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1. PURPOSE

This specification defines the minimum requirements for design, manufacture, qualification and acceptance of an electrical cable element composed by Six cables with one 0.6/1.0 (1.2) kV, 6.0mm² Shielded Twisted Pair (STP) each (Option 1), or by One Armored Cable with Six 0.6/1.0 (1.2) kV, 6.0mm² STP in a Bundled Configuration (option 2), both options complete with subsea wet mate electrical connectors and accessories for Pre-sal standard dynamic Steel Tube Umbilical (STU) types.

The scope of supply of the electrical cable element in this specification includes the field (offshore) assembly of all subsea end electrical connectors on all cables of each STU, according to the latter's PETROBRAS respective Request of Material (RM or I-RM) document package or call for electrical cable element anticipated qualification.

1.1. ELECTRICAL CABLE ELEMENT CONFIGURATION

1.1.1. Option 1: Each STU shall have six individual electrical cables with one 0.6/1.0 (1.2) kV Shielded Twisted Pair of 6.0mm² conductor cross section each. In this Option the use of armor on each individual cable is not obligatory.

1.1.2. Option 2: Each STU shall have six individual cable units of one 0.6/1.0 (1.2) kV Shielded Twisted Pair of 6.0mm² conductor cross section each, with all bundled and twisted together in one (single) armored electrical cable.

1.1.3. In both options, each individual cable with one 0.6/1.0 (1.2) kV Shielded Twisted Pair of 6.0mm² conductors shall have a common copper electrostatic screen (shield) applied over the twisted pair bundle, a polymeric bedding layer followed by an electromagnetic steel tape or wire (or equivalent) screen, and an outermost polymeric cover sheet.

1.1.4. In Option 2 all six individual cables according to 1.1.3 above shall be bundled and twisted together under a common polymeric layer, followed by the armor layer and an outermost polymeric cover sheet.

1.2. APPLIED CODES AND STANDARDS

1.2.1. The following codes and standards that applies for each electrical cable element design, manufacture and testing:

- API Spec 17E, Fourth Edition (October 2010, Effective date: April 1, 2011): Specification for Subsea Umbilicals.
- ISO 13628-5:2009: Design and operation of subsea production systems, Part 5: Subsea Umbilicals.
- IEC 60502-1 Power cables with extruded insulation and their accessories for rated voltages from 1 kV (U_m = 1.2 kV) up to 3 kV (U_m = 3.6 kV).
- IEC 60228: Conductors of insulated cables.

Alternative standards, if proposed, shall be submitted to PETROBRAS for approval before the umbilical detail design.

2. GENERAL SPECIFICATIONS

2.1. Unless specified otherwise, “Cable” or “electrical cable” will be used instead of “electrical cable element”;

2.2. The electrical cable and all its accessories shall be suitable for operation in permanent contact with seawater during at least 30 years or the service life specified for the umbilical, whichever is the greatest. Manufacturer shall document all characteristics of the material used to construct such components confirming that degradation will not occur (including aging and corrosion);

2.3. The electrical cable shall be manufactured in continuous lengths suitable for the umbilical sections specified by Petrobras. No splices are allowed in the electrical cables inside the umbilical;

2.4. 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 umbilical specified service life;

2.5. 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;

2.6. 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 prior to cable manufacture;

2.7. Supplier shall provide a Grounding Procedure document detailing the electrical connections of all conductors, shield wire or tape, etc. between each umbilical section. The connections shall be detailed in order to avoid earth loops.

