PETROBRAS	TECHNICAL SPECIFICATION	N°: I-ET-3000.00-1519-29B-PZ9-003	
	CLIENT: -		SHEET: 1 of 16
	JOB: -		
	AREA: -		
	TITLE: SUBSEA UMBILICAL SYSTEMS		SUB/ES/EDD/EDF INTERNA

INDEX OF REVISION

REV.	DESCRIPTION AND/OR REVISED SHEETS
D	WHERE HIGHLIGHTED

NOTE1: CJME(GUSTAVO.M) / ES50(PEDRO.H.P) / CSMP(ANDRÉ A.)

	REV. D					
DATE	18/12/2023					
EXECUTION	UPOV(YONATHAN)					
CHECK	NOTE 1					
APPROVAL	CSOU(WILLIAM)					

CONTENTS

1 OBJECTIVES

1.1 This TECHNICAL SPECIFICATION defines the minimum requirements for the design, manufacture, qualification, acceptance tests, handling and installation of subsea umbilical systems.

1.2 The umbilical systems application, functional requirements and DWD are presented in MATERIAL REQUISITION.

2 NORMATIVE REFERENCES

2.1 Unless otherwise specified, the latest revision of references shall be considered.

Ref.	Standard/Code	Title	Rev./Ed.
[1]	API 17E	Specification for Subsea Umbilicals	-
[2]	I-ET-3000.00-1519-29B-PZ9-009	Design scenarios for subsea umbilical projects	0
[3]	I-ET-3000.00-1519-29B-PZ9-004	Load-effect analysis of subsea umbilicals	C
[4]	I-ET-3010.00-1500-274-P56-001	Riser interference analysis	0
[5]	I-ET-3000.00-1519-29B-PZ9-002	Low voltage/signal electric cables and terminations for subsea umbilical systems	A
[6]	I-ET-3000.00-1500-700-PEK-004	High-Voltage Electrical Power Cable for Subsea Umbilical	0
[7]	NORSOK M-501	Surface preparation and protective coating	-
[8]	N-2037	Pintura de equipamentos submersos em água do mar	-
[9]	ET-3000.00-1500-940-PZ9-001	Projeto de proteção catódica para dutos flexíveis e umbilicais submarinos	0
[10]	ET-3010.00-1500-941-PLR-004	Análise de cargas de dutos em equipamentos submarinos	0
[11]	ET-3000.00-1500-941-PMU-003	Padronização de acessórios para kit pull-in	F
[12]	I-ET-3010.00-1500-960-PPC-011	General bend stiffener requirements	G
[13]	ET-3000.00-1500-251-PEK-001	Fixadores em aço baixa liga de alta resistência para aplicação submarina	B
[14]	ET-3000.00-1500-251-PEK-002	Rastreabilidade de fixadores de alta resistência para utilização submarina	A
[15]	ET-3000.00-1519-29B-PZ9-010	Engates rápidos para umbilicais submarinos	A
[16]	API SPEC 17L1	Specification for Ancillary Equipment for Flexible Pipes and Subsea Umbilicals	-
[17]	API RP 17L2	Recommended Practice for Ancillary Equipment for Flexible Pipes and Subsea Umbilicals	-
[18]	I-I-ET-3000.00-1500-600-PEK-010	Mechanical requirements for umbilical termination assemblies - UTAs	0
[19]	ET-3000.00-1519-29B-PZ9-006	Adaptadores de flanges para umbilicais submarinos	A
[20]	EN 10257-2	Zinc or zinc alloy coated non-alloy steel wire for armouring either power cables or telecommunication cables. Part 2: Submarine cables	-
[21]	EN 10244-2	Steel wire and wire products – Nonferrous metallic coatings on steel wire. Part 2: Zinc or zinc alloy coatings	-
[22]	ET-3000.00-1519-29C-PMU-001	Identificação de dutos flexíveis e umbilicais novos	0
[23]	ET-3000.00-1500-800-PMU-001	Flushing e preenchimento de umbilicais da PETROBRAS	0
[24]	ET-3000.00-1500-290-PMU-004	Requisitos para confecção de curvas de aperto de dutos flexíveis e umbilicais	D
[25]	DNVGL-ST-F201	Riser systems	-

3 TERMS AND DEFINITIONS

3.1 AIB: Accredited Inspection Body

3.2 CVD: Conexão Vertical Direta (Direct Vertical Connection)

3.3 DWD: Design Water Depth. Water depth specified by PETROBRAS for which umbilical shall be designed independently of operational water depth.

