver wet mate connectors MALE & FEMALE as indicated in Figure 5) that interfaces with umbilical lines are not scope of supply of the UTA CONTRACTOR.

**7.1.14** UTA CONTRACTOR shall request PETROBRAS, in the project's detailing phase, the models of SESDV ROV wet mate connector models with which SESDV ELECTRICAL SYSTEM and the UTA ELECTRICAL SYSTEM shall be compatible. See the SESDV & UTA ELECTRICAL SYSTEM interface schematic drawing in Figure 7.



**Figure 7 – SESDV & UTA ELECTRICAL SYSTEM interface schematic drawing**

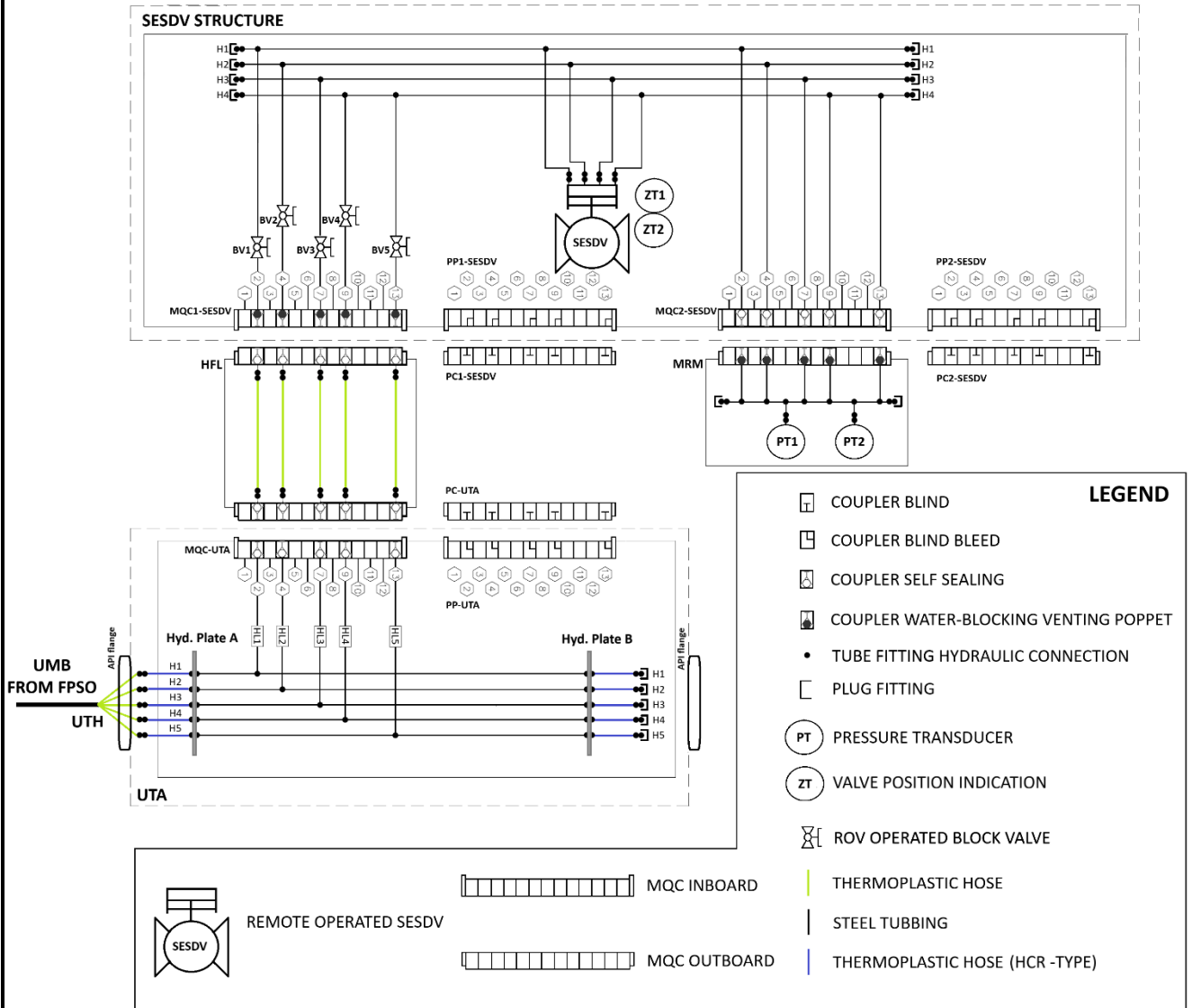
**7.1.15** The installation of the electrical bulkhead connectors in ROV panel shall be in accordance with the dimensions shown in Figure 8.



**Figure 8 – Standardization of electrical connector housing for ROV panel**

## 7.2 HYDRAULIC SYSTEM

**7.2.1** HYDRAULIC SYSTEM shall carry out the distribution of the hydraulic control lines according to the arrangement to Figure 9.



**Figure 9** – HYDRAULIC SYSTEM diagram from SESDV MONITORING SYSTEM and standard UTA

**7.2.2** For the distribution of hydraulic control, HYDRAULIC SYSTEM shall consist of 4 (four) main lines and 1(one) spare line, without communication between each other inside the UTA.

**7.2.3** All 5 (five) hydraulic headers shall be intended for the control of SESDV and shall be steel tubings made of stainless steel S31600 with requirements established in [13]. The steel tubing shall have internal diameter of ½ inches.