2.8. 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);

2.9. The electrical cable design shall allow the lowest possible friction between cable elements themselves and other components they may be in contact in the umbilical. Supplier shall state how the cable design and manufacture will address the movement between its components. Lubricants, if used, shall be compatible with cable materials;

2.10. 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;

2.11. 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 standard;

2.12. Electrical shielding requirements for each cable shall be according with API Spec 17E or ISO 13628-5 standards. Drain wire total cross-sectional area shall not be less than 0.30 mm²;

2.13. All conductors shall be insulated with single or double pass thermoplastic material such Ethylene Propylene Rubber (EPR), Cross-Linked Polyethylene (XLPE) or other equivalent suitable for subsea use. Supplier shall state the minimum and average insulation thickness in the cable data sheet and confirm it prior the electrical cable manufacture;

2.14. Cable conductors shall be longitudinally sealed to prevent water penetration (between the wires) along the electrical power cable in case of umbilical (cable) severance. The sealing material must be thermally and chemically compatible with all other materials in the umbilical. The Supplier shall state in the umbilical proposal the designed technical characteristics related to the water penetration prevention, explaining how this requirement will be addressed;

2.15. 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;

2.16. 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;

2.17. During manufacturing phases, special care shall be taken to the cleanliness of extrusion machines in order to avoid metallic particles to pollute the insulation material;

2.18. The insulated conductors shall be coded as per API Spec 17E or ISO 13628-5 standards. 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;

2.19. 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 or ISO 13628-5 standards;

2.20. 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. Armored cable outer sheet shall not be considered as a mechanical barrier against sea water intrusion. Cable shall be designed in order for the electrical insulated conductors to be capable to operate in a fully flooded environment;

2.21. The cable layer sheath intended for electric connector sealing shall be extruded within predefined close diameter tolerances and free from lumps and hollows to enable field (offshore)

assembly of the electric connector with the sealing to be performed. Supplier shall made available cable samples for the electric connector manufacturer qualify the cable-connector interface and assembly procedures;

2.22. Cable minimum bending radius shall be compatible with the umbilical's, including dimensions of accessories such as pull-in heads for which the cable may be stored during deployment or abandonment in the sea bed;

2.23. Cable design shall be compatible with umbilical cathodic protection, including related ancillary equipment for the service life. Electrical continuity shall be implemented throughout the umbilical system and all metallic interfaces within terminations shall be measured and be less than 0.1Ω;

3. CABLE ELECTRICAL DATA (Typical)

Cable Voltage Class	0.6 / 1.0 (1.2) kV
Nominal Operating Frequency (Power)	50/60 Hz (see Note 1 below)
Nominal Operating Frequency (Signal)	15.5 kHz (see Note 1 below)
Maximum DC Conductor Resistance:	3,1 Ώ/km
Minimum Insulation Resistance:	1 GΏ @ 500 VDC @ 20°C @ 1 min.
Operating Temperature	-10 to + 40°C
Maximum Inductance @ 1 kHz	0.8 mH/km
Maximum Mutual Capacitance @ 1 kHz	84 nF/km
Maximum Attenuation @ 1 kHz	0.48 dB/km
Maximum Attenuation @ 2 kHz	0.58 dB/km
Maximum Attenuation @ 5 kHz	0.72 dB/km
Maximum Attenuation @ 10 kHz	0.93 dB/km
Maximum Attenuation @ 15 kHz	1.09 dB/km
Maximum Attenuation @ 20 kHz	1.25 dB/km
Maximum Attenuation @ 30 kHz	1.52 dB/km
Max. Near End Differential Mode Cross Talk @ 1 kHz	- 63 dB
Max. Near End Differential Mode Cross Talk @ 2 kHz	- 59 dB
Max. Near End Differential Mode Cross Talk @ 5 kHz	- 53 dB
Max. Near End Differential Mode Cross Talk @ 10 kHz	- 48 dB
Max. Near End Differential Mode Cross Talk @ 15 kHz	- 46 dB
Max. Near End Differential Mode Cross Talk @ 20 kHz	- 44 dB
Max. Near End Differential Mode Cross Talk @ 30 kHz	- 41 dB
Maximum AC Loop Resistance @ 20C	6.16 Ώ/km
Characteristic Impedance @ 1 kHz	127.0 Ohm
Characteristic Impedance @ 2 kHz	102.6 Ohm
Characteristic Impedance @ 5 kHz	89.6 Ohm
Characteristic Impedance @ 10 kHz	82.7 Ohm
Characteristic Impedance @ 15 kHz	80.8 Ohm
Characteristic Impedance @ 20 kHz	79.3 Ohm
Characteristic Impedance @ 30 kHz	78.2 Ohm

Note 1: Typical system with comms-on-power Subsea Control Systems

4. CABLE TERMINATIONS AND ACCESSORIES

4.1. 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) Umbilical Splices (if required by RM): 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.

