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

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SPECIFICATION SS-140/10

0.6/1 (1.2) kV CONTROL AND POWER UNDERGROUND CABLES WITH PVC OR XLPE INSULATION AND PVC JACKET

I. SCOPE

Present specification covers the furnishing of 0.6/1 (1.2) kV multi-copper conductor, power and control cables to be used in open and closed type Substations switchyards.

II. INSULATION VOLTAGE

The nominal voltage between conductor and earth is 600 V and between conductors is 1000 V. The maximum operation voltage between conductors in normal conditions is 1200 V.

III. CHARACTERISTICS OF SYSTEM ON WHICH CABLES ARE TO BE USED

1. Kind of current
   Both alternating and direct current.

2. Nominal operating voltage
   In alternating current 400 V between phases and in direct current 220 V between conductors.

3. Frequency
   50 Hz for alternating current.

4. Grounding
   Neutral solidly grounded.

IV. DESCRIPTION OF INSTALLATION

Both in underground ducts and direct burial in ground.

V. CONDITIONS OF INSTALLATION

Ambient temperature: Minimum 0°C - Maximum 40°C.

VI. DESIGN REQUIREMENTS

The design and construction of the cables will follow IEC 60502-1.
The nominal area of the conductors in mm^2, the number of conductors per cable and number of strands per conductor are given in Table I and IA.

TABLE I

Cables with PVC/A insulation
Size of conductors - Insulation and Jacket thickness

CONDUCTORS						
Nominal area (mm^2)	**Conduc-tor number per cable**	**Number and diameter of wires (mm)**	**Nominal thickness of insulation (mm)**	**Approx. thickness of inner covering, lapped (extruded) (mm)**	**Nominal thicknes s of outer jacket (mm)**	**Approx. external cable diameter (mm)**
1.5	22	7 x 0.52	0.8	0.4 (1.0)	1.8	21.4
2.5	2	7 x 0.67	0.8	0.4 (1.0)	1.8	11.2
2.5	3	7 x 0.67	0.8	0.4 (1.0)	1.8	11.7
2.5	4	7 x 0.67	0.8	0.4 (1.0)	1.8	12.6
2.5	7	7 x 0.67	0.8	0.4 (1.0)	1.8	14.6
2.5	8	7 x 0.67	0.8	0.4 (1.0)	1.8	16.1
2.5	12	7 x 0.67	0.8	0.4 (1.0)	1.8	18.5
2.5	19	7 x 0.67	0.8	0.4 (1.0)	1.8	21.4
4	4	7 x 0.85	1.0	0.4 (1.0)	1.8	14.8
4	8	7 x 0.85	1.0	0.4 (1.0)	1.8	19.2
6	2	7 x 1.05	1.0	0.4 (1.0)	1.8	14.0
6	4	7 x 1.05	1.0	0.4 (1.0)	1.8	16.0
10	2	7 x 1.35	1.0	0.4 (1.0)	1.8	15.6
10	4	7 x 1.35	1.0	0.4 (1.0)	1.8	18.0
25+16	3 + 1	7 x 2.13 + 7 x 1.70	1.2 + 1.0	0.4 (1.0)	1.8	22.9
35+16	3 + 1	7 x 2.52 + 7 x 1.70	1.2 + 1.0	0.4 (1.0)	1.8	24.8
50	2	19 x 1.83	1.4	0.4 (1.0)	1.8	26.0
50	4	19 x 1.83	1.4	0.4 (1.2)	1.9	30.8

CONDUCTORS						
Nominal area (mm^2)	**Conduc-tor number per cable**	**Number and diameter of wires (mm)**	**Nominal thickness of insulation (mm)**	**Approx. thickness of inner covering, lapped (extruded) (mm)**	**Nominal thicknes s of outer jacket (mm)**	**Approx. external cable diameter (mm)**
50+25	3 + 1	19x 1.83 + 7x 2.13	1.4 + 1.2	0.4 (1.0)	1.9	29.0
95+50	3 + 1	19x2.52 + 19x1.83	1.6 + 1.4	0.4 (1.2)	2.2	37.4
120+70	3 + 1	37x2.03 + 19x2.17	1.6 + 1.4	0.4 (1.4)	2.3	41.0
300	1	61x 2.50	2.4	0.4 (1.0)	1.9	28.9

