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TECHNICAL DESCRIPTION TD-220/3
SINGLE CORE UNDERGROUND 150 kV CABLES
WITH CROSS - LINKED POLYETHYLENE INSULATION (XLPE)

I. SCOPE

This document covers the general IPTO requirements of the technical and constructional characteristics of single core underground 150 kV cables with cross-linked polyethylene insulation (XLPE) and copper (Cu) or Aluminum (Al) conductor and also describes the required tests for the aforementioned cables that are to be installed at the Hellenic Electricity Transmission System.

II. KEYWORDS

Underground cables, high voltage cables with cross - linked polyethylene insulation.

III. STANDARDS

The applicable standard for the cables shall be the IEC 60840, IEC 60228, IEC 60287, IEC 60853.

IV. USE

The cables are to be used in Underground Cable Lines of Alternating current (AC) in National Transmission System of Greece.

V. SYSTEM CHARACTERISTICS

The cables are to be used in an electrical power system which has the following characteristics:

1. Rated system Voltage (phase-to-phase) : 150 kV rms
2. Maximum operating system Voltage : 170 kV rms
3. Basic Insulation Level (BIL) (Impulse level) : 750 kV peak
4. Frequency : 50 Hz
5. Number of phases : 3
6. Short circuit level : 31.5 kA
7. Time duration of short circuit : 1 s
8. Method of earthing : The 150 kV system is solidly earthed (grounded)

VI. CABLE REQUIRED CHARACTERISTICS

1. Rated Voltage, Uo / U(U max)	:	87/150 (170) kV, where Uo= voltage (rms) between conductor and earth or metallic sheath, U= phase to phase rms value, Umax=maximum phase to phase voltage (rms)
2. Impulse withstand voltage (1.2/50ms)	:	750 kV peak
3. A.C. 50 Hz voltage withstand for 30 min	:	218 kV rms
4. Power transmitting capacity levels	:	a. 200 MVA b. 140 MVA (unless otherwise specified by IPTO)

The maximum continuous current carrying capacity calculations will be performed according to the I.E.C. publications 60287 and 60853. The conditions to be used are as follows:

1)	Thermal resistivity of the soil	: 1.2 K·m/W
2)	Thermal resistivity of backfill material	: According to the actual thermal resistivity of the materials which are to be used and shall be as much as needed, in order to achieve the required transmitted power, and not more than the max permissible values according to Table 1.
3)	Ground temperature	: +25 °C
4)	Air temperature	: +40 °C
5)	Cable arrangement	: Flat or trefoil (As defined by IPTO)
6)	Trench depth	: The depth alters depending on the crossings and the underground texture (eg. high water table) Typical value X = 1700 mm in cases where there is no kind of crossing. The maximum max burial depth is taken into consideration in the final study. Maximum permissible depth 3.5m.
7)	Minimum trench width	: 80 cm
8)	Minimum distance between phases	: a. Flat formation → 25 cm b. Trefoil → Adjoining (unless otherwise specified by IPTO)

9) Minimum distance between two circuits (if required) : 160 cm (unless otherwise specified by IPTO)

10) Load factor : 1 (unless otherwise specified by IPTO)

11) Grounding : a. Cross earthed
b. Single point earthed
(unless otherwise specified by IPTO)

Backfill Material	Thermal resistivity
Sand	0.6 - 0.8 K·m/W
Crashed material mixed with sand (3A)	1.2 – 1.6 K·m/W
Crashed material mixed with sand (3A) and excavated soil	1.2 – 1.6 K·m/W
Cement	0.5 - 0.8 K·m/W
Grout of proper ratio among sand, gravel & water (CBS)	≤1.0 K·m/W

Table 1: Range of thermal resistivity of backfill materials.

During the final study, the compliance with the limit of power transmitting capacity, under any circumstances, is prerequisite for the study's approval and the validation of the system's adequacy, taking into consideration the technical data that will be provided by the manufacturer and the drawings of the cable system's installation.

