INDEPENDENT POWER TRANSMISSION OPERATOR S.A.
TNPRD/ SUBSTATION SPECIFICATION & EQUIPMENT SECTION

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TECHNICAL DESCRIPTION TD-102/3
SINGLE CORE UNDERGROUND 400 kV CABLES
WITH CROSS - LINKED POLYETHYLENE INSULATION (XLPE)

I. SCOPE

This hereby technical description sets forth the required technical and constructional characteristics of single core underground 400 kV cables with cross- linked polyethylene insulation (XLPE) and aluminum conductor and also sets forth the required tests for the cables in question.

II. KEYWORDS

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

III. STANDARDS

The applicable standards for the cables shall be IEC 62067, IEC 60228 and IEC 60811, regarding the test methods and technical requirements. Their electrical characteristics will be calculated following IEC 60183, IEC 60287, IEC 60853 and IEC 61443.

IV. USE

The cables are to be used for the connection of 400/150/30 kV autotransformer or 400 kV reactor to the 400 kV buses.

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)	: 400 kV rms
2.	Maximum operating system Voltage	: 420 kV rms
3.	Basic Insulation Level (BIL) (Impulse level)	: 1550 kV crest
4.	Frequency	: 50 Hz
5.	Number of phases	: 3
6.	Short circuit level	: 40 kA
7.	Time duration of short circuit	: 1 s
8.	Method of earthing	: The 400 kV system is solidly earthed

VI. SOIL CHARACTERISTICS AND AMBIENT AIR TEMPERATURES

The cables are to be used in a soil which has the following characteristics:

1.	Soil thermal resistivity	: 1.2 Km/W
2.	Average soil temperature	: 20°C
3.	Soil temperature range	: +10° to +30° C
4.	Ambient air temperature range	: - 25 °C to 45°C

VII. INDICATIVE CABLE INSTALLATION METHOD

Details of the cable installation in to the soil:

1.	Number of circuits	:	One or two three-phase circuits
2.	Distance between circuits (middle phases)	:	about 1.20 m
3.	Cable arrangement in the soil	:	flat or trefoil formation
4.	Distance between phases in flat formation	:	about 0.40 m
5.	Laying depth	:	about 1.70 m
6.	Metallic sheath earthling method	:	At one or at both ends depending on circuit length and the Inquiry.

VIII. CABLE REQUIRED CHARACTERISTICS

1. Rated Voltage, $U_o/U(U_m)$	:	230/400(420) kV, where U_o= voltage (rms) between conductor and earth or metallic sheath, U= phase to phase rms value, U_m=maximum phase to phase voltage (rms)
2. Lightning impulse withstand voltage (1.2/50µs)	:	1550 kV peak
3. Switching impulse withstand voltage (250/2500µs)	:	1175 kV peak
3. AC 50 Hz voltage withstand for 60 min (IEC 62067)	:	580 kV rms
4. Components of the cable	:	The cable shall consist of the following parts: - Conductor - Semi-conducting layer for conductor - XLPE insulation, - Semi-conducting layer for shielding - Shielding - Semi-conducting tapes swelling in the presence of moisture - Outer sheath

IX. REQUIRED CHARACTERISTICS OF THE CABLE CONDUCTOR

1. Number of conductors	:	One (1)
2. Conductor material	:	Aluminium
3. Cross section of the conductor	:	according to the Inquiry
4. Conductor shape	:	Circular in shape, multi -wire 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 1 s, minimum

X. CABLE'S METALLIC SHEATH REQUIRED CHARACTERISTICS

1. Metallic sheath material	:	Lead alloy (for example lead alloy type E as per BS-801) or alternatively: - aluminium tape with copper wires - corrugated aluminium - smooth aluminium
2. Radial protection of the cable against water and moisture	:	The metallic sheath must provide radial protection against water and moisture, as well as mechanical and anti-corrosion protection.
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	:	40 kA for 0.5 s.

XI. 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 production with the triple extrusion method.

XII. OUTER SHEATH OF THE CABLE

The outer sheath of the cable will be manufactured with the method of extrusion. PVC of ST_2 type and polyethylene (PE) of ST_7 type are 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 extraction or with other method, which will be approved by IPTO.

XIII. 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 $U_o/U(U_m)$
   - Year of manufacturing
   - Contract number
   - Metallic sheath material

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.

XIV. TESTS

The prequalification tests, regarding the reliability of the cable and accessories manufacturer at 400kV voltage, as well as the routine, special, type and after installation tests shall be in accordance with IEC 62067.