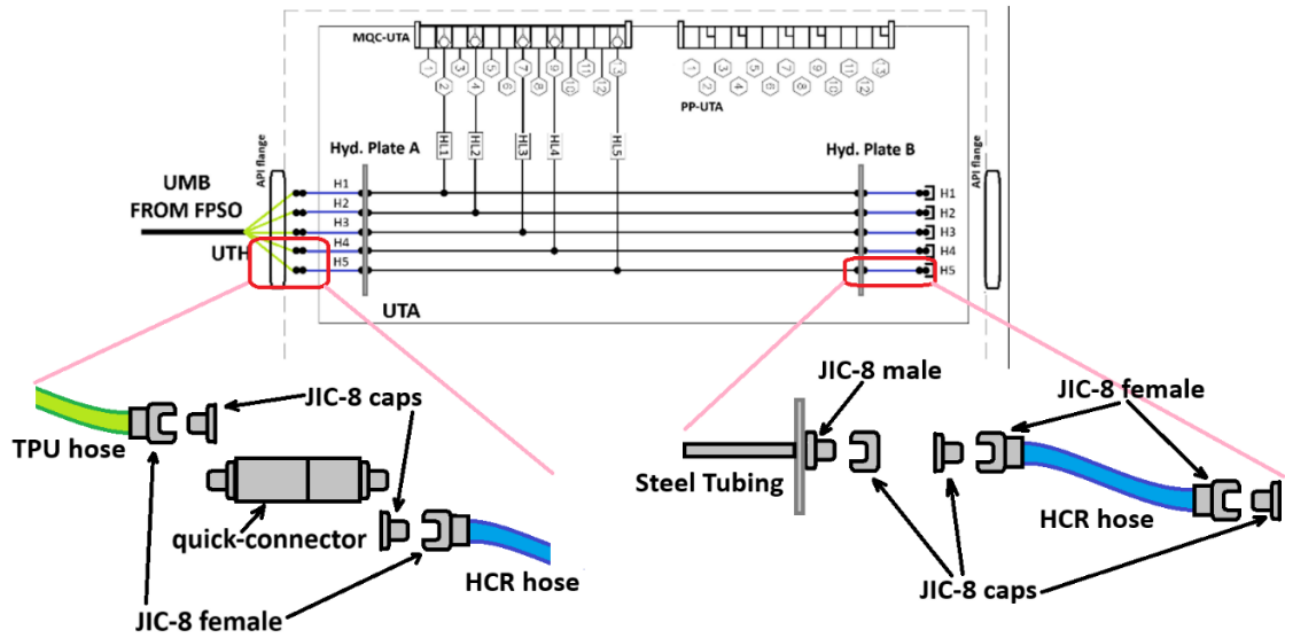
**7.2.4** The other terminations of the 5 (five) hydraulic control lines shall be placed in a hydraulic plate with hydraulic male JIC SAE 37° SIZE-8 tube fitting to connect offshore with the hydraulic pigtails from UTH (see Figure 10).

**7.2.5** UTA CONTRACTOR shall supply 10 (ten) hydraulic internal jumpers (see Figure 10). These hydraulic internal jumpers shall be supplied for the interconnection between

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UTA internal steel tubings and UTH hydraulic pigtails (at both flanges interface). All Hydraulic internal jumpers shall be specified as per item 6.3.19.

- 7.2.6 UMBILICAL CONTRACTOR** shall supply hydraulic quick couplers connectors for all 5 (five) hydraulic pigtails from UTH (see Figure 10) for UTA end-line configuration or more in the case of a UTA in-line configuration and it shall be detailed in the project RM.



**Figure 10** – Internal UTA HYDRAULIC SYSTEM example of detailed components

- 7.2.7** At UTA Hydraulic plate all JIC connections shall be tagged to support hydraulic channels identification.
- 7.2.8** The MQC hydraulic inboard connectors at ROV panel shall be compatible with the MQC hydraulic outboard connectors, operable by ROV, of the HFLs of the ASSEMBLY OF JUMPERS (see Figure 9).
- 7.2.9** “MQC-UTA” hydraulic inboard connector branch shall be responsible for the SESDV hydraulic actuation lines.
- 7.2.10** Regarding the hydraulic piping of the headers H1/H2/H3/H4/H5 at UTA HYDRAULIC SYSTEM:
- 7.2.10.1 It will be only four headers inside SESDV HYDRAULIC SYSTEM because the SESDV hydraulic actuator shall have only four hydraulic inlets.
  - 7.2.10.2 In the proposed schematic design illustrated at Figure 9, the five hydraulic headers shall have two hydraulic plates aligned for both UTH flanged interfaces.
  - 7.2.10.3 The HL5 from the umbilical line shall be connected at H4 header at SESDV HYDRAULIC SYSTEM to be used as a spare hydraulic line.
- 7.2.11** UTA HYDRAULIC SYSTEM shall have 1 (one) MQC hydraulic “parking place” [PP-UTA presented in Figure 9] mounted on the ROV panel from UTA structure. Such multi-connector shall be compatible for connection to the HFL hydraulic multi-connectors.
- 7.2.12** UTA HYDRAULIC SYSTEM shall have 1 (one) MQC hydraulic long-term pressure

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protective cap [PC-UTA presented in Figure 9], operable by ROV. The hydraulic termination, residing in this protection multi-connector, shall be individual for the hydraulic line and establish tightness when in contact with the hydraulic coupler belonging to the hydraulic multi-connector residing in the UTA structure. Such protection multi-connector shall be compatible with all hydraulic multi-connector resident in the UTA and SESDV structure.

