This Technical Specification applies for umbilicals with three individual signal cables, terminated (all three together) on a Petrobras standard oil filled hose crossover interface

INDEX OF REVISIONS

REV	DESCRIPTION AND/OR AFFECTED SHEETS
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<u>Nota para os usuários PETROBRAS:</u> Esta ET têm o caráter de diretriz para uso na aquisição de umbilicais submarinos que utilizem um ou mais cabos elétricos de sinal individuais, com 1 par de condutores de 2,5 mm².

	ORIGINAL	REV. A	REV. B	REV. C	REV. D	REV. E	REV. F	REV. G	REV. H
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Historical Background:
Based on ET-3500.00-1500-896-PAZ-001 Rev. A

1.0 - PURPOSE

This specification defines the minimum requirements for design, manufacture, qualification and acceptance of the electrical cable element and accessories for a static/dynamic umbilical for subsea applications.

NOTE: This specification is part of a document package for product development or bid purposes, that shall be referred in full for all relevant umbilical design data and its intended application.

2.0 - GENERAL

2.0.1-The electrical cable in this document shall be composed of 1 (ONE) shielded twisted pair of 2.5 mm² conductors. Typically, three such cable elements are to be used in a single umbilical, according to the respective umbilical RM document;

2.0.2- Unless otherwise herein specified, the standard that applies for the electrical cable design, manufacture and testing is the API Spec 17E (3rd Edition) & ISO 13628-5 (2004-01): Design and operation of subsea production systems, Part 5: Subsea Umbilicals. Variations or alternatives, if proposed, shall be submitted to PETROBRAS for approval prior to cable manufacture;

2.0.3-The electrical cable shall be provided with adequate mechanical strength to protect it over the range of loads during manufacture, handling, installation, operation and retrieval expected during the specified service life;

2.0.4-The electrical cable functional characteristics shall be assured during umbilical manufacturing, storage, transportation, handling, installation, testing, operation and retrieval, for the specified umbilical service life;

2.0.5-Materials to be used in the electrical cable and its accessories shall withstand the aging and degradation due to ambient conditions during the specified service life. It includes, among others, agents such as sea water and marine growth, as well as UV radiation when the cable extremities are subjected to long term (i.e. six months) sun radiation during umbilical storage at a non protected area or during operation (i.e. cable sections connected to the platform facilities);

2.0.6-The electrical cable design shall allow the lowest possible friction between the cable elements. Supplier shall state how the cable design and manufacture will address the movement between its components. Lubricants, if used, shall be compatible with other materials of the cable;

2.0.7-The electrical cable shall have at least two mechanical barriers against water to get into contact with the electrical conductors. Supplier shall state in its proposal how the cable design will accomplish this feature;

2.0.8-Each electrical conductor shall be made of high conductivity plain or tinned annealed copper wire with a minimum of 7 strands, complying with IEC 60228 (2004-11) Conductors of insulated cables standard;

2.0.9-All conductors shall be insulated with single or double pass ethylene copolymer, polyethylene or equivalent thermoplastic material suitable for subsea use. Supplier shall state the minimum and average insulation thickness prior the electrical cable manufacture;

2.0.10-The twisted conductor pair shall be covered with a thermoplastic material suitable for subsea use;

2.0.11-The electrical cable shall be designed and manufactured in such a way that fusion between polymeric layers and between insulation and copper cores is avoided. Supplier shall state in its proposal how the cable design and manufacture will accomplish this feature;

2.0.12-The electrical cable shall have sheaths with thickness and physical properties suitably selected to not compress the electrical cores due to shrinkage after extrusion. Also, extruded layers which are designed to assure water tightness at the interface between electrical cable and its connector, in order to assure such property, shall have their circularity controlled during manufacturing process. Supplier shall state in its proposal how the cable design and manufacture will accomplish the above features;

2.0.13-The shielding requirements shall be according with API Spec.17E standard. Drain wire total cross-sectional area shall not be less than 0.30 mm²;

2.0.14-The insulated conductors shall be coded as per API Spec 17E standard. Sequential numbers shall be used for conductor identification. Color coding may be used as an alternative. Conductor markings shall be stable under all environmental conditions for storage, handling and operation during the specified service life and shall not impair conductor insulation.