3.4 DWP: Design Working Pressure

3.5 HCR: High Collapse Resistant

3.6 LV: Low Voltage

3.7 MBR: Minimum Bending Radius

3.8 MV: Medium Voltage

3.9 ROV: Remote Operated Vehicle

3.10 Shall: Mandatory action

3.11 SMYS: Specified Minimum Yield Strength

3.12 SWL: Safety Working Load

3.13 UF: Utilization Factor

3.14 Umbilical(s): group of functional components, such as electric cables, optical fibre cables, hoses, and tubes, laid up or bundled together or in combination with each other.

3.15 Umbilical System: Umbilical, complete with end terminations and other ancillary equipment

3.16 WD: Water Depth

4 DESIGN REQUIREMENTS

4.1 Umbilical systems shall comply with all requirements of [1] and this TECHNICAL SPECIFICATION. In case of conflict this TECHNICAL SPECIFICATION prevails over [1].

4.2 PETROBRAS adopts the standardization of umbilicals, i.e., the same umbilical is applied on different projects. For that, umbilicals shall be designed for hypothetical scenarios defined by PETROBRAS, with conservative parameters, designated as Design Scenarios, which are presented in [2].

4.3 For each project, the Project-specific scenario is presented in the MATERIAL REQUISITION. The umbilicals, designed for the Design Scenarios, shall be evaluated for the Project-specific scenario.

4.4 When qualification is required, the qualification process shall, besides to demonstrate the SUPPLIER design methodology, to demonstrate that umbilical is fit for purpose for the Design Scenario.

4.5 All umbilicals shall be designed for dynamic operation. Even those intended for static use in project.

4.6 LOADS

4.6.1 FUNCTIONAL LOADS

4.6.1.1 The umbilical systems shall be designed to be installed by any of the installation vessels presented in MATERIAL REQUISITION and in any installation sequence.

4.6.1.2 The umbilical systems shall be designed considering cycles of crushing loads in installation vessel tensioners.

4.6.1.3 The umbilical systems shall be designed considering that during installation the same region of umbilical can remain for 3 hours under crushing and installation tension.

4.6.1.4 The umbilical systems shall be designed considering that loading tensioners of installation vessel (load-out tensioners) have two tracks with 140° shoes angle.

4.6.2 ENVIRONMENTAL LOADS

4.6.2.1 The environmental loads for Project-specific scenario are presented in MATERIAL REQUISITION.

4.6.2.2 The environmental loads for Design Scenario are presented in [2].

4.7 LOAD-EFFECT ANALYSIS

4.7.1 The load-effect analyses shall comply with [3].

4.7.2 The data for Project-specific interference analysis are presented in MATERIAL REQUISITION.

4.7.3 The analyses for temporary abandonment of umbilical systems with the buoyancy system shall comply with Table 4-I.

Table 4-I

Analyses		Requirements
#1	Step-by-step static analysis of riser umbilical abandonment in seabed	For step cases of smaller umbilical bending radius, a dynamic analysis shall be performed as per [3]
#2	On-bottom stability analysis to define necessity of anchoring after umbilical abandonment	10 years current shall be considered
#3	Maximum lateral displacement of buoyancy systems after umbilical abandonment	10 years current shall be considered

4.8 ELECTRICAL SYSTEM ANALYSIS

4.8.1 The common induction from MV in LV, i.e. induced voltage between conductors and between conductors and system (screen or ground), shall not exceed 0.2 volt in the entire umbilical length. It shall be considered power frequency from 20Hz to 80Hz. The system screens grounding connections to obtain such parameter shall be demonstrated.

4.8.2 As per [1], in addition to determining the electrical characteristics and performance of the MV conductors within the umbilical, analysis shall be performed to establish the levels of induced voltages between multiple MV power circuits, and between the MV power circuits and any LV power/signal cables and any other electrically conductive materials within the umbilical.

4.9 THERMAL ANALYSIS

4.9.1 For umbilicals with MV electric cables, as per [1], the analysis should evaluate the steady state temperature distribution throughout the cross-section of the umbilical. Analysis shall demonstrate that temperatures in the umbilical are within all materials limits at the specified environmental and loading conditions.

4.10 FATIGUE LIFE

4.10.1 A minimum fatigue life of 3 times the service life shall be considered for umbilical systems without metallic tubes.