NOTE: The following types of electrical connectors shall be avoided on all splices:

I. Dry-mate connectors without oil-filled controlled-environment chambers to protect the front electrical contacts will not be allowed;

II. A single connector for all individual electrical cables.

b) Subsea Termination: Electrical cable/oil-filled hose crossover for interface with the subsea equipment according with the types and quantities specified in the respective STU I-RM or RM document.

c) Topside Termination: Supplier shall refer to the respective umbilical RM or contact PETROBRAS to clarify the specific requirements. Supplier shall refer to the respective STU I-RM, RM.

4.2. 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;

4.3. Suitable protection caps to prevent water ingress in the electrical cable shall be supplied in order to cope with the following situations: (i) the electrical cable is not terminated during the pull-in operation or (ii) the umbilical needs to be abandoned on the sea bed. Temporary abandonment cap for wet storage installation/immersion of pull-in head up to 6 months. Fire resistant protective conduits to protect the topside electrical pigtails;

4.4. All electrical connectors and the crossover(s) required for splices and terminations subsea 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: 2□C;
d) Shock and vibration conditions compatible with the umbilical handling and installation;

4.4.2. Electrical Characteristics:

a) Number of electrical contacts: min. 4 (four);
b) Contact capacity: > 10 Amperes/contact;
c) Voltage rating phase to ground: 1000 VAC rms (1414 VAC peak);
d) Voltage rating phase to phase: 2000 VAC rms (2828 VAC peak);

e) Insulation resistance (without connections): > 5 GΩ @ 20°C;

4.4.3. Electrical Cable Interface: Conductor packing in electrical cable connectors, cable/oil-filled hose crossover's entrance, and the anchorage and packing system of the cable at the connector shall be compatible with the 6.0 mm² electrical cable conductor cross section (with crimps and extended cable glands, if necessary), 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(s) according to the configuration, types and quantities specified in the respective STU I-RM or RM document.
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) Crossover cap (hose end) shall have a 3/4" (Three Quarters of an Inch) - 16 UNF, JIC 37° male fitting interface and shall incorporate a filling plug to allow the hose testing and filling up with silicon oil. Refer to the configuration, types and quantities specified in the respective STU I-RM or RM document.
g) The penetrator insert that interfaces with the hose side shall have solder cups of at least 2.5mm². 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(s) in place on the subsea equipment where it will be permanently attached;

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 individual pair shields shall be electrically tied together and connected through a single pin in the electrical connectors used for each splice.

5. QUALIFICATION TESTS: General Requirements

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

5.2. As a general directive, the electrical characteristics of the electrical cable, connectors, shall be checked and documented before, during and after the mechanical resistance and hydrostatic pressure tests, whenever it is applicable;

5.3. Qualification is mandatory even if Supplier has already tested the proposed electrical cable, connectors, and accessories under similar conditions to those in this technical specification or previously supplied the same products to PETROBRAS;

5.4. 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;

6. QUALIFICATION TESTS: Electrical Cable

6.1. As a general directive, the qualification tests for the electrical cable shall verify the specified cable electrical data. All other electrical parameters to be verified according with API Spec 17E shall comply with Supplier written specifications and acceptance criteria in the test procedures. Qualification shall comply with the API Spec 17E Standard, complemented by the following 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 sample shall withstand a test voltage of at least 20 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 be: 50/60 Hz, 1 kHz, 10 kHz and 15.5 kHz.
i) Capacitance Characteristics: see API Spec. 17E.
j) Attenuation Characteristics: see API Spec. 17E.
k) Characteristic Impedance: see API Spec. 17E.