A. In order for the cable to be evaluated, it shall be covered by a prequalification tests certificate of par.13, IEC 62067. Cable, for which its manufacturer does not possess the above mentioned certification for cable systems of 400kV rated voltage at least (420kV max) and lightning impulse withstand of 1550kV, will not be accepted. The submission of the test certificate of par.13, IEC 62067, is a prerequisite.

B. The type tests shall be executed before the cable industrialization, according par.12, IEC 62067. If the manufacturer decides to execute the type tests in parallel with the cable industrialization, it bears full responsibility in case of failure.

C. The routine tests will be executed according par.9 and the sample tests according par.10 of IEC 62067. All tests, mentioned in the above paragraphs, which refer to XLPE insulated cables, will be executed.

D. The tests after installation, which check the reliable and secure installation and operation of the cable system, will be executed according par.16 of IEC 62067, as follows:
   a. DC voltage test of the outer sheath.
   b. AC voltage test of the cable insulation with 260kV (phase-to-earth) test voltage for one (1) hour and 20Hz – 300Hz frequency. Alternatively, a voltage U_o=230 kV for 24 hours can be applied.

XV. 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

XVI. 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 attachment "A". He will also provide a detailed calculation 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, as well as calculations for the maximum continuous operating current for the installation conditions, according to the Inquiry. Offers which have not completely filled attachment "A" and the above calculations shall be rejected.
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.

XVII. 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, handling and installation of the cable.

XVIII. WARRANTY PERIOD

The supplier must provide a warranty period consisting of three (3) years beginning from the delivery date of the cable.

ATTACHMENT "A"

Failure to provide all information will result in rejection of the offer.

A. General

1. Manufacturer ……
……
2. Cable type ……
……
3. Rated voltage $U_0/U(U_m)$ ……kV

B. Conductor

1. Nominal conductor cross section ……..…..mm2
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

C. 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 ……

Shielding semi-conducting layer

6. Nominal thickness ..... mm
7. Minimum outer diameter ..... mm
8. Maximum outer diameter ..... mm
9. Specific electrical resistance ..... Ω.m
10. Material of the semi-conducting layer ……

D. Insulation

1. Material of the insulation .....
2. Nominal thickness ..... mm
3. Minimum outer diameter ..... mm
4. Maximum outer diameter ..... mm
5. Nominal dielectric stress at conductor (E_i) ..... kV/mm

6. Nominal dielectric stress at shielding (E_o) ..... kV/mm

E. Shielding wires (if existing)

1. Material ……
……
2. Nominal thickness ..... mm.
3. Minimum outer diameter ..... mm
4. Maximum outer diameter ..... mm
5. Tension strength .....N/mm^2

F. Metallic Sheath

1. 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 moisture protection .....
.....
7. Material and data of the radial moisture protection .....
.....

G. Cable outer sheath

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

H. Cable data

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)
trefoil installation ……..……Ω/km
flat installation, 400mm distance ……..……Ω/km
4. Nominal capacitance between conductor and shielding ……..……µF/km
5. Maximum continuous current for one circuit (3 cables)
conductor temperature of 90°C, trefoil installation and
the metallic sheaths earthed at both ends ……A
6. Maximum continuous current for one circuit (3 cables),
conductor temperature of 90°C, flat installation at 400mm
distance and the metallic sheaths earthed at both ends ……A
7. Positive sequence impedance of

one circuit (3 cables)

trefoil installation ……..……Ω/km

flat installation, 400mm distance ……..……Ω/km

8. Zero sequence impedance of
one circuit (3 cables)

trefoil installation ……..……Ω/km

flat installation, 400mm distance ……..……Ω/km

9. Losses of one circuit (3 cables)

- load losses at conductor and shielding (maximum continuous current)

trefoil installation ……..……..……W/m

flat installation, 400mm distance ……..……..……W/m

- dielectric (nominal voltage) ……..……..……W/m

10. Short circuit current capability

- for conductors ……..……kA for 1 s

- for the shielding ……...kA for 0.5 s

11. Impulse withstand voltage …...……...…kV

12. AC withstand voltage, 50Hz, 60min …...……...…kV

13. Weight of the cable .....kg/m

14. Minimum bending radius ……m

15. Maximum pulling tension ……..……daN

16. Does the offered cable meet the
requirements of paragraphs XI, XII, XIII? ……