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**TECHNICAL DESCRIPTION TD-221/1**  
**SINGLE CORE UNDERGROUND 400 kV CABLES**  
**WITH CROSS - LINKED POLYETHYLENE INSULATION (XLPE)**

**I. SCOPE**

This document covers the general IPTO requirements of the required technical and constructional characteristics of single core underground 400 kV cables with cross- linked polyethylene insulation (XLPE) and copper (Cu) 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, extra high voltage cables with cross - linked polyethylene insulation.

**III. STANDARDS**

The applicable standard for the cables, as far as the testing methods & the technical specifications are concerned, shall be the IEC-62067 (latest edition), while the calculation of the cables' electrical characteristics shall be in accordance to the following standards: IEC 60228 – IEC 60287 – IEC 60853, IEC 60949 & IEC 61443.

**IV. USE**

The cables are to be used either for the power supply of 400 kV HVSS or for the undergrounding of 400 kV Transmission.

## **V. SYSTEM CHARACTERISTICS**

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

- |                                                      |                                                   |
|------------------------------------------------------|---------------------------------------------------|
| 1. Rated system Voltage (phase-to-phase)             | : 400 kV                                          |
| 2. Maximum operating system Voltage (phase-to-phase) | : 420 kV                                          |
| 3. Basic Insulation Level (BIL) (Impulse level)      | : 1425 kV                                         |
| 4. Frequency                                         | : 50 Hz                                           |
| 5. Number of phases                                  | : 3                                               |
| 6. Short circuit level                               | : 40 kA                                           |
| 7. Time duration of short circuit                    | : 1,0 sec                                         |
| 8. Method of earthing                                | : The 400 kV system is solidly earthed (grounded) |

## **VI. SOIL CHARACTERISTICS AND AMBIENT TEMPERATURES**

The cables in question are to be used in soil, usually with the following characteristics:

- |                                    |                                 |
|------------------------------------|---------------------------------|
| 1. Thermal resistivity of the soil | : $\leq 1,2^{\circ}\text{Km/W}$ |
| 2. Average soil temperature        | : 25 °C                         |
| 3. Soil temperature range          | : 10° C to +30 °C               |
| 4. Ambient air temperature range   | : -25° C to +45 °C              |

## **VII. CABLE REQUIRED CHARACTERISTICS**

- |                                                  |                                                                                                                                                                                                                                                                                 |
|--------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. Rated Voltage, $U_0$ / $U(U_{\text{max}})$    | : 230/400 (420) kV where:<br>$U_0$ = voltage (rms) between conductor and earth or metallic sheath,<br>$U$ = phase to phase rms value,<br>$U_{\text{max}}$ = maximum phase to phase voltage (rms)                                                                                |
| 2. Impulse withstand voltage (1.2/50ms)          | : 1425 kV peak                                                                                                                                                                                                                                                                  |
| 3. A.C. 50 Hz voltage withstand for 60 min       | : 440kV (rms)                                                                                                                                                                                                                                                                   |
| 4. Components of the cable:                      | : The cable shall consist of the following basic parts:<br>conductor, semi-conducting layer for conductor, XLPE insulation, semi-conducting layer for insulation, armor, semi-conducting tapes swelling in the presence of moisture, metallic protective sheath & outer sheath. |
| 5. Maximum pulling tension and sidewall pressure | : During the installation process of the cable system, the pulling                                                                                                                                                                                                              |

tension and sidewall pressure shall not exceed the maximum permissible ones.