T A B L E IA

Cables with XLPE insulation
Size of conductors - Insulation and Jacket thickness

CONDUCTORS						
Nominal area (mm^2)	**Conduct or number per cable**	**Number and diameter of wires (mm)**	**Nominal thickness of insulation (mm)**	**Approx. thickness of inner covering, lapped (extruded) (mm)**	**Nominal thicknes s of outer jacket (mm)**	**Approx. external cable diameter (mm)**
25+16	3 + 1	7 x 2.13 + 7 x 1.70	0.9 + 0.7	0.4 (1.0)	1.8	21.4
35+16	3 + 1	7 x 2.52 + 7 x 1.70	0.9 + 0.7	0.4 (1.0)	1.8	23.4
50	2	19 x 1.83	1.0	0.4 (1.0)	1.8	24.4
50	4	19 x 1.83	1.0	0.4 (1.0)	1.9	28.8
50+25	3 + 1	19x 1.83 + 7x 2.13	1.0 + 0.9	0.4 (1.0)	1.8	27.1
95+50	3 + 1	19x2.52 + 19x1.83	1.1 + 1.0	0.4 (1.2)	2.1	35.0
120+70	3 + 1	37x2.03 + 19x2.17	1.2 + 1.1	0.4 (1.2)	2.2	39.5
300	1	61x 2.50	1.8	0.4 (1.0)	1.8	27.6

T A B L E Ⅱ

Colour sequence for control cables

CONDUCTOR NUMBER	COLOURS	
	Base Colour	Tracer
1	Black	
2	White	
3	Red	
4	Green	
5	Orange	
6	Blue	
7	White	Black
8	Red	Black
9	Green	Black
10	Orange	Black
11	Blue	Black
12	Black	White
13	Red	White
14	Green	White
15	Blue	White
16	Black	Red
17	White	Red
18	Orange	Red
19	Blue	Red
20	Green	Red
21	Blue	Green
22	Orange	Blue

T A B L E Ⅱ A

Colour sequence

CONDUCTOR	COLOURS
Phase A	Brown
Phase B	Black
Phase C	Grey
Neutral (N)	Light Blue
Earth Wire	Green/Yellow

For low-voltage power cables, color coding conforming to the HD 308 S2 standard is also accepted

a) Conductors

Conductors shall be circular of annealed, uncoated (plain) copper, stranded, of class 2 according to IEC 60228, as specified in Table I and IA.

b) Insulation

Each stranded and uncoated copper conductor shall be insulated with PVC/A of nominal thickness as outlined in Table I. For cables with area greater or equal to 25 mm^2, the insulation will be made alternatively with XLPE, if this is explicitly mentioned in the inquiry, as outlined in Table IA. Maximum copper temperature in normal operation is to be taken at 70°C for PVC/A insulation and at 90°C for XLPE insulation.

After the insulation coating and before the integration in cable, each conductor will pass through a spark-testing device, according to standard IEC 62230, to ensure that there is no fault in the insulation.

c) Cabling and Assembly

Individual conductors shall be cabled together to give a round core.

d) Conductor identification in control cables

Colour coding by pigmenting insulation of conductor or otherwise specified by the bidder, according to the Table II.

e) Conductor identification in power cables

Colour coding by pigmenting insulation of conductor, according to the Table IIA. For two (2) conductor cables, the colours of phase A and neutral will be implemented.

f) Inner covering and filler

Above the insulation and below the concentric conductor, an inner covering of extruded or lapped manufacture shall be applied. In case of lapped manufacture and up to five conductors per cable, low moisture absorbent filler shall be also employed internally. The approximate thickness of the inner covering is mentioned in Tables I and IA for lapped and extruded material (extruded in brackets).