4.10.2 The construction of S-N data shall be approved by PETROBRAS.

5 COMPONENT DESIGN, MANUFACTURE AND TEST

5.1 All metallic terminations of components that operates underwater shall have, or shall be linked to, cathodic protection.

5.2 ELECTRIC CABLES

5.2.1 The LV electric cables and terminations shall comply with [5].

5.2.2 The MV electric cables and terminations shall comply with [6].

5.3 HOSES

5.3.1 The hoses liner material shall be polyamide 11 low oligomer or PVDF. Other qualified materials shall be approved by PETROBRAS upon complete qualification process provided by SUPPLIER.

5.3.2 The HCR hoses design shall consider installation and operation with hoses empty and with atmospheric internal pressure. Minimum external hydrostatic pressure shall be 150% of umbilical system DWD.

5.3.3 The control hoses design shall consider installation and operation with hoses full of hydraulic control fluid.

5.3.4 The maximum volumetric expansion of control hoses shall comply with Table 5-I.

Table 5-I

	Maximum volumetric expansion (cm^3/m)	
Pressure (PSI)	**3/8" ID hoses**	**½" ID hoses**
3000	5,67	10,03
5000	7,56	13,45
7500	9,66	17,16
10000	11,76	20,90

5.3.5 The hoses end fittings material shall be AISI 316L. Other qualified materials with corrosion properties equal to or better than AISI 316L may be proposed for PETROBRAS approval.

5.3.6 The hoses end fittings shall be swaged. Swage shall not induce superficial indentations, deep marks and martensitic transformation. Maximum superficial hardness after swage, measured all along the swaged surface, shall be 35 HRC.

5.3.7 The hoses end fittings shall be marked with material traceability and hose numbering. Marks shall be durable throughout umbilical service life.

5.3.8 The hoses pigtails outer sheath shall have apertures for air release during umbilical system installation.

5.3.9 The hoses pigtails shall have stiffener elements to prevent hoses overbending.

5.4 OPTICAL-FIBER CABLE

5.4.1 The optical-fiber cables shall comply with MATERIAL REQUISITION.

5.5 METALLIC TUBES

5.5.1 The tubes shall be seamless or seam-welded super duplex stainless steel, being UNS S32750 and UNS S39274 the accepted grades.

5.5.2 The tubes shall be over-sheathed with a polymeric layer.

5.5.3 The tubes design calculation shall consider:

- Umbilical system DWD for tube external pressure
- Water density of 1025 kg/m3
- Tube internal pressure of 0,1 MPa
- 1.5% tube ovality

5.5.4 The tubes material SMYS temperature derating shall comply with [25].

5.5.5 All tubes welds, including tubes end fittings welds, shall be x-ray inspected.

5.5.6 The tubes end fittings material shall be the same material of tubes.

5.5.7 The tubes end fittings shall be marked with tubes numbering. Two marks 180° to each other. Marks shall be durable throughout umbilical service life.

6 TERMINATIONS AND ANCILLARY EQUIPMENT DESIGN

6.1 DESIGN PRINCIPLES

6.1.1 The terminations/ancillary equipment in 6.2, 6.3, 6.5, 6.9, 6.10, 6.11 and 6.16 shall be designed for load classes of SWL of 20tf (i.e., 20 tf, 40 tf, 60 tf, and so on).

6.1.2 The terminations/ancillary equipment shall be designed for temporary abandonment in umbilical system DWD.

6.1.3 The terminations/ancillary equipment dimensions shall consider limits of installation vessels presented in MATERIAL REQUISITION.

6.1.4 The terminations/ancillary equipment shall be marked with the drawing/part number, a traceability code and the SWL. Marks shall withstand system life.

6.1.5 Coating of terminations/ancillary equipment for underwater operation shall comply with system No. 7B of [7] or [8] and coating design shall ensure electric continuity with fasteners, bolts and nuts. Coating of terminations/ancillary equipment for surface operation shall comply with system No. 1 of [7] or [8].

6.1.6 Cathodic protection of terminations/ancillary equipment for underwater operation shall comply with [9]. Sizing of anodes shall consider umbilical system service life plus two years of temporary abandonment in umbilical DWD. Anodes may be attached directly to terminations/ancillary equipment or anode collars may be designed.

6.1.7 All flanged connections of top and bottom end terminations, pull-in and handling heads, bend restrictors, transition spools, joint box, termination assemblies and flange adapters shall be designed for hydraulic torque wrench use. Dimensions of Hytorc model Stealth commercial tool shall be considered for design.