- 7.2.13** The hydraulic multi-connectors shall be identified by TAGs at the UTA structure, for viewing by ROV. The identification shall adopt abbreviations that will be defined by PETROBRAS during the details of the project.
- 7.2.14** The hydraulic multi-connectors of the hydraulic system shall be modeled with a minimum of thirteen (13) and a maximum of fourteen (14) hydraulic couplers.
- 7.2.15** UTA CONTRACTOR shall use HFL with hydraulic connectors from the same SUPPLIER model, except in cases indicated at project's RM. During the UTA detailing design phase, UTA CONTRACTOR shall make a formal consultation to PETROBRAS for the definition of MQC model from UTA HFL before placement of the AFM.
- 7.2.16** UTA CONTRACTOR shall supply one HFL as presented in Figure 9. The HFL shall be supplied with all hydraulic components disassembled, i.e. with the 2 MQC OUTBOARD and 5 thermoplastic hoses set separated.
- 7.2.17** UTA CONTRACTOR shall present, for PETROBRAS approval, the operational procedure for commissioning and decommissioning the UTA in the field.

### 7.3 Flying leads jumpers set

- 7.3.1** UTA CONTRACTOR's scope of supply for main flying lead JUMPERS SET: 2 (two) UTA EFLs and 1 (one) HFL to complete the interconnection between UTA and SESDV, as shown in Figure 3.
- 7.3.2** UTA CONTRACTOR shall supply as a minimum of 1 (one) spare UTA EFL and 1 (one) spare HFL in dedicated transportation "IP-65" boxes.
- 7.3.3** All flying leads from the JUMPERS SET shall be at least 50 m long.
- 7.3.4** The physical routing of flying leads, in the arrangement of UTA and SESDV, according to Figure 3, shall be presented in the Technical Proposal.
- 7.3.5** All flying leads jumpers set shall be ROV operated subsea, including the operations of connection and disconnection terminations at UTA and FLDF.
- 7.3.6** All flying leads JUMPERS SET shall allow subsea installations and recovery operations using FLDF.
- 7.3.7** With respect to the EFLs JUMPERS SET:
- 7.3.7.1 The 3 (three) EFLs (2x main and 1x spare) of the JUMPERS ASSEMBLY shall be interchangeable and shall have identical electrical specifications.
  - 7.3.7.2 The connectors of EFLs terminations shall be 7 (seven) ways electrical model with all pins interconnected by electrical wiring (in twisted pair).
  - 7.3.7.3 The connector of EFLs termination that connects to the UTA shall have an electrical FEMALE CONNECTOR.

7.3.7.4 The connector of EFLs termination that connects to the SESDV shall have an electrical MALE CONNECTOR.

7.3.7.5 UTA CONTRACTOR shall request PETROBRAS, in the project detailing phase, the model of the electrical connector that shall be adopted at such termination of the EFL to SESDV (UTA and SESDV models).

**7.3.8** With respect to the HFLs JUMPERS SET:

7.3.8.1 The 2 (two) HFLs (main and spare) of the JUMPERS ASSEMBLY shall be interchangeable and shall have identical hydraulic specifications.

7.3.8.2 For each HFL, both hydraulic connectors terminations shall be identical, shall be exchangeable and shall be of "MQC" type.

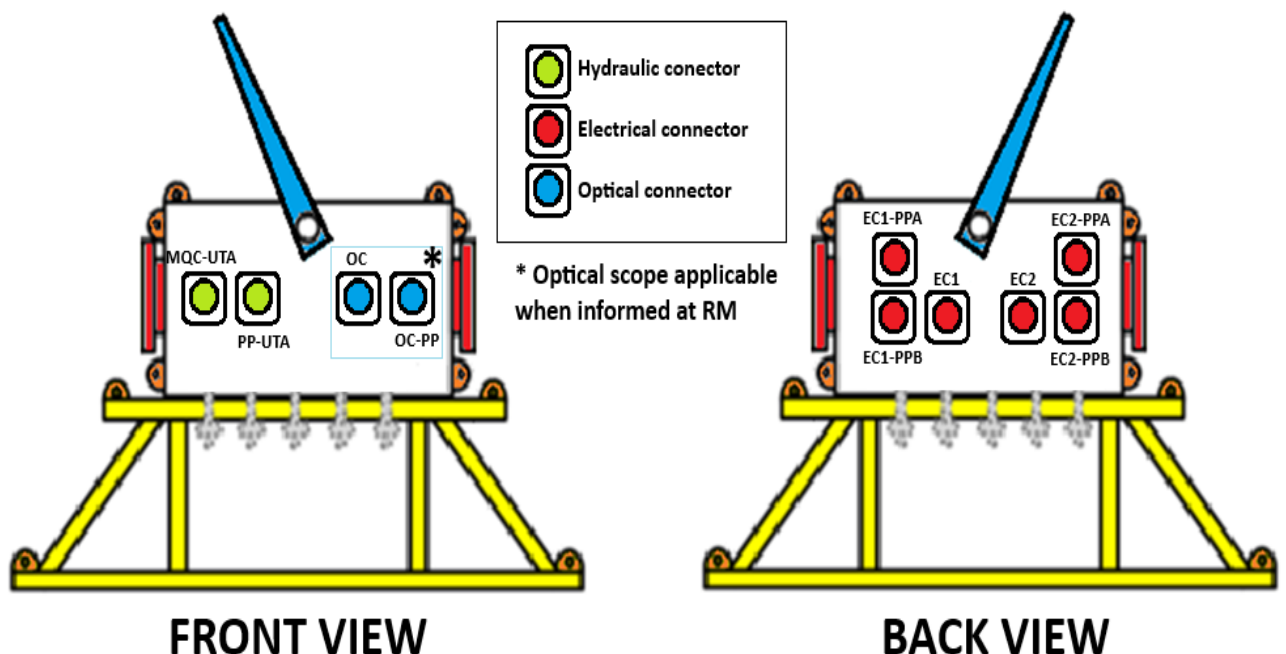
7.3.8.3 Each HFL shall contain 5 (five) independent hydraulic lines.