For conductor area > 10mm^2, the inner covering can be avoided, if this is the standard design of the manufacturer. In cables without inner covering, the special bending test, as in par.VII.C.m, is obligatory.

g) Concentric tape conductor

In order that present cables resist against rodent or insect damage, a concentric conductor under the jacket and over all conductors should be provided, which will be constructed from copper tape of 0.1 mm nominal thickness with galvanic continuity trough all cable length.

h) Outer jacket

Outer jacket must be provided for the cables. The jacket will be made from flame retardant PVC-ST_1 for PVC conductor insulation and PVC-ST_2 for XLPE conductor insulation.

The jacket colour will be black. The nominal thickness of the jacket, as well as the approximate total cable diameter is given in Table I and IA.

VII. INSPECTION AND TESTS

All material shall be subject to inspection and must not be shipped without release from IPTO's representative. Release of material shall not relieve the Manufacturer from the responsibility of furnishing material to conform to requirements of the order nor invalidate any claim which IPTO may make because of defective or unsatisfactory material. The cable Manufacturer shall provide adequate facilities to IPTO's representative to test and inspect the manufacture and packing of all material.

The Manufacturer is obliged to inform IPTO of the progress of work in his shops and shall advise him as to the expected dates of completion, and the progress of work should be clearly indicated in order that inspection and witnessing of test may be scheduled without delay.

Copies of manufacturer's test reports shall be furnished to IPTO as requested. Apart of these reports, all test certificates of the materials (conductors, polymer materials) used for the cable construction shall be submitted.
These reports shall be certified as correct by a responsible representative of the Manufacturer.

All cable tests must follow the standard IEC 60502-1. The tests of the non metallic cable materials shall be executed according the standards of IEC 60811 series, while the acceptance criteria will follow the standard IEC 60502-1.

All existing test reports for every offered cable type shall be included in the bid.

A. ROUTINE TESTS

Routine tests will be performed at every produced cable length.
The following tests will be performed:

a. DC resistance of all cable conductors

The DC resistance at 20°C must not exceed the resistance mentioned in standard IEC 60228.

b. Voltage test

Voltage equal to 1.8 kV AC or 4.3 kV DC will be applied for continuous duration of 5 min between each insulated conductor and any other conductor, including the concentric conductor of the cable.

B. SAMPLE TESTS

One (1) cable sample for each type and production lot shall be obtained, for the execution of tests (a) and (b). If the production lot includes above 10000m or 20000m from a cable type, then two (2) or three (3) cable samples will be respectively obtained from this cable type.
For XLPE insulated cables, equal number of samples as above will be obtained, in order test (c) to be executed.

a. Examination of all cable conductors
The construction and the diameter of the conductors, as well as the conductor strands shall follow the standard IEC 60228 and Tables I and IA.

b. Examination of thickness of all non-metallic and metallic cable sheaths
The thickness of the conductor insulation will be measured according to IEC 60822-201, of the concentric conductor, of the outer jacket according to IEC 60811-202, as well as the total cable diameter according IEC 60811-203. The measurement values will be compared with the values in Tables I and IA, following the standard IEC 60502-1 for cable acceptance.

c. Hot-set test for XLPE insulation
The test will be performed according to the standard IEC 60811-507. The test conditions and the acceptance criteria are included in standard IEC 60502-1.

C. TYPE TESTS

The type tests shall be executed, submitted to IPTO and be accepted by it, before the construction of the cable length to be delivered. If the same tests have been executed to the same cable type for a previous contract with IPTO, before less than five years, then test repeating is not necessary.