6.1.8 Pull-in dimensional verification shall be performed for all top terminations/ancillary equipment.

6.2 ARMOUR TERMINATIONS

6.2.1 The top and bottom end terminations shall have flanges API 6A type 6B 2000 psi for interface with other equipment. Required flange sizes are presented in MATERIAL REQUISITION. For flange sizes of 9” or above, SUPPLIER can propose reducing quantity of bolt holes to 8, if structurally feasible.

6.2.2 The top and bottom end terminations shall have an outer sheath locking system to avoid outer sheath displacement and exposure of umbilical armoring.

6.2.3 The top and bottom end terminations shall have electric continuity with umbilical armouring.

6.2.4 For umbilical with metallic tubes the top and bottom end terminations shall have an anchoring system to avoid axial and radial displacement of tubes pigtails.

6.2.5 The top end terminations shall have water ingress sealing systems, in both extremities of accessory, to prevent water to ingress into the end termination during umbilical system

operation. The necessity of including an air release system to prevent outer sheath rupture during umbilical installation shall be addressed.

6.2.6 The top end termination interface with topside hang-offs shall be one of the standard grooves of Table 6-I.

Table 6-I

Standard groove	Groove dimensions (mm)	
	Inner diameter	Height
SG-A	170	100
SG-B	240	100
SG-C	270	100

6.2.7 When top end terminations are integrated with bend stiffeners, it shall have four pad eyes, each rated according to top end termination load class.

6.2.8 The bottom end terminations, or bend restrictors, shall have one of the standard grooves of Table VI for support in the installation vessel.

6.2.9 The bottom end terminations interface with bend restrictors shall be the same flange defined in 6.2.1 for other equipment. SUPPLIER shall define number of bolt holes for interface.

6.2.10 The bottom end terminations shall have at least two pad eyes, each rated according to bottom end termination load class.

6.2.11 The bottom end terminations design shall consider, in addition to other loads, the loads as per [10], cases: CVD 2ª – Topo (Caso 1), CVD 1ª – Equilíbrio (Caso 2) and CVD 1ª – Lançamento (Caso 3).

6.2.12 The components pigtails shall be protected against overbending in the interface with top and bottom end terminations, especially in umbilicals with armouring and intermediate inner sheath, see Figure 6-I.

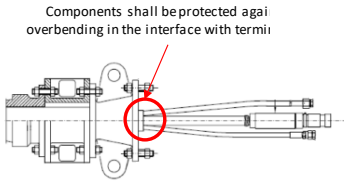


Figure 6-I

6.3 PULL-IN HEADS AND HANDLING HEADS

6.3.1 The pull-in heads and handling heads shall be composed by two split parts. Each part shall have at least one pad eye rated and suitable positioned for handling.

6.3.2 The pull-in heads and handling heads shall have apertures for accessing components pigtails for inspection, monitoring and testing. For handling heads the minimum dimensions of apertures shall be 270mm x 455mm.

6.3.3 The pull-in heads and handling heads shall have internal features to fasten components pigtails, terminations and connectors. Fastening of components shall be designed to allow easy access for components tests and inspection.

6.3.4 The pull-in heads and handling heads shall have cathodic protection sized as per [9] for two years of subsea abandonment in umbilical system DWD.

6.3.5 The pull-in heads design shall consider installation loads and pull-in loads. For pull-in loads, the load for rupture of fuse cables, as specified in 6.4, shall also be considered.

6.4 PULL-IN KIT

6.4.1 The pull-in kit systems shall comply with [11]. Any cable construction of classes defined in [11] are acceptable for fuse cables.

6.5 TOPSIDE HANG-OFF

6.5.1 The topside hang-offs shall be composed by two split parts. Each part shall have at least two pad eyes rated and suitable positioned for handling.

6.6 BEND RESTRICTORS

6.6.1 The bend restrictors shall be designed for a minimum coverage angle of 45°.

6.6.2 The bend restrictors shall be composed by split parts, i.e, to be assembled to and disassembled from umbilical without the need of removing umbilical end termination.

6.6.3 The bend restrictors interface with end terminations shall be a flange as per 6.2.9.

6.6.4 The bend restrictors design shall consider, in addition to other loads, the loads as per [10], cases: CVD 2ª – Topo (Caso 1), CVD 1ª – Equilíbrio (Caso 2) and CVD 1ª – Lançamento (Caso 3).

6.6.5 The bend restrictors, or bottom end terminations, shall have one of the standard grooves of Table VI for support in the installation vessel.