2.0.15-Fillers, if used, shall be of polymeric material that shall not degrade other materials in the cable, specially the conductor insulation. Refer also to API Spec.17E standard;

2.0.16-Steel wires for armoring, if used, shall not degrade with corrosion. Supplier shall be asked at any moment prior to the final delivery of the umbilical to make accelerated corrosion tests to demonstrate that mechanical strength of the armor wires will be compatible with the umbilical service life. Supplier shall present PETROBRAS a report on the necessity (or not) of anti-corrosive treatment of cable armoring, if used, prior cable manufacture;

2.0.17-The electrical cable outer sheath shall be of a thermoplastic material that shall not degrade the quality of other materials which it may be in contact in the lay-up. The cable outer sheet shall not be considered as a mechanical barrier against sea water intrusion. The outer sheet shall be designed so that the electrical insulated conductors are capable to operate in a fully flooded environment;

2.0.18-The electrical cable minimum bending radius shall be compatible with the dimensions of accessories such as pull-in heads for which the umbilical may be stored during deployment or abandonment in the sea bed. The reference minimum bending radius for the cable (without armors, if armored) shall be less than 250 mm;

2.0.19-The electrical cable subsea interface shall be according to the respective umbilical RM document issued by PETROBRAS;

2.0.20-The specified service life of the electrical cable and accessories shall be according to the respective umbilical RM document issued by PETROBRAS. Manufacturer shall document all characteristics of the material used to construct such components confirming that all kinds of possible degradation will not occur (including aging and corrosion);

3.0 - ELECTRICAL CHARACTERISTICS

3.0.1-The product shall comply with the following electrical characteristics:

a) Conductor resistance at 20° C: To be informed;

b) Nominal insulation resistance between conductors: > 500 MΩ/km @ 500 VDC;

c) Rating class: 0.6 kV RMS;

d) Nominal capacitance (1 kHz) < 168 nF/ km.

4.0 - CABLE TERMINATIONS AND ACCESSORIES

4.0.1-It shall be included the electrical cable scope of supply the following items already assembled in the umbilical cable or to be assembled by Supplier technicians on board the laying vessel prior the pull-in operations:

a) Male-female pairs of controlled-environment (subsea) type electrical connectors with suitable mating halves for hand made assembly of the umbilical splices onshore or onboard the laying vessel. The use of dry-mateable connectors without oil-filled controlled-environment chambers to protect the front electrical contacts will not be allowed.

b) One electrical cable/oil-filled hose crossover for the subsea termination on the X-Tree. This crossover shall be suitable to terminate all three individual cable elements of the umbilical to interface with a single oil-filled hose

NOTE: The item above refers to base case where the umbilical is to be used for a satellite well tied directly to its topside production facility. For other applications such the connection between a X-Tree and a Subsea Manifold or between non-standard subsea equipement, Supplier shall refer to the respective umbilical RM or contact PETROBRAS to clarify the specific requirements required for:
a) Electrical cable topside termination , if used;
b) Subsea Manifold or special equipment cable termination(s).

4.0.2-The electrical connector and the cable/oil-filled hose crossover shall guarantee the functional characteristics of the electrical cable and be adequate for the umbilical handling, installation and operational conditions;

4.0.3-Suitable protection caps to prevent water ingress in the electrical cable. It shall be supplied since (i) the electrical cable is not terminated during the pull-in operation or (ii) the umbilical needs to be abandoned on the sea bed;

4.0.4-All electrical connectors and the crossover(s) required for splices and terminations shall comply with the following characteristics:

4.4.1-Operating Conditions:

a) Maximum operating water depth: see RM;

b) Maximum operating temperature: 60°C;

c) Minimum operating temperature: 3°C;

d) Shock and vibration conditions compatible with the umbilical handling and installation;

4.4.2-Electrical Characteristics:

a) Minimum number of electrical contacts: 6 (six);

b) Contact capacity: 5 Amperes/contact;

c) Voltage rating: 600 VAC;

d) Insulation resistance (without connections): > 5 G ohm;

4.4.3-Electrical Cable Interface:

a) The conductor packing at the electrical connector and the cable/oil-filled hose crossover entrance and the anchorage and packing system of the cable at the connector shall be compatible with the electrical cable dimensions and materials;

4.4.4-Electrical Connector Specification:

a) Suitable for long term subsea application according with the service life specified by the umbilical RM;

b) Parts such male pins that may have eventual short term contact with seawater during abandonment shall be made of high corrosion resistant alloys.