5. Components of the cable:

The cable shall consist of the following parts:

- Conductor
- Semi-conducting layer for conductor
- XLPE insulation,
- Semi-conducting layer for insulation
- Semi-conducting tapes swelling in the presence of moisture
- Sheath of lead alloy or alternatively of copper wires and aluminum tapes shield or alternatively of corrugated and seamless or smooth welded aluminum sheath.
- Outer sheath of PVC or alternatively of HDPE
- Semi-conducting layer for outer sheath.

6. During the installation process of the cable system, the pulling tension and sidewall pressure shall not exceed the maximum permissible ones.

VII. REQUIRED CHARACTERISTICS OF THE CABLE CONDUCTOR

1. Number of conductors	:	Single Core
2. Conductor material	:	Copper (Cu) or Aluminium (Al) (As defined by IPTO)
3. Conductor shape	:	Circular or multi –wire consisting of circular stranded compacted wires or Milliken conductor or concentric layers of key-stone shaped profile wires. In any case the conductor shape will be in accordance with IEC-60228.
4. Conductor Insulation	:	The insulation of the conductor shall consist of super clean extruded layer of cross -linked polyethylene (XLPE). The mechanical characteristics of the insulation shall be in accordance with the values of table IV of IEC - 60840.
5. Conductor withstand in short circuit current	:	31.5 kA for 1 s, minimum
6. Maximum permissible conductor temperature	:	90 °C

VIII. CABLE'S METALLIC SHEATH REQUIRED CHARACTERISTICS

1. Metallic sheath material	:	Lead alloy (for example lead alloy type E as per BS-801) or alternatively copper wires with aluminum tapes shield or alternatively corrugated and seamless or smooth welded aluminum
2. Radial protection of the cable against water and moisture	:	The metallic sheath must provide radial protection against water and moisture.
3. Longitudinal protection of the cable against water and moisture	:	The longitudinal protection against water and moisture shall be achieved by the use of swelling tape or material applied under the metallic sheath.
4. Metallic sheath withstand in short circuit current	:	31.5 kA for 0.5 s.

IX. SEMICONDUCTING LAYERS FOR CONDUCTOR AND INSULATION OF THE CABLE

The semi-conducting layers for the conductor and the insulation are both compulsory and they must be produced with the triple extrusion method.

X. OUTER SHEATH OF THE CABLE

The outer sheath of the cable will be manufactured with the method of extrusion from PVC of red or neutral color. Alternatively, polyethylene of high density (HDPE) is considered acceptable material for the outer sheath of the cable.
The outer surface of the sheath shall be made conducting with the addition of proper semi-conducting layer with the method of extrusion.

XI. CABLE MARKINGS

1. The cable must bear on its outer sheath the following markings:
   - Manufacturer's trade mark
   - Cross - section and material of the conductor
   - Insulation material
   - Rated voltage Uo /U (Umax)
   - Year of manufacturing
   - Contract number

2. Furthermore, the outer cable sheath shall bear indication of total progressive length count per meter length for the total length of cable ordered.
   The indication must be indelible written with engraved characters/numerals. The minimum height of the characters/numerals shall be 4 mm.

XII. TESTS

The routine, special and type tests shall be in accordance with IEC – 60840/last revision.

1. Routine tests

The following tests shall be carried out on each manufactured length of cable :

1. Partial discharge test
2. Voltage test (dielectric test for 50 Hz, 30 min).
3. DC Voltage test of the lead (or aluminum) sheath and the PVC (or polyethylene) outer sheath. Test Voltage: 10 kV DC for one min, according to IEC 60229.

2. Special Tests

The following tests shall be carried out on only one representative cable sample :

1. Conductor examination
2. Measurement of electrical resistance of the conductor.
3. Measurement of thicknesses of the insulation and the non - metallic layers.
4. Measurement of thickness of the metallic sheath
5. Measurement of conductor's and cable's diameter.
6. Hot set test for the XLPE insulation.
7. Measurement of capacitance between conductor and the metallic sheath.