6.7 BEND STIFFENERS

6.7.1 The bend stiffeners shall comply with [12], except utilization factors for metallic parts presented for GD cases where requirements of [3] shall be considered.

6.7.2 The bend stiffeners design shall consider at least one of the following combinations of top tension and angle between riser and bend stiffener neutral axis:

- For regular wave analyses: maximum top tensions with maximum angles between riser and bend stiffener neutral axis, even if not occurring in the same load case.
- For irregular wave analyses or regular wave verified by irregular wave analyses: maximum top tensions with associated angle between riser and bend stiffener neutral axis and maximum angles between riser and bend stiffener neutral axis with associated top tension.
- Top tensions and angles between riser and bend stiffener neutral axis that give the maximum bending moment calculated based on the maximum pseudo-curvature [$\kappa p = Ttop * (1-\cos \alpha)$ or $\kappa p = 2 * Ttop * \sin 2(\alpha/2)$].

6.7.3 The bend stiffeners cap geometry shall comply with [11].

6.7.4 The bend stiffeners cap height for bell mouth with nominal diameter bigger than 32” shall be 955mm, see Figure 6-II. For bell mouth with nominal diameter equal to or smaller than 32”, the cap height shall comply with MATERIAL REQUISITION.

6.7.5 Internal bend stiffener metallic elements, structures and inserts shall not be aligned with the end of the bend stiffener cap, see Figure 6-II.

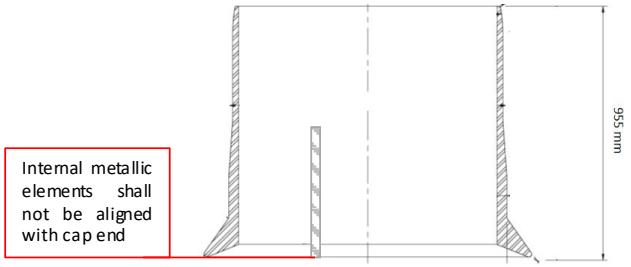


Figure 6-II

6.8 RIGID JOINT/BEND RESTRICTOR FOR TOP END TERMINATION/BEND STIFFENER

6.8.1 The rigid joint/bend restrictor shall be designed to prevent umbilical overbending in the region between the top end termination and the bend stiffener during umbilical system transportation, handling, pull-in, pull-out, abandonment and recovery from seabed.

6.8.2 The rigid joint/bend restrictor shall be resident in the top end termination after umbilical system pull-in.

6.8.3 The rigid joint/bend restrictor shall not require diver or ROV intervention during umbilical system pull-in.

6.8.4 The rigid joint/bend restrictor may be part of pull-in kit.

6.9 TRANSITION SPOOL

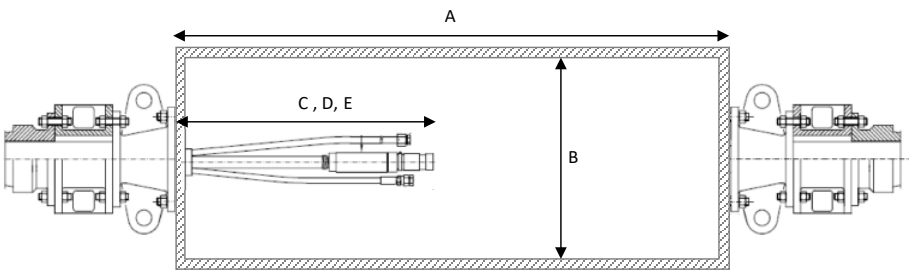
6.9.1 Transition spools shall be composed by at least two split parts. Each part shall have at least two pad eyes rated and suitable positioned for handling. Dimensions of transition spools shall consider minimum space for routing, connections and tools required.

6.9.2 The transition spools design shall consider, in addition to other loads, the loads as per [10], cases: CVD 2ª – Topo (Caso 1), CVD 1ª – Equilíbrio (Caso 2) and CVD 1ª – Lançamento (Caso 3).

6.10 JOINT BOX

6.10.1 The joint boxes shall be composed by at least two split parts. Each part shall have at least two pad eyes rated and suitable positioned for handling.

6.10.2 The joint boxes shall have the preferable dimensions of Figure 6-III. SUPPLIER shall verify applicability of those dimensions and propose adjustments if necessary.