6.2. Hydrostatic Pressure Test: A sample each of the STU electrical 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.

6.3. 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 STU 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, deformation, buckling and Z-kink;

6.4. Supplier shall demonstrate the effectiveness of the conductor water block system by performance verification test in which three samples of the STU electrical cable with one end open shall be immersed in a hyperbaric chamber filled with fluorescent liquid and kept pressurized for at least 72 hours with a pressure equivalent to 1.1x the umbilical rated water depth. The sample length and the maximum % of the length which the water can penetrate will

be specified by the Supplier prior the test and is to be verified by careful stripping and visual inspection of each sample to see how far the liquid has penetrated in the cable;

7. QUALIFICATION TESTS: Electrical Connectors and Cable Termination

7.1. The qualification tests specified below shall be included in the scope of supply of the umbilical electrical cable. It shall be carried for each type/model of a matched (male/female) pair of electrical connectors, including dummy units and protection caps:

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;

7.2. Each type of cable-connector termination for the STU shall be qualified in 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;

8. QUALIFICATION TESTS: Abandonment Cap

8.1. 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 a sample of the STU electrical cable;

8.2. After the Hydrostatic Test, it shall be performed Continuity Test and the Conductor Resistance Test for each conductor of the cable sample, then the cap shall be removed and the cable stripped for visual inspection of signs of the fluorescent liquid ingress into the electrical cable;

9. FACTORY ACCEPTANCE TESTS: General Requirements

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

9.2- 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;

10. FACTORY ACCEPTANCE TESTS: Electrical Cable

10.1. As a general directive, the FAT for each umbilical electrical cable shall comply with the "Factory Acceptance Tests" of API 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 electrical cable shall withstand a test voltage of at least 20 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 if the cable have a metal screen layer (shied). In this case the voltage shall be applied between each insulated conductor and all the other conductors and collective metallic layers.
f) Inductance Characteristics: see API Spec. 17E. Test frequencies shall be: 50/60 Hz, 1 kHz, 10 kHz and 15.5 kHz.
g) Capacitance Characteristics: see API Spec. 17E.
h) Attenuation Characteristics: see API Spec. 17E.
i) Characteristic Impedance: see API Spec. 17E.
j) Cross-Talk for the total length: see API Spec. 17E.
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.

10.2. Hydrostatic Pressure Test: A sample each of the STU electrical 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.

10.3. Bending Under Tension Cyclic Test: 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 STU 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 stripped 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, deformation, buckling and Z-kink.

10.4. Supplier shall demonstrate the effectiveness of the conductor water block system by performance verification test in which three samples of each STU electrical cable, with one end open shall be immersed in a hyperbaric chamber filled with fluorescent liquid and kept pressurized for at least 72 hours with a pressure equivalent to 1.1x the STU rated water depth. The sample length and the maximum % of the length which the water can penetrate will be specified by the Supplier prior the test and is to be verified by careful stripping and visual inspection of each sample to see how far the liquid has penetrated in the cable.

11. FACTORY ACCEPTANCE TESTS: Electrical Connectors

11.1-The acceptance tests, specified below shall be included in the scope of supply of the umbilical electrical cable. It shall be carried for each type/model of a matched (male/female) pair of electrical connectors, including dummy units and protection caps:

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;

12. FACTORY ACCEPTANCE TESTS: Completed Umbilical

12.1. On completion of umbilical manufacturing and prior to fitting of end terminations, the umbilical electrical cores shall be tested according to Section 11.3 of API Spec17E.

13. MANUFACTURING REQUIREMENTS

13.1. 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;

13.2. For manufacturing, the diameter variation range of cable extruded layers shall be defined in such a way that the interface cable/connector and cable/crossover is assured watertight, 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.

13.3. 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.

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

a) Electrical;

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);

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