c) To allow at least 30 dry connections and disconnections without damage in the coupling and packing systems;

d) It shall have at least two independent barriers to avoid water penetration between the electrical contacts or interfaces and the external environment;

e) A pressure compensated chamber shall be incorporated between the cable water blocking and the electrical connector harness to prevent water ingress;

f) The design of the electrical connector cable termination shall allow field assembly and testing on board of the laying vessel;

g) The electrical connector shall have an aligning, coupling and clamping system compatible with the required clearances for packing and operation during the umbilical specified service life;

h) The electrical connector shall incorporate a cable termination that shall be able to anchor firmly the cable outer jacket or its armor;

4.4.5-Cable/Oil-Filled Hose Crossover Specification:

a) The cable/oil-filled hose crossover shall be able to field assembly into the umbilical electrical cable;

b) The crossover shall be designed in two sections (cable termination and oil-filled hose section) bolted together and insulated by a penetrator;

c) The crossover shall have at least two independent mechanical barriers against sea water ingress at the rear of the penetrator insert which shall allow it to be tested separately during qualification and final assembly;

d) The umbilical electrical cable termination at the crossover shall incorporate a fully pressure balanced system that shall also be compatible to be field assembly and testing;

e) The crossover umbilical electrical cable termination shall be able to anchor firmly the cable outer jacket or its armor;

f) The crossover mechanical interface with the oil filled hose shall be a ¾" - 16 UNF, JIC 37° male fitting and shall incorporate a filling plug to allow the hose testing and filling up with silicon oil;

g) The penetrator insert that interfaces with the hose side shall be suitable for an insulated 1,5 mm OD wire. The necessary boot sleeves shall also be included in the scope of supply;

h) It shall be included in the scope of supply the necessary accessories to hold the crossover in place on the X-Tree flowline hub;

i) Parts such electrical contacts that may have eventual short term exposition to seawater during abandonment shall be made of high corrosion resistant alloys.

4.4.6-Shied Electrical Connection (Splices):

a) If the umbilical length is such that requires one or more subsea splices, the three individual shields shall be electrically tied together and connected through a single pin in the electrical connectors used for each splice.

5.0 - QUALIFICATION TESTS – General Requirements:

5.0.1-The electrical cable and its accessories shall be subjected to the qualification tests hereafter specified;

5.0.2-As a general directive, the electrical characteristics of the electrical cable, connectors, cable/oil-filled hose crossover and components (i.e. those to be verified by testing) shall be checked and documented before, during and after the mechanical resistance and hydrostatic pressure tests, whenever it is applicable;

5.0.3-If Supplier decides to change the configuration of a cable previously qualified by PETROBRAS, new qualification tests are required for the new design (the old results of tests are not valid anymore). Change in the cable configuration means any modification in its characteristics (or in its accessories) such as: cross section, dimensions, lay angles, manufacturing process, materials, sealing systems, etc...

5.0.4-If Supplier has already tested the proposed electrical cable, connectors, cable/oil-filled hose crossover, accessories under similar conditions to those in this technical specification or previously supplied to PETROBRAS the same products under this technical specification, it may present the gathered data and final results for PETROBRAS approval in order not to repeat them. However, PETROBRAS, at its own discretion, may reject results of any tests which procedures have not been previously approved by PETROBRAS or coming from tests that have not been witnessed by a PETROBRAS representative;

5.0.5- Supplier shall present PETROBRAS for comments and approval the fully qualification test program specifications at least 60 days in advance prior to the scheduled start of the tests. Each test procedure shall include its acceptance criteria. No test shall be done without PETROBRAS representatives in attendance, or without a written waiver by PETROBRAS;

5.0.6- Supplier must repeat any qualification test herein specified, at PETROBRAS discretion, in order to confirm (i) the results of qualification tests previously carried out for any cable configuration, materials, accessories, connectors, etc..., (ii) the control of manufacturing process of such items.

5.1 - QUALIFICATION TESTS – Electrical Cable:

5.1.1-As a general directive, the qualification tests for the electrical cable shall comply with the section 11 “Design Verification and Characterization Testing” of the Second Edition (9/98) of API Spec.17E, according with the following minimum requirements below:

a) **Visual and Dimensional Checks:** at least 5 (five) meters of cable/conductor shall be striped for examination and verified for signs of imperfections and damages. Each conductor shall be free of internal or external damages or failures such as breakage, deformations, buckling and Z-kinks. If any damage is found by the visual examination described above, it shall be repeated again in consecutive lengths of the cable at least three more times without any damage or failure for the cable to be considered as passed in this test.
b) **Conductor Resistance Test:** a Direct Current (DC) resistance test shall be performed on each insulated conductor of two complete cable samples (i.e. maintaining the cable configuration) at least 1 (one) meter long each, following the further criteria of API Spec. 17E. This test shall be performed before and after the sample pressurization according with the Hydrostatic Pressure Test (see below).
c) **Resistivity of the Screening Layers:** see API Spec. 17E.

