



# SPECIFICATIONS FOR 132KV AND 33KV SINGLE CORE XLPE INSULATED COPPER CABLES AND ACCESSORIES

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## SPECIFICATIONS FOR 132KV AND 33KV SINGLE CORE XLPE INSULATED COPPER CABLES AND ACCESSORIES

### FOREWORD

This specification has been prepared by the Research and Development Department in collaboration with Infrastructure turnkey Department both of The Kenya Power and Lighting Company Limited (KPLC) and it lays down requirements for 33kv and 132kv single core XLPE Insulated copper cables and their accessories, It is intended for use by KPLC in sourcing for XPLE single core insulated copper cables.

The manufacturer shall submit information which confirms satisfactory service experience with products which fall within the scope of this specification.

#### 1. SCOPE

This specification is for single core XLPE Insulated copper cables and their accessories for operation at 50Hz ac voltages of 19.05Kv and 76.2kV between any conductor and sheath or earth, 33Kv and 132kV between phase conductors and maximum sustained power frequency voltage between phase conductors of 36Kv and 145kV.

The specification also covers inspection and test of the cables and their accessories as well as schedule of Guaranteed Technical Particulars to be filled, signed by the manufacturer and submitted for tender evaluation.

The specification stipulates the minimum requirements for 33Kv and 132kV single core XLPE insulated copper cables and their accessories acceptable for use in the company and it shall be the responsibility of the Manufacturer to ensure adequacy of the design, good workmanship and good engineering practice in the manufacture of the cables for KPLC.

The specification does not purpose to include all the necessary provisions of a contract.

#### 2. REFERENCES

The following standards contain provisions which, through reference in this text constitute provisions of this specification Unless Otherwise stated, the latest editions (Including amendments) apply.

IEC 60840: Power cables with extruded insulation and their accessories for rated voltages above 30kV ( $U_m=36k$  up to 150kV ( $U_m=170kV$ ) – Test methods and requirements.

IEC 60228:	Conductors of insulated cables.
IEC/TS 60859:	Cable connections for gas-insulated metal-enclosed switchgear for rated voltages of 72,5 kV and above - Fluid-filled and extruded insulation cables - Fluid-filled and dry type cable-terminations
IEC 60332-3:	Tests on electric cables under fire conditions - Part 3: Tests on bunched wires or cables
IEC 60332-3-10:	Tests on electric and optical fibre cables under fire conditions - Part 3-10: Test for vertical flame spread of vertically-mounted bunched wires or cables - Apparatus
IEC 60332-1-1:	Tests on electric and optical fibre cables under fire conditions - Part 1-1: Test for vertical flame propagation for a single insulated wire or cable – Apparatus
IEC 60332-1:	Tests on electric cables under fire conditions - Part 1: Test on a single vertical insulated wire or cable
IEC 61034-1:	Measurement of smoke density of cables burning under defined conditions - Part 1: Test apparatus
IEC 61034-2:	Measurement of smoke density of cables burning under defined conditions - Part 2: Test procedure and requirements
IEC 60754-1:	Test on gases evolved during combustion of materials from cables - Part 1: Determination of the amount of halogen acid gas
IEC 60754-2:	Test on gases evolved during combustion of electric cables - Part 2: Determination of degree of acidity of gases evolved during the combustion of materials taken from electric cables by measuring pH and conductivity

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### **3. TERMS AND DEFINITIONS**

For the purpose of this specification the definitions given in the reference standards shall apply.

### **4. REQUIREMENTS**

#### **4.1 SERVICE AND SYSTEM CONDITIONS**

The cables and accessories shall be suitable for the following service conditions and applications:

#### 4.1.1 Cable Application

- a) The cable shall be a transmission cable for use in outdoors installations and tropical conditions (temperature range of  $-1^{\circ}\text{C}$  to  $+40^{\circ}\text{C}$ , humidity of upto 95%, saline conditions and altitudes of upto 2200m above sea level).
- b) The cable shall be suitable for laying in cable ducts and directly in the ground in switching stations, between stations and underground to overhead conversion.
- c) The cable shall also be suitable for laying on slopes.
- d) Permissible continuous loading operating temperature shall be  $90^{\circ}\text{C}$ .
- e) Permissible emergency loading temperature shall be  $130^{\circ}\text{C}$  for at least 8 hours. Permissible short circuit temperature shall be  $250^{\circ}\text{C}$  (for short-circuit duration of 5s as per IEC 60840).