7.3.8.4 The hydraulic control lines shall be thermoplastic hoses.

7.3.8.5 UTA CONTRACTOR shall submit to PETROBRAS approval the volumetric expansion values specified for the hydraulic hoses of the HFLs JUMPERS SET.

7.3.8.6 UTA CONTRACTOR shall request PETROBRAS, in the project detailing phase, the model of the MQC connector that shall be adopted at such termination of the HFL to SESDV (UTA and SESDV models).

**7.3.9** A general overview of the UTA connections and parking places is illustrated on Figure 11.



**Figure 11** – General schematic views from UTA ROV panels interface

**7.4 Flying leads deployment frame**

7.4.1 FLDF consists of a structure to support the flying leads JUMPERS SET underwater handling by single ROV.

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- 7.4.2** FLDF descent and ascent method (including structural and hydrodynamic aspects), as well as the handling of flying leads during operations with FLDF, shall be submitted for approval by PETROBRAS at the project detailing phase.
- 7.4.3** At FLDF structure, it shall be designed with appropriate locations for parking and ROV manipulation by the electrical and hydraulic connectors of both the ends of any flying lead jumpers set.
- 7.4.4** FLDF shall be able to simultaneously accommodate 2 (two) EFLs and 1 (one) HFL of the JUMPERS SET, during the installation and underwater recovery of the flying leads.
- 7.4.5** FLDF shall admit its submarine operation (descent and ascent) in cases where they are accommodated simultaneously in its structure any combination of EFLs and HFL.
- 7.4.6** The number of FLDFs that will make up the scope of supply will be defined in the RM to which this ET is attached (minimum supply of 1 unit).
- 7.4.7** FLDF shall contain resident hydraulic instrumentation that allows to safely depressurize the HFL lines, when recovered from the underwater environment.
- 7.4.8** During the FLDF design and geometry definition phase, considering the preliminary dimensions (length, width and height), UTA CONTRACTOR shall prepare and submit a Preliminary Installation Analysis to PETROBRAS. This analysis aim to verify the technical feasibility of installing the FLDF at all stages of the operation (over boarding, entering the water, descent, settlement and recovery). These hydrodynamic studies shall include calculations of the hydrodynamic coefficients, calculations of increased mass, coefficient of dynamic amplification and forces involved during installation.
- 7.4.9** FLDF shall be designed for safe installation and uninstillation for an operational window as follows:
- 7.4.9.1 Significant wave height  $H_s$ :  $1.5\text{m} \leq H_s \leq 2.0\text{m}$ , with an interval of 0.1 m;
- 7.4.9.2 Peak period  $T_p$ :  $6.0\text{ s} < T_p < 12.0\text{ s}$ , with an interval of 1.0 s.
- 7.4.10** In the Preliminary Installation Analysis, UTA CONTRACTOR shall inform PETROBRAS of the feasibility or not of the operation for each sea state ( $H_s \times T_p$ ).
- 7.4.11** UTA CONTRACTOR shall adopt standard [11] for analysis installation and uninstillation in the FLDF project.
- 7.4.12** FLDF sling design shall consider both transport handling, installation and uninstillation operations. The slings and all accessories (e.g., shackles, sling yokes etc) shall be part of the scope of supply of the FLDF and shall be in accordance with [20].
- 7.4.13** The pick-up point on the FLDF shall be designed for only 1 (one) pad eye, meeting the condition of transport handling, installation and uninstillation.
- 7.4.14** FLDF design shall be compatible with the soil equation, which will be provided in the RM of which this ET is part.
- 7.4.15** During the project detailing phase, PETROBRAS will inform UTA CONTRACTOR of the installation vessel and the characteristics of the installation cable.
- 7.4.16** The structure and the lifting and installation eyes of the FLDF shall be designed even to withstand the suction loads during displacement (tool recovery) of the seabed.
- 7.4.17** The approval of the final geometry of the FLDF is subject to the approval of the

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Preliminary Installation Analysis by PETROBRAS. This analysis does not replace the FLDF "Installation Analysis" document, which shall be delivered by UTA CONTRACTOR in the final phase of the project.

**8 INSTALLATION AND INTERVENTION REQUIREMENTS**

**8.1.1** The structure of the UTA shall contain and support flange terminations to mechanically connect to the umbilical line structures and shall have baskets at UTA mud mat structure to accommodate 1 (one) HFL and 2 (two) EFLs, from the JUMPERS SET. The placement of baskets in the structure shall make it possible to:

8.1.1.1 The offshore installation of UTA, with the flying leads being simultaneously accommodated in the structure.

8.1.1.2 The handling by the ROV manipulator of the flying leads accommodated in UTA.

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

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

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

**9 SYSTEM AVAILABILITY**

**9.1.1** The availability of the CONTROL SYSTEM shall be guaranteed by adequate MTTF values.

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

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

**10 TECHNICAL DOCUMENTATION**

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

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

**10.1.3** UTA CONTRACTOR shall present in the project detailing phase, for approval by PETROBRAS, the procedure for assembling the ELECTRICAL SYSTEM at UTH.

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

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

**10.1.6** 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;
- General arrangement with routing of hydraulic system including HFLs;
- General arrangement with routing of electrical system including EFLs;
- Electrical connectors drawings and datasheet;
- Hydraulic connectors drawings and datasheet;
- Factory Acceptance Test Procedure/Reports;
- Acceptance and Performance test (TAP) Procedure/Reports;
- Operational procedure for UTA and FLDF;
- UTA and FLDF ROV accessibility report.