3. Type Tests

The type tests shall be made before the manufacturer begins the continual production of the cable.

1. Full Cable Electrical Tests

The tests listed below shall be performed on a sample of complete cable at least 10 m in length.

With the exception of the "measurement of tanδ", all the other tests must be applied successively to the same sample.

The tests and the sequence of them shall be as follows:

1. Bending test followed by partial discharge test.
2. Tanδ measurement
3. Heating cycle voltage test, followed by partial discharge measurement.
4. Impulse withstand test, followed by a power frequency voltage test.

XIII. PACKING

The cable shall be winded on a reel and shall be protected against damage during transportation to its destination site.
Each end of each cable length must be sealed water-tight immediately after the testing.
The reels supplied by the manufacturer must be metallic and of robust construction, with steel axes capable of withstanding the mechanical stresses exerted during the installation of the cable.
The reel axis hole shall have a diameter not less than 80 mm.
Each reel must bear either directly on it or upon a non corrosive metallic plate the following markings:
- cable length
- unwinding direction
- net and gross weight
- contract number

XIV. INFORMATION WHICH MUST BE PROVIDED BY ALL BIDDERS

1. The supplier must provide complete technical data, along with the technical offer, as it is required in the attached "Technical Characteristics Datasheet".

2. A preliminary drawing of cross-section of the cable offered with description. Failure to comply with this request will result in rejection of the offer.

3. Technical prospectus of the offered cable and its components, such as joints, etc.

4. Any available type test certificates. Acceptance or not shall lie at the judgment of IPTO.

5. Detailed calculations of the maximum continuous current carrying capacity will be performed according to the I.E.C. publications 60287 and 60853.

6. Detailed calculations of transient overcharge analysis of the cables for temperatures of 90 ^{o}C and 95 ^{o}C and with initial permanent cable load of 75%, 80%, 85% and 100% of the maximum is required.

7. Detailed calculations of the maximum short circuit current capability of the conductor (for 1 s) and of the metallic sheath of the cable (for 0.5 s), according to IEC 60949 shall be provided.

XV. INFORMATION WHICH MUST BE PROVIDED BY THE SUCCESSFUL BIDDER

1. A detailed drawing depicting a cross-section view of the cable offered and complete description of its parts.

2. Detailed instructions regarding bending, handing, and installation of the cable.

TECHNICAL CHARACTERISTICS DATASHEET

SINGLE CORE UNDERGROUND 150 kV CABLES WITH CROSS - LINKED POLYETHYLENE INSULATION (XLPE)

A. Conductor

1. Nominal conductor cross section ..... mm^2
2. Conductor material .....
3. Minimum outer diameter .....mm
4. Maximum outer diameter .....mm
5. DC resistance at 20° C .....μΩ/m
6. AC resistance at 90° C ..... μΩ/m
7. Number of wires .....
8. Nominal diameter of each wire .....mm

B. Semi-conducting layers

Do semi-conducting layers meet the Requirements of par. XI? .....

Conductor semi-conducting layer

1. Nominal thickness ..... mm
2. Minimum outer diameter ..... mm
3. Maximum outer diameter ..... mm
4. Specific electrical resistance ..... Ω.m
5. Material of the semi-conducting layer .....

Insulation semi-conducting layer

1. Nominal thickness ..... mm
2. Minimum outer diameter ..... mm
3. Maximum outer diameter ..... mm
4. Specific electrical resistance ..... Ω.m
5. Material of the semi-conducting layer .....

Outer sheath semi-conducting layer

1. Nominal thickness ..... mm
2. Minimum outer diameter ..... mm
3. Maximum outer diameter ..... mm
4. Specific electrical resistance ..... Ω.m
5. Material of the semi-conducting layer .....