Standard dimensions (mm)	
A – Joint box length from end terminations flange faces	1300
B – Joint box minimum internal diameter	500
C – HCR hoses with terminations from end termination flange face	750
D – Electric cables with terminations from end termination flange face	760
E – Hoses with terminations from end termination flange face	770

Figure 6-III

6.11 ANCHORING COLLAR

6.11.1 The anchoring collars shall be composed by two split parts. Each part shall have at least one pad eye rated and suitable positioned for handling.

6.11.2 The anchoring collars shall have two pad eyes for interface with umbilical system anchoring system. Each pad eye shall be rated according to anchoring collar load class and shall be metallic insulated from shackles.

6.12 FASTENERS, BOLTS AND NUTS

6.12.1 The fasteners, bolts and nuts subjected to installation and/or operation loads shall comply with [13] and [14]. Items 5.4.2, 5.4.6, 5.4.8 and 5.4.9 of [14] can be disconsidered.

6.13 HYDRAULIC QUICK CONNECTORS

6.13.1 The quick connectors for hoses and metallic tubes shall comply with [15].

6.14 BOUYANCY MODULE

6.14.1 The buoyancy modules shall comply with [16] and [17].

6.15 TERMINATION ASSEMBLIES

6.15.1 The termination assemblies shall comply with [18].

6.16 FLANGE ADAPTERS

6.16.1 The flange adapters shall comply with [19].

7 UMBILICAL DESIGN

7.1 Minimum weight-to-diameter for umbilicals without metallic tubes shall comply with Table 7-I. For umbilicals with metallic tubes the weight-to-diameter shall comply with MATERIAL REQUISITION. Any exception defined by PETROBRAS will be presented in MATERIAL REQUISITION.

Table 7-I

	Minimum submerged flooded weight-to-diameter ratio (kN/m²)
Umbilical DWD ≤ 1000m	1,2
Umbilical DWD > 1000m	1,7

7.2 For umbilicals without metallic tubes, design shall consider at least six deploy-recovery operations throughout service life.

7.3 The capacity curves described in Table 7-II and crushing curves for installation vessels presented in MATERIAL REQUISITION, as per [24], shall be provided.

Table 7-II

Capacity curves		Requirements
#1	Tension versus curvature	Capacity curve shall clearly present umbilical capacity for temporary condition, normal operation and abnormal operation and the design criteria, based on components/elements utilization factor, that define each region of the curve
#2	Tension versus maximum crushing (installation)	Capacity curve shall present the maximum crushing that umbilical can withstand for the following tension conditions: - Zero tension - 100% Design tensile load - 50% Design tensile load
#3	Maximum crushing (loading in installation vessel)	Not needed a capacity curve. It shall be presented the maximum allowable crushing for the following conditions: - Loading tensioner with two tracks with 140° shoes angle - Hoses/tubes at internal atmospheric pressure - Tension of 10 ton
#4	Tension versus cycles of crushing (installation)	Capacity curve shall clearly present the maximum number of cycles of crushing that umbilical can withstand for at least the following tension-crushing conditions: - Tension of 10 ton and crushing of 20 ton/m/track - Tension of 100% of umbilical DWD and necessary crushing - Tension of 50% of umbilical DWD and necessary crushing

7.4 TEMPERATURE RANGE

7.4.1 The umbilicals design shall consider seawater temperature from 4°C to 26°C and air temperature from 12°C to 60°C.

7.5 CROSS-SECTIONAL ARRANGEMENT

7.5.1 When in the same cross-section, LV and MV electric cables shall have different lay angles to reduce induced voltage between components.

7.6 ARMOURING

7.6.1 The armouring shall consist of steel wires and be torque-balanced. Other materials shall be approved by PETROBRAS.

7.6.2 The maximum UFs in Table 7-III shall be considered. UFs shall be relative to SMYS or 0.9 of UTS when tensile tests cannot accurately define material yield stress.

Table 7-III

	Temporary conditions	Normal operation	Abnormal operation
Combined loads	1	0,8	1

7.6.3 The steel wires shall comply with [19] and be zinc coated as per [20]. Wire welds shall have same mechanical properties of wires.

7.6.4 The steel wires and welds shall be qualified as per tests of [20] and complementary requirements in Table 7-IV. The tests shall be performed for each dimension, class, type and supplier of steel wires.