## 11 TESTS AND INSPECTIONS

### 11.1.1 Regarding the qualification tests:

11.1.1.1 All components of the CONTROL 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.

11.1.1.2 The compatibility of the CONTROL SYSTEM components with hydraulic fluids shall be proved from a qualification plan to be executed after the execution of the supply contract. It will not be necessary to requalify with respect to hydraulic fluids, if the system components have already been qualified according to Standard [12] and if they fully meet the requirements of this ET. In this case, during the project detailing phase, UTA CONTRACTOR shall submit a report of the respective qualifications for approval by PETROBRAS.

### 11.1.2 With respect to FATs:

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

11.1.2.2 For hoses and electrical cables, the FAT shall have at least:

11.1.2.3 Continuity test;

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

11.1.2.5 Visual and dimensional inspection test;

11.1.2.6 For electrical connectors, the FAT shall have at least:

11.1.2.7 Electrical tests: insulation resistance test ( $> 1\text{G}\Omega$  at 500VDC), continuity test and contact resistance test.

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

**11.1.3** The SIT shall be performed by UTA CONTRACTOR before the CLM, with at least 1

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(one) UTA, 1 (one) JUMPERS SET and, if it is the scope of supply, 1 (one) FLDF.

- 11.1.4** UTA CONTRACTOR shall have all the manufacturing facilities for any repairs and alterations that are necessary to the electrical components in an emergency, including services in marine units.
- 11.1.5** 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.
- 11.1.6** 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.

## 12 PACKAGING AND STORING

- 12.1.1** In this ET, the term "IP-65" is used as defined in Standard [10].
- 12.1.2** The packaging methods shall be designed to completely protect all the equipment and parts of the CONTROL SYSTEM against possible damage during transport, loading and unloading.
- 12.1.3** UTA CONTRACTOR shall submit for approval of PETROBRAS the procedures for handling the CONTROL SYSTEM equipment, depending on the means of transport specified.
- 12.1.4** ELECTRICAL SYSTEM shall be delivered to PETROBRAS disassembled from UTA, 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.
- 12.1.5** The spare EFL/HFL jumpers set shall be delivered to PETROBRAS packed in boxes IP65 which are protected from weather, suitable for sea shipment. The use of wooden boxes shall not be allowed.
- 12.1.6** The UTA EFLs and HFLs jumpers set shall be delivered to PETROBRAS accommodated in existing basket in the UTA structure (UTA body), respecting the total quantity according to RM in which this ET is referenced.
- 12.1.7** The FLDF shall be delivered to PETROBRAS covered in canvas to protect against ultraviolet rays and other weather conditions.
- 12.1.8** The UTA structure shall be delivered to PETROBRAS covered in canvas to protect against ultraviolet rays, so that the CONTROL SYSTEM, components located in the UTA structure, shall be protected from the weather.
- 12.1.9** The description of the packaging of CONTROL SYSTEM components shall be included in the Technical Documentation and shall be submitted for approval by PETROBRAS during the project detailing phase.

## 13 CONDITIONING

- 13.1.1** UTA CONTRACTOR shall be responsible for the conditioning of CONTROL SYSTEM equipment from the beginning of the manufacture until delivery to the PETROBRAS staff for which it is intended, including the period of transportation.
- 13.1.2** When required in RM, UTA CONTRACTOR shall submit for approval of



## ANNEX A: TELECOM REQUIREMENTS

### A.1 Main requirements

A.1.1 If requested in project RM, the UTA can be used as a big subsea pass-through box for the umbilical lines for the optical telecom functionality. The UTA shall be designed as in-line equipment. See Figure 13.

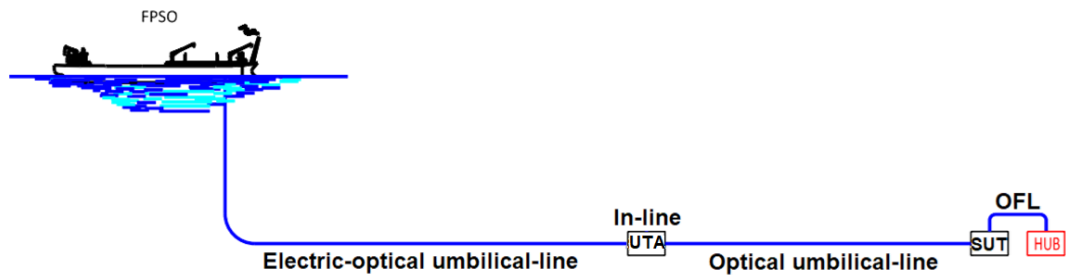


Figure 13 — Schematic of subsea layout with UTA from ANNEX A case

A.1.2 An optical basic schematic arrangement for UTA from ANNEX A case is shown in the Figure 14. UTA CONTRACTOR, however, may suggest a different internal arrangement and submit it to PETROBRAS for approval.