C. Insulation

1. Material of the insulation .....
2. Nominal thickness ..... mm
3. Minimum outer diameter ..... mm

4. Maximum outer diameter ..... mm
5. Maximum dielectric stress ..... kV/mm

D. Metallic sheath

D1. Lead alloy sheath

1. Type of alloy and description of its chemical composition .....
2. Nominal thickness ..... mm
3. Minimum outer diameter ..... mm
4. Maximum outer diameter ..... mm
5. Tension strength ..... .N/mm^2
6. Material and data of the longitudinal protection .....

Or alternative

D2. sheath of Aluminum and Copper

1. Type of sheath material .....
2. Nominal thickness ..... mm
3. Minimum outer diameter ..... mm
4. Maximum outer diameter ..... mm
5. Tension strength ..... .N/mm^2
6. Number of copper wires .....
7. Nominal diameter of each copper wire .....
8. Material and data of the longitudinal protection .....
   .....

Or alternative

D3. corrugated and seamless aluminum

1. Type of sheath material .....
2. Nominal thickness ..... mm.
3. Minimum outer diameter ..... mm
4. Maximum outer diameter ..... mm
5. Tension strength ..... .N/mm^2
6. Material and data of the longitudinal protection .....

Or alternative

D4. smooth welded aluminum

1. Type of sheath material .....
2. Nominal thickness ..... mm.
3. Minimum outer diameter ..... mm
4. Maximum outer diameter ..... mm
5. Tension strength ..... .N/mm^2

6. Material and data of the longitudinal protection .....

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E. Cable outer sheath

E1. PVC sheath

1. Nominal thickness of the sheath .....mm
2. Material and method of application of the conducting sheath .....

or alternative

E2. HDPE-MDPE sheath

1. Nominal thickness of the sheath .....mm
2. Material and method of application of the conducting sheath .....

F. Cable

1. Maximum outer diameter of the single core cable .....mm
2. Minimum outer diameter of the single core cable .....mm
3. Cable inductive reactance (XL) .....μΩ/kV

4α. Positive sequence capacitance of cable at full load C_1 .....μΩ/kV

4β. Zero sequence capacitance of cable C_0 .....μΩ/kV

5. Maximum continuous current carrying capacity for one circuit (3 cables) based on the data of the paragraphs V, VI, VII, VIII, IX and X, according to the I.E.C. publications 60287 and 60853, latest editions .....A
6. Maximum continuous current carrying capacity for two parallel circuits (6 cables) based on the data of the paragraphs V, VI, VII, VIII, IX and X, according to the I.E.C. publications 60287 and 60853, latest editions Circuit I.....A
   Circuit II.....A
7. Weight of the cable ..... kg/m
8. Minimum bending radius .....m.
9. Positive sequence impedance of one circuit (3 cables) ($Z_1=R_1+jX_1$) .....μΩ/m
10. Zero sequence impedance of one circuit (3 cables) ($Z_0=R_0+jX_0$) .....μΩ/m
11. Losses (for 3 cables)

a. 100% of the load in continuous operation
- in conductors ..... W/m
- in lead alloy sheaths .....W/m
- dielectric ..... W/m

b. 50% of the load in continuous operation
- in conductors ..... W/m

- in lead alloy sheaths ……...W/m

- dielectric ..... W/m

12. Losses (two circuits – 6 cables)

a. 100% of the load in continuous operation

- in conductors ..... W/m

- in lead alloy sheaths ……...W/m

- dielectric ..... W/m

b. 50% of the load in continuous operation

- in conductors ..... W/m

- in lead alloy sheaths ……...W/m

- dielectric

13. Short circuit current capability

- in conductors ……kA for 1 s

- in the sheath ……kA for 0.5 s

14. Impulse withstand voltage ……..kV

15. Maximum permissible pulling tension ……N

16. Maximum permissible sidewall pressure ……N

17. A.C 50 Hz voltage withstand

for 30 min ……kV

18. Does the offered cable meet the

requirements of paragraphs XIII, XII, XV? ……

19. Line resistance (Ω/Km) …… Ω/Km