### **VIII. REQUIRED CHARACTERISTICS OF THE CABLE CONDUCTOR**

The conductor shall be in accordance to the IEC-60228 standard and shall have the following characteristics:

- |                                                 |                                                                                                                    |
|-------------------------------------------------|--------------------------------------------------------------------------------------------------------------------|
| 1. Number of conductors                         | : Single Core                                                                                                      |
| 2. Conductor material                           | : Copper (Cu)                                                                                                      |
| 3. Conductor cross-section                      | : 2500 mm <sup>2</sup>                                                                                             |
| 4. Conductor shape                              | : Multi-wire, Milliken type shaped, consisting of circular stranded compacted wires.                               |
| 5. Conductor Insulation                         | : The insulation of the conductor shall consist of super clean extruded layer of cross-linked polyethylene (XLPE). |
| 6. Conductor withstand in short circuit current | : 40 kA for one (1) sec, minimum                                                                                   |
| 7. Maximum permissible conductor temperature    | : 90 °C                                                                                                            |

### **IX. CABLE'S ARMOR & METALLIC SHEATH REQUIRED CHARACTERISTICS**

- |                                                                    |                                                                                                                                                                                                                                                                                                        |
|--------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. Armor material                                                  | : CU                                                                                                                                                                                                                                                                                                   |
| 2. Metallic sheath material                                        | : Lead alloy (for example lead alloy type E as per BS-801). Alternatively, the use of other materials is acceptable, such as Al, with characteristics in accordance to the Tables 1, 2 & 5 of the IEC-62067 standard.                                                                                  |
| 3. Radial protection of the cable against water and moisture       | : The metallic sheath must provide radial protection against water and moisture. In order to achieve that, acceptable techniques for the installation of the metallic sheath are either the extrusion of Mb, Al or the continuous welding of Al. The method of glued Aluminum foils is not acceptable. |
| 4. 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.                                                                                                                                                  |
| 5. Metallic sheath withstand in short circuit current              | : 40 kA for 0,5 sec.                                                                                                                                                                                                                                                                                   |

## **X. 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 together, during the insulation production, with the triple extrusion method.

## **XI. OUTER SHEATH OF THE CABLE**

The outer sheath of the cable will be manufactured with the method of extrusion. Polyvinylchloride (PVC) and polyethylene of high density (HDPE), and of color grey, are considered as acceptable materials 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 or another one defined by IPTO.

## **XII. 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  $U_0 / U$  ( $U_{max}$ )
  - 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.

## **XIII. TESTS**

As far as the reliability of the manufacturer is concerned, the prequalification tests of the cables and their accessories at 400kV as well as the required routine, sample, type and after-installation tests, shall be executed according to the IEC-62067 standard.

### **Prequalification Cable Tests**

- A.** In order to evaluate the cable, it shall be covered by successful execution's certificate of the prequalification tests of the IEC-62067 standard, par. 13.

Cables whose manufacturer has no such certificate for cable systems of 400 kV nominal voltage at least (420 kV max), are not acceptable. The submission of the Tests in par. 13 of the IEC-62067 standard is mandatory.

- B.** The type tests shall be made before the manufacturer begins the continual production of the cable, according to par. 12 of the IEC-62067 standard. In case that the manufacturer decide the execution of the tests in parallel with the continual production of the cable, they take full responsibility for potential failure.
- C.** The routine tests shall be executed as it is prescribed in par. 9.1, 9.2, 9.3 and 9.4 and the sample tests in accordance to par. 10 of the IEC-62067 standard.
- D.** After-installation tests concerning the control of proper, safe and complete installation and operation of the cable system shall be executed as follows:
- a) Sheath DC voltage Testing according to par. 14.1 of the IEC-62067 standard.
  - b) Insulation AC Voltage Testing according to par. 14.2 of the IEC-62067 standard, with testing voltage 260 KV for 1h, accompanied by partial electrical discharges' measurement at the installed components. Alternatively, with testing voltage 220 V for 24h.

### **XIV. 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

## **XV. 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.

## **XVI. 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.
3. Detailed calculation of maximum short circuit current capability of the conductor for 1 sec and the metallic sheath of cable for 0.5 sec (IEC 60949).