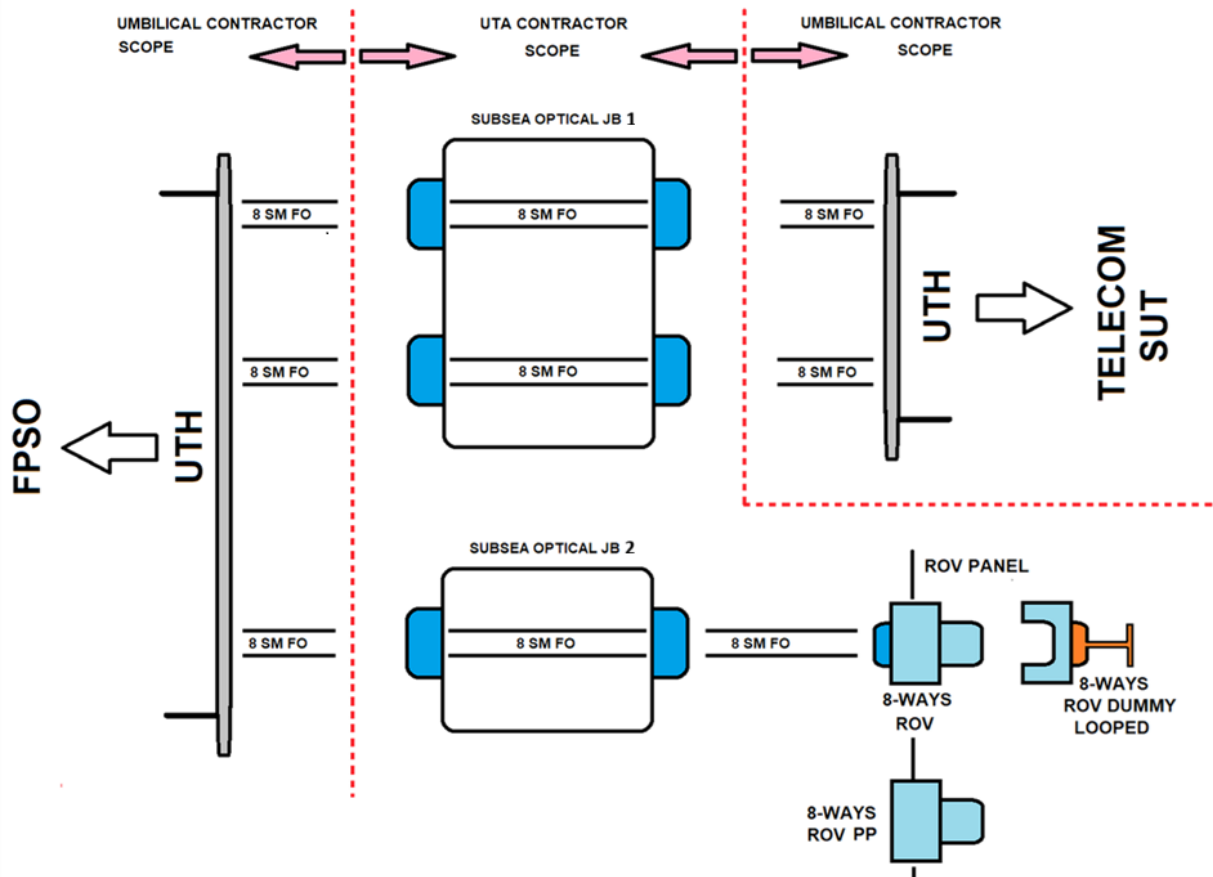
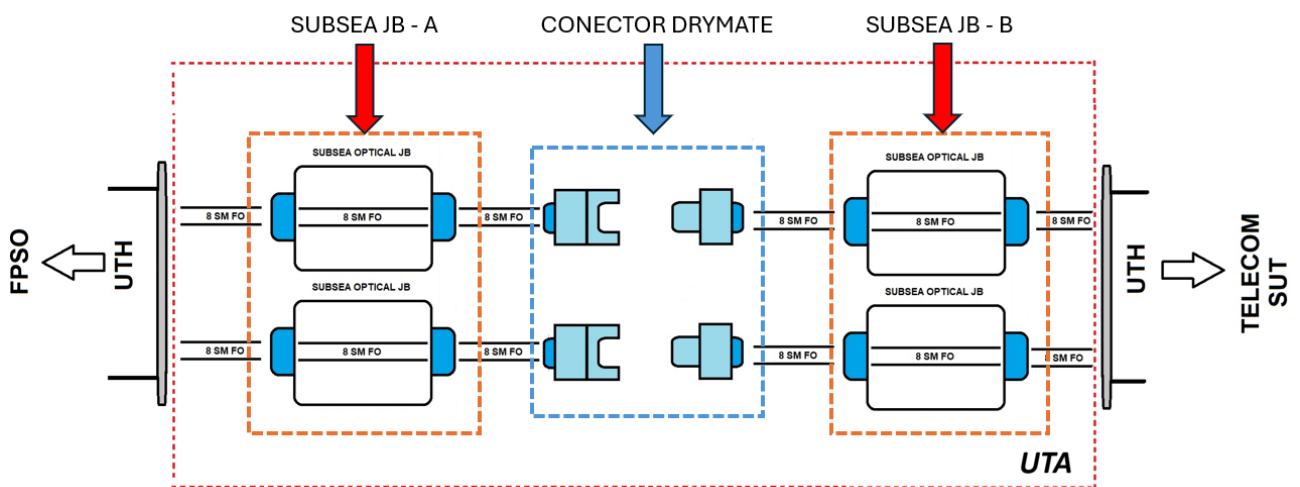


Figure 14 — Optical basic schematic arrangement for UTA in-line from ANNEX A case

- A.1.3 A detailed schematic layout of the SUBSEA UMBILICAL JB 1 is presented at Figure 15. This layout shall be assembled onshore by UTA/UMBILICAL CONTRACTOR to simplify the activities at PLSV offshore.
- A.1.4 UTA CONTRACTOR may avoid using the optical subsea JBs (as per Figure 14 and Figure 15) at the detail design if it should be possible to integrate the optical connectors (dry mate and wet mate) from UTA OPTICAL SYSTEM with the UTH optical pigtails.
- A.1.5 UTA design shall consider maximization of the UTA optical component's integration onshore to facilitate PLSV offshore activities.