d) **Insulation Resistance:** a DC insulation resistance test shall be performed according to the API Spec 17E, except that it shall be carried out in on each insulated conductor of two complete cable samples (i.e. maintaining the cable configuration) at least 1 (one) meter long each. This test shall be performed before the sample pressurization - according with the Hydrostatic Pressure Test (see below) - and repeated under pressure after at least 24 hours is elapsed and again after the sample depressurization.
e) **High Voltage DC Test:** a high voltage DC test shall be performed according to the API Spec 17E, except that it shall be carried out in on each insulated conductor of two complete cable samples (i.e. maintaining the cable configuration) at least 1 (one) meter long each. This test shall be performed before the sample pressurization - according with the Hydrostatic Pressure Test (see below) - and repeated after the sample depressurization. Each stranded pair shall withstand a test voltage of 3 kV applied for at least 5 (five) minutes to the dielectric composed by the conductors and the cable shield and also between conductors.
f) **High Voltage AC Test:** see API Spec. 17E.
g) **Complete Voltage Breakdown:** see API Spec. 17E.
h) **Inductance Characteristics:** see API Spec. 17E. Test frequencies shall cover the spectrum between 10 Hz and 20 kHz in the following steps: 10 Hz, 500 Hz, 1 kHz, and 20 kHz
i) **Capacitance Characteristics:** see API Spec. 17E.
j) **Attenuation Characteristics:** see API Spec. 17E.
k) **Characteristic Impedance:** see API Spec. 17E.

5.1.2-**Hydrostatic Pressure Test:** a two meter long sample of the specified cable shall be subjected to a pressure equivalent to 1,5 times the umbilical specified maximum water depth for at least 24 hours. The test bench shall include a hyperbaric chamber with instrumentation to record the internal pressures and temperatures.

5.1.3-**Bending Under Tension Cyclic Test:** the purpose of this test is to verify if the electrical cable can withstand the expected strain imposed by tension and compression loads after manufacture and installation. A minimum of five samples of the electrical cable shall be subjected to at least 5000 (five thousand) cycles of bending under tension. The samples shall be flexed from negative to positive bending radius per cycle. The bending radius shall be equivalent to 30 times the radius of the cable and the applied tension shall be equivalent to one third of respective (armored or unarmored) cable breaking load. Electric continuity shall be monitored during the test to provide instant indication of any conductor failure. The samples dimension (i.e. diameter and length) shall be recorded before and after the test. Electrical tests that shall be carried on each sample before and after the bending under tension test are: Insulation Resistance, Conductor Resistance and High Voltage DC (the late only after the bending test). After the final electrical tests, each sample shall be striped for examination and verified for signs of imperfections and damages. Each conductor shall be free of internal or external damages or failures such as breakage, deformations, bucklings and Z-kinks.

5.2 - QUALIFICATION TESTS – Electrical Connectors, Crossovers and Cable Termination:

5.2.1-The qualification tests, specified below, shall be carried for each type/model of a matched (male/female) pair of electrical connectors and crossovers included in the scope

of supply of the umbilical electrical cable. Supervision by the umbilical supplier is required whenever this qualification test are carried out by sub-suppliers or third parties:

a) **Insulation Resistance:** According to MIL-STD-202, method 302, condition B (500V), minimum insulation resistance: 5 G ohms;
b) **Dielectric Withstanding Voltage:** According to MIL-STD-202 method 301, with a test voltage of 3 kV or lower up to the electrical connector maximum;
c) **Durability:** 30 (thirty) cycles of dry connection and disconnection;
d) **Thermal Shock:** 5 (five) cycles between limits of +1 and +70° C, according to MIL-STD- 1344A method 1003.1;
e) **Humidity:** According MIL-STD-1344A, method 1.002.2 for 240 hours;
f) **Hydrostatic Tests:** in hyperbaric chamber at 1,5 times the pressure equivalent to the umbilical specified maximum water depth, after assembling in electrical cable sample;