# **TECHNICAL CHARACTERISTICS DATASHEET**

## **SINGLE CORE UNDERGROUND 400 kV CABLES**

### **WITH CROSS - LINKED POLYETHYLENE INSULATION (XLPE)**

#### **A. Conductor**

- |                                    |                       |
|------------------------------------|-----------------------|
| 1. Nominal conductor cross section | ..... mm <sup>2</sup> |
| 2. Conductor material              | .....                 |
| 3. Minimum outer diameter          | ..... mm              |
| 4. Maximum outer diameter          | ..... mm              |
| 5. Maximum 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**

##### 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 | .....     |

#### **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/m |

#### **D. Metallic sheath**

##### Sheath of smooth welded Al

1. Type of sheath material 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<sup>2</sup>
6. Material and data of the longitudinal protection against water and moisture .....  
.....  
.....

#### **E. Cable outer sheath**

##### HDPE 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 ( $X_L$ ) .....  $\mu\Omega/\text{km}$
- 4a. Positive sequence capacitance of cable at full load  $C_1$  .....  $\mu\text{F}/\text{km}$
- 4b. Zero sequence capacitance of cable  $C_0$  .....  $\mu\text{F}/\text{km}$
5. Maximum continuous circuit (3 cables) current based on the data of the study and the paragraphs V, VI, VII, VIII, IX, X, and XI, conductor temperature of 90° C and the metallic sheaths earthed at one end ..... A
6. Maximum continuous circuit (3 cables) current based on the data of the study and the paragraphs V, VI, VII, VIII, IX, X and XI, conductor temperature of 90° C and the metallic sheaths earthed at both ends ..... A
7. Maximum continuous circuit (3 cables) current based on the data of the study and the paragraphs V, VI, VII, VIII, IX, X and XI, conductor temperature of 90° C and the metallic sheaths cross earthed ..... A
8. Maximum continuous current for two parallel (6 cables) based on the data of the study and the paragraphs V, VI, VII, VIII, IX, X and XI,



conductor temperature of 90° C and the metallic sheaths earthed at one end	Circuit I..... A Circuit II.....A
9. Maximum continuous current for two parallel circuits (6 cables) based on the data of the study and the paragraphs V, VI, VII, VIII, IX, X and XI, conductor temperature of 90° C and the metallic sheaths earthed at both ends	Circuit I..... A Circuit II..... A
10. Maximum continuous current for two parallel circuits (6 cables) based on the data of the study and the paragraphs V, VI, VII, VIII, IX, X and XI, conductor temperature of 90° C and the metallic sheaths cross earthed	Circuit I..... A Circuit II..... A
11. Weight of the cable	..... kg/m
12. Minimum bending radius	..... m
13. Positive sequence impedance of one circuit (3 cables) ( $Z_1=R_1+jX_1$ )	..... $\mu\Omega/m$
14. Zero sequence impedance of one circuit (3 cables) ( $Z_0=R_0+jX_0$ )	..... $\mu\Omega/m$
15. Losses (for 3 cables)	
a. 100% of the load in continuous operation	
- In conductors	..... W/m
- In metallic sheaths	..... W/m
- dielectric	..... W/m
b. 50% of the load in continuous operation	
- In conductors	..... W/m
- In metallic sheaths	..... W/m
- dielectric	..... W/m
16. Losses (two circuits – 6 cables)	
a. 100% of the load in continuous operation	
- In conductors	..... W/m
- In metallic sheaths	..... W/m
- dielectric	..... W/m
b. 50% of the load in continuous operation	
- In conductors	..... W/m
- In metallic sheaths	..... W/m
- dielectric	..... W/m
17. Short circuit current capability	
- In the conductor	..... kA για 1sec
- In the sheath	..... kA για 0,5sec
18. Impulse withstand voltage (BIL)	..... kV
19. Maximum permissible pulling tension	..... N
20. Maximum permissible sidewall pressure	..... N
21. A.C 50 Hz voltage withstand for 30 min	..... kV
22. Does the offered cable meet the requirements of paragraphs XIII?	.....
23. Line resistance ( $\Omega/Km$ )	..... $\Omega/km$