**Figure 15 – A detailed schematic layout of the Subsea Optical JB 1**

## A.2 Optical wet mate connector and optical flying lead

- A.2.1 The optical (wet mate and dry mate) connectors' model shall be chosen during the construction phase in formal consultation with PETROBRAS.
- A.2.2 The optical wet mate optical connector model shall conform to the following requirements:
- A.2.3 be 8 (eight) or more-ways optical fiber cores, with fibers end face Angled Physical Contact (APC).
- A.2.4 be ROV-operated for the wet-mate connectors.
- A.2.5 be suitable for operation in the foreseen environment, with a maximum operating depth of at least 3,000-meters (three-thousand meters).
- A.2.6 be able to withstand at least 100 mates/demates cycles.
- A.2.7 have a design life of at least 25 years.
- A.2.8 be qualified according to [4] and [17] (shall present evidences).
- A.2.9 have a track record of at least 30 units installed worldwide and operating continually without failure for a period of 2 years.

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A.2.10 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 field 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

A.2.11 The optical wet mate optical bulkhead connectors' pigtails shall be designed/supplied with same specification of the fibers from umbilical cables.

A.2.12 The mechanical/optical interface mounting assembly (e.g. subsea junction box) between the wet mate bulkhead connectors' pigtails and the umbilical lines' pigtails inside UTA shall be qualified according to [4] and [17].

A.2.13 For all UTAs, all the optical wet mate bulkhead connectors shall be supplied with dummy connectors to protect the connectors' integrity during operations offshore.

A.2.14 Some of 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 during the construction phase in formal consultation with PETROBRAS.

A.2.15 UTA CONTRACTOR shall supply parking places for all optical wet mate bulkhead connectors. Parking places shall be designed in UTA's structure.

A.2.16 UTA CONTRACTOR shall provide 1 (one) test connectors kit for optical wet mate connectors for supporting UTA OPTICAL SYSTEM mounting/testing. All UTA OPTICAL SYSTEM (including test connectors) shall be supplied in dedicated transportation "IP-65" boxes.

A.2.17 UTA CONTRACTOR shall supply OFL to connect with single ROV operations.

A.2.18 The OFL shall be designed with PBOF hoses of 50-meters length and both ends mounted with optical wet mate connectors compatible with wet mate bulkhead connectors from UTA.

A.2.19 The OFL shall be designed/supplied with same specification of the fibers from umbilical cables. UTA CONTRACTOR shall supply as a minimum of 1 (one) OFL in a dedicated transportation "IP-65" box.

A.2.20 UTA CONTRACTOR shall supply FLDF (from section 7.4) with parking places for both optical wet mate connectors from the OFL.

### A.3 TELECOM optical cable requirements

A.3.1 The Telecommunication Optical Cable from umbilical line shall comply with the

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following requirements:

- A.3.1.1 Have a total of 24 (twenty-four) or more single mode optical fiber cores at sets of 8 fiber cores.
  - A.3.1.2 Be suitable for operation in the foreseen environment, with a maximum operating depth of at least 3,000-meters (three-thousand meters).
  - A.3.1.3 Have a design life of at least 25 years.
  - A.3.1.4 Operate with sea water temperature from -10° up to +50° C.
  - A.3.1.5 Withstand with air temperature from -10° up to +50° C.
  - A.3.1.6 Storage temperature from -15° up to +50° C.
  - A.3.1.7 Certification and qualification by UJ CONSORTIUM.
  - A.3.1.8 Supplier shall inform all optical and mechanical characteristics of the provided cable.
  - A.3.1.9 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.
  - A.3.1.10 Considering a period of 14 days after rupture, the longitudinal water ingress shall respect the maximum allowed ingress of 1 km.
  - A.3.1.11 Cable structure shall ensure that there will be no performance degradation on fiber during deployment, burial, and recovery, considering industry best practices.
  - A.3.1.12 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.
  - A.3.1.13 The acceptable cable to be used is Single Armoured Cable.
  - A.3.1.14 Fiber optic coating shall:
    - A.3.1.14.1 Inhibit armature corrosion.
    - A.3.1.14.2 Resist to marine life and rodents.
    - A.3.1.14.3 Be flexible enough to allow the cable to follow seabed detours.
    - A.3.1.14.4 Not to be toxic or flammable.
    - A.3.1.14.5 Have properties that ensure handling, settling and recovery during launch and maintenance operations.
    - A.3.1.14.6 Not damaging the environment.
  - A.3.1.15 Cable application shall comply [15].
  - A.3.1.16 PETROBRAS shall approve the cable application.
  - A.3.1.17 Cables in discordance with [15] shall be evaluated and authorized by PETROBRAS if it is necessary due to environmental variables to be mapped during the protect stage.
- A.3.2 Cable marks and identification:
- A.3.2.1 Cable shall be identified and marked in accordance with recommendation 16, emission 1 from ICPC.

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- A.3.2.2 The physical structure, colors and fonts from labels and markings shall be proposed by supplier and approved by PETROBRAS.
- A.3.2.3 IDs shall be visible considering a 0,5 m distance.
- A.3.2.4 Cable shall have an alphanumeric ID printed on cable. This code shall be enough to identify number and type of fibers and other cable specification.
- A.3.2.5 ID shall be repeated every 5 meters.
- A.3.2.6 IDs and markings shall remain intact during loading, unloading, deployment, recovery, and repair.
- A.3.2.7 A numeric length scale shall be printed on cover.
- A.3.2.8 Cable shall present distance markings on every one km.
- A.3.2.9 Cables shall have labels that define the marking of all junctions.
- A.3.2.10 Besides junctions, every cable transition shall be marked and identified.