Table 7-IV

Tests		Requirements
#1	Hydrogen embrittlement (for steel wires of materials with Yield stress ≥ 700MPa and/or Ultimate tensile strength ≥ 900MPa)	- Sampling: Minimum 5 samples of wires without weld and 5 samples of wires with weld. - Test plan: Degreased samples immersed in seawater (salinity of 3,2% to 3,8%). Potencial of -1,10 V (Ag/AgCl/seawater). Tensile of design tensile load. Test for 150h. - Metallography after test: All samples shall be microscope analyzed. For samples without welds a minimum of three sections shall be taken for analyze. For samples with welds a longitudinal section of weld shall be taken for analyze. - Acceptance criteria: No cracks, blistering, ruptures during test and metallography.
#2	Metallography with microhardness for welds (teste novo)	- Sampling: Minimum 5 samples - Test plan: Microscope analyses of longitudinal sections of welds. Microhardness profile (base metal, heat affected zone and weld metal) - Minimum acceptance criteria: No cracks, welds discontinuities, fragile microstructures.

7.6.5 The welders and welding procedures shall be qualified according to one of the following standards: ASME Boiler and Pressure Vessel Code Section IX, EN 287-1, ISO 13847 or equivalent.

7.6.6 The welding procedures shall include acceptance/rejection criteria.

7.7 OUTER SHEATH

7.7.1 The outer sheath repairs shall be designed for umbilical system service life.

7.7.2 The outer sheath repairs shall have the same performance of the intact outer sheath and shall be qualified by bending-tensile and crushing-tensile tests.

7.8 LENGTH MARKING

7.8.1 Each umbilical length shall be identified as per [21]. Identification shall be printed on umbilical outer sheath at every 100m.

7.8.2 The umbilical lengths outer sheath shall be printed with circumferential bands as following:

- Band with 50mm minimum width: one band each 10m, two bands each 50m, three bands each 100m.
- Band with 150mm minimum width: one band each 1000m.

8 QUALIFICATION TESTS

8.1 Qualification shall comply with MATERIAL REQUISITON.

9 FACTORY ACCEPTANCE TEST

9.1 The FATs shall comply with [1] and requirements herein presented.

9.2 VISUAL AND DIMENSIONAL INSPECTION

9.2.1 The completed umbilical outer sheath shall be 100% visual inspected. Shall be free from damage, faults and sinuosity and have the required length marking.

9.2.2 The completed umbilical terminations/ancillary equipment and components terminations shall be 100% visual inspected. Shall be free from damage, faults and coating defects and have the required identification.

9.2.3 The completed umbilical components terminations shall be 100% visual inspected. Shall be free from damage and faults and have the required identification.

9.3 ELECTRIC CABLE

9.4 LV electric cables FAT parameters according to [5].

9.5 MV electric cables FAT shall comply with [6].

9.6 HOSES AND TUBES

9.6.1 For HCR hoses, after fluid cleanliness is achieved first time the umbilical shall be spooled twice and the fluid cleanliness to be verified. If fluid cleanliness is not maintained, the fluid shall be recirculated and verified until cleanliness to be maintained.

9.6.2 The flushing of hoses and tubes shall comply with [23].

10 DOCUMENTATION

10.1 The minimum information of documentation shall comply with [1] and complementary information detailed below.

Document		Minimum information
#1	Single line diagram	- Schematic of umbilical system supplied - List of all materials to be supplied with part number and quantities. Materials shall be identified with CONTRACT item and PURCHASE ORDER item. - Information of materials supply condition (assembled on umbilical / to be assembled in installation vessel / to be assembled in platform) - Umbilical lengths identified as per [22] - Hoses/tubes fluids type, volume and cleanliness (for each hose/tube) - Schematic of hoses/tubes, electric cables and optic cables terminations in umbilical ends (top, splice and bottom) - Hydraulic, electric and optic circuits in termination assemblies - Reference to design report, packing, data book, handling and operating procedures, material requisition, contract and purchase order.
#2	Packing	- Umbilical system arrangement in reel - Reel dimensions - Umbilical system weight and total weight (umbilical system + reel) - Packing of materials not assembled in umbilical
#3	Umbilical data-sheet	- Umbilical: Identification according PETROBRAS umbilical structures (US) standardization - Umbilical: section with all layers of components, structural elements and fillers - Umbilical: all layer dimensions (inner, outer diameter and thickness) - Umbilical: material properties of armouring, fillers and sheaths - Umbilical: components and armouring lay angle - Umbilical: armouring wires quantity for each layer - Umbilical: weight in air (dry and flooded) and weight underwater (dry and flooded). Hoses/tubes filled. - Umbilical: maximum tensile load for temporary condition, normal and abnormal operation - Umbilical: ultimate tensile load - Umbilical: components and armouring lay angle - Umbilical: armouring wires quantity for each layer - Umbilical: weight in air (dry and flooded) and weight underwater (dry and flooded). Hoses/tubes filled. - Umbilical: maximum tensile load for temporary condition, normal and abnormal operation - Umbilical: ultimate tensile load - Umbilical: axial, bending and torsional stiffness - Umbilical: storage, handling and installation (for umbilical DWD) MBR - Umbilical: tension vs bending capacity curve - Umbilical: maximum radial compression for loading tensioner - Umbilical: reference to umbilical qualification report - Umbilical: reference to radial compression curves (as per [24]) - Hoses/tubes/electric cables and optic cables: section with layers and dimensions (with tolerances) - Hoses/tubes/electric cables and optic cables: MBR - Hoses/tubes/electric cables and optic cables: identification code (SUPPLIER code) - Hoses/tubes: design working pressure (DWP) - Hoses/tubes: maximum pressurization and depressurization rate