5.2.2-The connector or crossover cable termination shall be terminated with an umbilical electrical cable test sample and a suitable test cable/hose assembly to simulate the complete interface. Then it shall be tested in a hyperbaric chamber at 1,5 times the pressure equivalent to the umbilical specified maximum water depth. Qualification tests shall include the verification of the integrity of secondary barriers against water penetration after simulating the primary (main) barrier failure;

5.3 - QUALIFICATION TESTS – Abandonment Cap:

5.3.1-Hydrostatic Tests: in hyperbaric chamber filled with fluorescent liquid at 1,5 times the pressure equivalent to the umbilical specified maximum water depth, after assembling in electrical cable sample;

5.3.2-After the Hydrostatic Test, it shall be performed Continuity Test and the Conductor Resistance Test for each conductor of the cable sample (as per item 5.1 above), then the cap shall be removed and the cable stripped for visual inspection of signs of the fluorescent liquid ingress into the electrical cable;

6.0- FACTORY ACCEPTANCE TESTS – General Requirements:

6.0.1-The acceptance tests shall be performed after the electrical cable is manufactured;

6.0.2- Supplier shall submit to PETROBRAS in the Quality Plan a full acceptance test program, including procedures and acceptance criteria, at least 60 days in advance prior to the scheduled start of the tests. No test shall be done without PETROBRAS representatives in attendance, or without a written waiver by PETROBRAS;

6.1 - FACTORY ACCEPTANCE TESTS – Electrical Cable:

6.1.1-As a general directive, the qualification tests for the electrical cable shall comply with the API Spec.17E, according with the following minimum requirements below:

a) **Visual and Dimensional Inspection:** see API Spec. 17E.
b) **Spark Test:** see API Spec. 17E.
c) **DC Conductor Resistance Test:** see API Spec. 17E.

d) **Insulation Resistance Test:** a DC insulation resistance test shall be performed according to the API Spec 17E, except that it shall be carried out in each insulated conductor of the complete cable (i.e. maintaining the cable configuration).
e) **High Voltage DC Test:** a high voltage DC test shall be performed according to the API Spec 17E, except that it shall be carried out in each insulated conductor of the complete cable (i.e. maintaining the cable configuration). Each stranded pair shall withstand a test voltage of 3 kV applied for at least 5 (five) minutes to the dielectric composed by the conductors and the cable shield and also between conductors.
Note: The insulation resistance and high voltage DC tests above are not required to be performed with the cable immersed in water.
f) **Inductance Characteristics:** see API Spec. 17E. Test frequencies shall cover the spectrum between 10 Hz and 20 kHz in the following steps: 10 Hz, 500 Hz, 1 kHz, and 20 kHz
g) **Capacitance Characteristics:** see API Spec. 17E.
h) **Attenuation Characteristics:** see API Spec. 17E.
i) **Characteristic Impedance:** see API Spec. 17E.
j) **(deleted)**
k) **Time Domain Reflectometry (TDR):** see API Spec. 17E. TDR shall be recorded for each cable length manufactured and for the complete umbilical prior installation. The results shall be included in the umbilical manufacturing data book.

6.1.2-**Hydrostatic Pressure Test:** Petrobras at its own discretion may require the carrying out of this test in order to verify if the manufactured cable is keeping its original characteristics which have been previously verified as per the original design and manufacturing methods. A sample of the specified cable shall be subjected to a pressure equivalent to 1,5 times the umbilical specified maximum water depth for at least 24 hours. The test bench shall include a hyperbaric chamber with instrumentation to record the internal pressures and temperatures.

6.1.3-**Bending Under Tension Cyclic Test:** Petrobras at its own discretion may require the carrying out of this test in order to verify if the manufactured cable is keeping its original characteristics which have been previously verified as per the original design and manufacturing methods. This test shall verify the if the electrical cable can withstand the expected strain imposed by tension and compression loads after manufacture and installation. A minimum of five samples of the electrical cable shall be subjected to at least 5000 (five thousand) cycles of bending under tension. The samples shall be flexed from negative to positive bending radius per cycle. The bending radius shall be equivalent to 30 times the radius of the cable and the applied tension shall be equivalent to one third of respective (armored or unarmored) cable breaking load. Electric continuity shall be monitored during the test to provide instant indication of any conductor failure. The samples dimension (i.e. diameter and length) shall be recorded before and after the test. Electrical tests that shall be carried on each sample before and after the bending under tension test are: Insulation Resistance, Conductor Resistance and High Voltage DC (this one only after the bending test). After the final electrical tests, each sample shall be striped for examination and verified for signs of imperfections and damages. Each conductor shall be free of internal or external damages or failures such as breakage, deformations, bucklings and Z-kinks.