**A.4 Optical fiber requirements**

- A.4.1 The following requirements shall be applied to the optical fibers of the umbilical, subsea umbilical optical cable, DUT, flying leads and optical connectors.
- A.4.2 The optical fibers shall be according to [16].
- A.4.3 On the 1550 nm window, the optical fiber shall have the following characteristics:
  - A.4.3.1 Attenuation shorter than or equal to 0.18 dB/km.
  - A.4.3.2 Dispersion shorter than or equal to 18.00 ps/nm.km.
  - A.4.3.3 Dispersion Slope shorter than or equal to 0.088 ps/nm<sup>2</sup>.km.
  - A.4.3.4 PMD shorter than or equal to 0.20 ps/ $\sqrt{\text{km}}$ .
- A.4.4 The optical fibers shall not present any variation of attenuation greater than 0.01dB/km throughout its length.
- A.4.5 The cladding diameter shall be 125 $\mu\text{m}$  with a maximum tolerance of  $\pm 2 \mu\text{m}$ .
- A.4.6 The cladding circularity error shall be shorter than 1%.
- A.4.7 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 [16].
- A.4.8 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 [16] recommendation.
- A.4.9 The optical fiber that will compound the optical fiber cable shall endure a minimum stretching tension of 0.69 GPa ( $\sim 7000 \text{ kgf/cm}^2$ ) without affecting its physical and optical characteristics.
- A.4.10 UTA CONTRACTOR and UMBILICAL CONTRATOR shall inform PETROBRAS the following characteristics of the optical fibers used to manufacture the optical fiber cable:

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- A.4.10.1 Refractive index profile;
- A.4.10.2 Maximum attenuation coefficient at the 1310 nm transmission window;
- A.4.10.3 Minimum attenuation coefficient at the 1310 nm transmission window;
- A.4.10.4 Maximum attenuation coefficient at the 1550 nm transmission window;
- A.4.10.5 Minimum attenuation coefficient at the 1550 nm transmission window;
- A.4.10.6 Maximum CD (ps/nm.km) at the 1300 nm transmission window;
- A.4.10.7 Maximum CD (ps/nm.km) at the 1550 nm transmission window;
- A.4.10.8 Cut-off wavelength;
- A.4.10.9 Detailing of Hydrogen impermeabilization;
- A.4.10.10 Modal field diameter;
- A.4.10.11 Core / cladding concentricity error;
- A.4.10.12 Core non circularity;
- A.4.10.13 PMD.

A.4.11 For acceptance, the optical fibers shall be followed by the characterization reports issued by the manufacturers.

## A.5 Optical tests

A.5.1 All subsea optical devices (i.e. umbilical lines, UTA, wet mate connectors, OFLs), shall be tested at the factory, on the installation vessel prior to launch and post launching at the commissioning stage.

A.5.2 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		

A.5.3 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.

A.5.4 UTA / UMBILICAL CONTRACTOR shall use appropriate instruments and with valid calibration certificates, to perform these factory and offshore tests.

A.5.5 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.

## A.6 Optical tests technical description

A.6.1 Total optical attenuation

A.6.2 This test shall be performed using a power meter and light source to measure the total attenuation / insertion loss of the DUT.

A.6.3 The tests shall be carried out on the 1550 nm optical window in both directions (A-B



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and B-A).

A.6.4 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 <sub>A</sub> [dBm]	P <sub>B</sub> [dBm]	Att[dB]	P <sub>B</sub> [dBm]	P <sub>A</sub> [dBm]	Att[dB]		

A.6.5 In addition to the results table, all measurement traces with identification of the respective events shall be presented.

**A.6.6 Optical attenuation – OTDR**

A.6.7 The optical attenuation tests shall be performed with OTDR in both directions, whenever possible to be performed.

A.6.8 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.

A.6.9 To perform measurements on the commissioned system, CONTRACTOR shall evaluate the need for the application of optical filters or C-OTDR type instruments.

A.6.10 In addition to the events throughout the DUT, the OTDR tests shall evaluate the ORL per event.

A.6.11 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					

A.6.12 Chromatic Dispersion.

A.6.13 Chromatic dispersion tests shall be performed at wavelengths 1310 nm, 1550 nm and 1625 nm.

A.6.14 The measurement technique to be applied in these tests shall be decided by the UMBILICAL CONTRACTOR.

A.6.15 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:			



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Fibers		Lambda Zero[nm]	Dispersion [ps/(nm.km)]			Total disp. @1550nm [ps/nm]	Inclination [ps/(nm <sup>2</sup> .km)]		Sellmeier Coefficients		
A	B		1310nm	1550nm	1625nm		Lambda Zero	1550nm	A	B	C

A.6.16 Dispersion by Polarization Mode.

A.6.17 The measurement technique to be applied in these tests shall be decided by CONTRACTOR.

A.6.18 Measurements shall be performed at intervals greater than 60 minutes.

A.6.19 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											

A.6.20 Acceptance criteria

A.6.20.1 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	<ul style="list-style-type: none"> <li>Attenuation per kilometer less than or equal to 0.20 dB/km @1550 nm;</li> <li>Optical splices with OIL less than 0.2 dB;</li> <li>Connections to wetmate connectors with OIL and ORL better or equal to that specified in the element datasheet.</li> </ul>	<ul style="list-style-type: none"> <li>Attenuation per kilometer less than or equal to 0.20 dB/km @1550 nm.</li> <li>Optical splices with insertion loss &lt;0.2 dB.</li> <li>Connections to wet mate connectors with OIL and ORL better or equal to that specified in the element datasheet.</li> </ul>
Chromatic Dispersion	CD < 18 ps/nm <sup>2</sup> *km	N/A
PMD	PMD < 0,2 ps/km <sup>0,5</sup>	N/A