		- Hoses/tubes: volumetric expansion at DWP - Hoses/tubes: pressure drop curve - pressure (psi) x flow (m3/h) - Electric cables: rated voltage - Optic cables: type (single-mode or multi-mode)
#4	LV electric cable data-sheet	- As per [5]
#5	Termination and ancillary equipment drawings	- Principal dimensions - Flange specifications - Coating specification - List of items/subcomponents with construction materials - SWL of accessory - SWL of pad eyes - Weight in air and underwater - Torque required for all fasteners including lubricant and friction factor - Allowable moment and shear force (for bend stiffeners) - Anode mass and surface area considered for anode calculation - Reference to cathodic protection report - Reference to structural design report
#6	Design premises report	- Methodology of load-effect analysis - Methodology and inputs of thermal and electrical analyses for umbilicals with MV cables - Methodology and inputs of temporary abandonment analyses of riser umbilicals with buoyancy systems - Umbilical: main properties (diameter, masses, stiffnesses) and reference to the umbilical data sheet - Umbilical: Rayleigh damping coefficient and its reference - Umbilical: capacity curves and their references - Umbilical: material properties with limit states (stress, strain etc.) and their references - Umbilical: S-N fatigue curves for all evaluated materials and their references - Umbilical: departure angle, azimuth clockwise relative to true north and configuration (free hanging catenary or lazy-wave) with their references - Umbilical: ancillary equipment data (bend stiffener and flotation modules) - Environment: water depth and its reference - Environment: drag and additional mass coefficients with their references - Environment: soil friction coefficients with their references - Environment: reference to wave and current source (metocean data) - FPU & PLSV: dimensions, draughts and heading clockwise relative to true north with their references - FPU & PLSV: reference to the RAO source - FPU & PLSV: origin of the coordinate system and the coordinates of the center of motion with their references - FPU & PLSV: coordinates of the top connection and its reference - FPU & PLSV: considered offsets and their reference
#7	Design report	- Extreme -load analysis results - On -bottom stability analyses results - Interference analyses results - Fatigue analyses results - Abandonment of riser umbilicals with buoyancy systems analyses - Thermal analyses results - Electrical analyses results - Pull -in dimensional analyses for top termination accessories and ancillary equipment - Reference to design premises report
#8	Data book	- Single line diagram of umbilical system - Actual umbilical lengths - Umbilical armouring weld map - Metallic tubes weld map - Electric cables splices map - Factory acceptance test results - Electric and optic termination report: detailed test results, photographic register of welds and final assembly of internal sealing components, traceability of terminations and internal sealing components - Photographic register of components pigtails accommodation and protection prior pull -in/handling head assemblies - Photographic register of umbilical system accommodation and protection in reel - Component data books - Nonconformities of components, umbilical, terminations, ancillary equipment, assemblies and acceptance tests
#9	Handling and operating (Umbilical system manual)	- Procedures/recommendations for pull-in/handling heads assembly/disassembly - Procedures/recommendations for pull-in kit assembly/disassembly - Procedures/recommendations for rigid joint assembly/disassembly - Procedures/recommendations for joint box assembly/disassembly - Procedures/recommendations for transition spool assembly/disassembly - Procedures/recommendations for hydraulic connections - Assembly sequence of hydraulic components (hoses jumpers, quick couplings, adaptors) - Assembly sequence in UTAs (Umbilical Termination Assemblies) - Handling limitations/recommendations