6.2 – FACTORY ACCEPTANCE TESTS – Electrical Connectors, Crossovers and Cable Termination:

6.2.1-The acceptance tests, specified below, shall be carried for each type/model of a matched (male/female) pair of electrical connectors and crossovers included in the scope of supply of the umbilical electrical cable. Supervision by the umbilical supplier is required whenever this acceptance test are carried out by sub-suppliers or third parties:

a) **Insulation Resistance:** According to MIL-STD-202, method 302, condition B (500V), minimum insulation resistance: 5 G ohms;
b) **Dielectric Withstanding Voltage:** According to MIL-STD-202 method 301, with a test voltage of 3 kV or lower up to the electrical connector maximum;
c) **Durability:** At least 10 (ten) cycles of dry connection and disconnection;
d) **Hydrostatic Tests:** in hyperbaric chamber at 1,5 times the pressure equivalent to the umbilical specified maximum water depth;

6.2.2-Even in the case the electrical cable and its connectors/crossovers interfaces has already been previously qualified for PETROBRAS, the umbilical supplier shall include a test to verify the integrity of the interface between the electrical cable after manufacture and one sample each of the connectors and crossovers included in each umbilical purchased by PETROBRAS. This test shall include the actual manufactured cable sample assembled in the connector or crossover cable termination to simulate the complete interface. Then it shall be tested in a hyperbaric chamber at 1,5 times the pressure equivalent to the umbilical specified maximum water depth. Acceptance tests shall include the verification of the integrity of secondary barriers against water penetration after simulating the primary (main) barrier has failed.
Note: Tests 6.2.1 (d) and 6.2.2 may be combined for one sample of each connector or crossover supplied. In any case, all internal connector/crossover boot seals that are in contact with the cable sample shall be replaced after testing.

6.3 – FACTORY ACCEPTANCE TESTS – Abandonment Cap:

6.3.1-Hydrostatic Tests: Petrobras at its own discretion may require the carrying out of this test in order to verify if the manufactured cable is keeping its original characteristics which have been previously verified as per the original design and manufacturing methods. In hyperbaric chamber filled with fluorescent liquid at 1,5 times the pressure equivalent to the umbilical specified maximum water depth, after assembling in electrical cable sample;

6.3.2-After the Hydrostatic Test, it shall be performed Continuity Test and the Conductor Resistance Test for each conductor of the cable sample (as per item 5.1 above), then the cap shall be removed and the cable stripped for visual inspection of signs of the fluorescent liquid ingress into the electrical cable;

6.4 – FACTORY ACCEPTANCE TESTS – Completed Umbilical

On completion of umbilical manufacturing and prior to fitting of end terminations, the umbilical electrical cores shall be tested according to section 12.4.3.3 of API Spec17E.

7.0 - MANUFACTURING REQUIREMENTS

7.0.1-In addition to the requirements found in the applicable ISO 9001, API, IEC and BS Standards and those adopted by the cable supplier, the cable supplier shall assure the traceability of materials used in cable construction as well as of all manufacturing records;

7.0.2-For manufacturing, the diameter variation range of cable extruded layers shall be defined in such a way that the watertightness in the interface cable/connector and cable/crossover is assured, as applicable. The external diameter and thickness of extruded layers shall be continuously monitored and recorded lengthwise during manufacturing or a Spark Test be performed according to API Spec. 17E requirements.

7.0.3-The cable supplier shall provide on request the data book of the electrical cable, connectors and penetrators. This documentation shall include materials certificates, manufacturing and testing records as wells as other documents as required by the umbilical Quality Plan.

7.0.4-The manufacturing data book supplied with each umbilical shall include a data sheet with the following minimum parameters of the electrical cable:

a) Electrical:
   - Maximum DC loop resistance @ 20C (Ω/km);
   - Maximum attenuation/ @ 1 kHz (dB/km);
   - Capacitance (nF/km);
   - Cross-talk @ specified frequencies (see RM);
   - Minimum insulation resistance @ 500 V @ 1 kHz (MΩ/km);

b) Physical:
   - Outer diameter (mm);
   - Axial strength (kN);
   - Weight in air (kg/km);
   - Weight in seawater (kg/km);
   - Minimum bending radius – complete cable (mm);
   - Minimum repeated bending radius – complete cable (mm);
   - Minimum bending radius – sheathed pair (mm);

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