Electrical tests on insulated cable conductors:
according to IEC 60502-1

a. Insulation resistance measurement at ambient temperature.
b. Insulation resistance measurement at maximum conductor temperature
c. Voltage test for 4h

Non-electrical tests for non-metallic materials:

a. Sheaths thickness measurement (according to IEC 60811-201, -202)
b. Mechanical properties measurement without aging (according IEC 60811-501)
c. Mechanical properties measurement after aging (according IEC 60811-401, -501)
d. Mechanical properties measurement in cable pieces after aging (according to IEC 60811-401, -501)
e. Hot pressure test (IEC 60811-508)
f. Mechanical properties test at low temperature (according IEC 60811-504, -505, -506)
g. Loss of mass of PVC (ST_2 type) at high temperature (according IEC 60811-409)
h. Resistance to cracking after heat shock (according to IEC 60811-509)
i. Hot set test (according to IEC 60811-507)
j. Flame retardance test (according to IEC 60332-1-1, -1-2, -1-3)
k. Water absorption test on insulation (according to IEC 60811-402)
l. Shrinkage test for XLPE insulation (according to IEC 60811-502)
m. Special bending test (according to IEC 60502-1)

Tests (a), (b), (c), (d), (e), (f), (h), (k) are applied to PVC/A insulation. Tests (a), (b), (c), (d), (i), (k), (l) are applied to XLPE insulation. Tests (a), (b), (c), (d), (e), (f), (h), (j) are applied to PVC (ST_1) outer jacket. Tests (a), (b), (c), (d), (e), (f), (g), (h), (j) are applied to PVC (ST_2) outer jacket. Test (m) is required only for cables without inner covering.

VIII. DATA TO BE SUPPLIED BY BIDDER

Bidders shall submit to Buyer the following data:

a) complete description of Mechanical and Electrical Properties of insulating material, covering jacket) material, fillers etc., to be used in manufacturing of the specified cables.

b) The effective (ac) resistance at 25°C and the reactance of the proposed cable.

c) Thickness of insulation, protective copper tape and jacket.

d) Type of fillers, and tape.

e) Overall diameter of the cable.

f) The cable weight per linear meter.

g) In the Bidder's proposal the construction and tests standards applied for the specified cables should be stated, and copies of the proposed standards must be submitted.

h) Minimum bending radius.

i) Test report for the tests mentioned above.

j) Any proposed departure from present specifications and the reasons, therefore.

IX. REELS

1. The cables shall be shipped on substantial non-returnable wood-reels.

2. The reels shall be delivered with maximum length of the cables 1000m and with minimum length of 500m and total weight less than 3 tones.

3. The reels should be brand new, of robust construction, covered in their entire perimeter, without voids, by wooden boards of 20mm thickness and capable of withstanding the mechanical stressed exerted during the handling and transportation of the cable.

4. The above mentioned covering of the reels should be performed after the inspection by IPTO's representative.

X. SEALING AND PACKING OF CABLES

The cables should be placed on reels in such a way that they will be protected from injury during shipment. Each end of cable shall be firmly and properly secured to the reel.
Each end of each length of cable shall be hermetically sealed and positively fixed on the reel before shipment.

XI. MARKING OF REELS

Each reel shall be marked as follows:

a) On both lateral vertical sides of each reel shall be plainly indicated in indelible ink, not on a tag, the following: the Purchaser's order number, length of the shipped cable on the reel (LENGTH:…), number and cross-section of the cable's conductors, as well as the cable's voltage rating. It will be also indicated the length count at the beginning of the cable, either this is zero (0 m) or not (BEGINNING:…).
Also, a shipping tag giving the same information shall be attached to the outer end of the cable beneath the reel legging.

b) With an arrow and suitable wording stenciled on the end to indicate which way it should be rolled.

c) Each reel should be branded with a serial number.

CABLE MARKINGS

The cables must bear on their outer sheath the following markings:

- Manufacturer's trademark.
- Cross-section of the conductors.
- Insulation material.
- Rated voltage.
- Year of manufacturing.
- Contract number.

Furthermore, the outer cable sheath shall bear indication of the progressive length count per meter length for each reel, which should start at zero and end at length equal to the length indicated on the reel's tag.

The indication must be indelible written with relief characters/numerals. The space between the end of one indication and the beginning of the next one must be equal to one (1) meter.