4.1.2 The cables shall be connected to underground system operating at a nominal voltage of 33KV and 132kV, 50Hz and maximum system voltage of 36kV and 145kV and are solidly earthed at the transformer neutrals. The short circuit level shall be taken as 31.5kA 3s.

4.1.3 The cables and accessories shall have suitable anti-termite protection to be approved by KPLC.

4.1.4 The cable shall have an oversheath with a fire performance that conforms to the requirements of: EC 60332-1 (Fire), IEC 60332-3A (Fire), EC 61034 (Smoke) and IEC 60754 (Minimal Halogen).

4.1.5 The cable and accessories shall be designed for reliable service life of at least 40 years.

## 4.2. MATERIALS AND CONSTRUCTION

4.2.1.1 The cable shall be designed and manufactured to IEC 60840, IEC 60228, other applicable IEC standards listed in clause 2 and the requirements of this specification.

4.2.1.2 All materials used shall be compatible and suitable for the continuous operating temperature of the cable of  $90^{\circ}\text{C}$  and short circuit temperature of  $250^{\circ}\text{C}$  (5 seconds duration).

### 4.2.2. Conductor

The cable shall be made from stranded circular plain copper conductors that conform to IEC 60228.

#### **4.2.3. Conductor Screen**

4.2.3.1 A conductor screen consisting of an extruded layer of cross-linkable semi-conducting compound shall be applied over the conductor and cover the surface of the conductor completely.

4.2.3.2 The extruded conductor screen shall be applied in the same operation as the insulation and be fully bonded to the insulation.

#### **4.2.4. Insulation**

4.2.4.1 The insulation shall be cross-linked polyethylene (XLPE) conforming to the requirements of IEC 60840.

4.2.4.2 The insulation shall be applied by extrusion and cross-linked to form a compact and homogeneous layer.

4.2.4.3 The colour of the insulation shall be such that it is easily distinguishable from the screening materials.

#### **4.2.5. Insulation Screen**

4.2.5.1 There shall be an insulation screen consisting of a cross-linked extruded semi-conducting layer in combination with a metallic layer.

4.2.5.2 The extruded semi-conducting layer shall consist of a strippable semi-conducting compound capable of removal for jointing and terminating. It shall be applied in the same operation as the insulation, directly over the insulation and shall cover the surface of the core completely.

4.2.5.3 A metallic screen shall be applied around the core. The screen shall consist of helically applied overlapped copper tape.

#### **4.2.6. Water Barriers**

Water barriers shall be provided to prevent water penetration between and along the various layers in the cable. A water impermeable barrier around the cable and longitudinal water barriers are required.

#### 4.2.7. Metallic Sheath

There shall be a seamless metallic sheath consisting of corrugated aluminium. The metallic sheath shall be impervious to water and shall be capable of carrying the earth fault current without exceeding 250°C.

The grain size of the sheath shall be uniform and the sheath shall exhibit no marked change after application, installation or in-service, particularly under extended periods of operation at elevated temperatures or under repeated cyclic variations of load.

In addition the metallic sheath shall provide a radial watertight barrier to the ingress of moisture into the extruded cable core, provide protection against minor accidental damage caused by third party interference with the cable during installation or service, provide low resistance path for cable charging current and be capable of sustaining the specified earth fault currents for the time stipulated.

#### 4.2.8. Over sheath

4.2.8.1 There shall be an extruded over sheath of suitable material for intended service conditions in 4.1.1.

4.2.8.2 The cable shall be embossed with the information required by IEC 60840 and with the following information throughout the length of the over sheath.

- (i) 132000 VOLTS XLPE POWER CABLE PROPERTY OF KPLC
- (ii) 33000 VOLTS XLPE POWER CABLE PROPERTY OF KPLC
- (iii) Name of manufacturer;
- (iv) Year of manufacture;
- (v) The number of cores, type and nominal area of conductors;

Letters and figures shall be raised and consist of upright block characters. Minimum size of characters shall be not less than 15% of average overall cable diameter and the distance between one set of markings and the next shall not exceed 500mm. All markings shall be clear and permanent. An indelible marking shall also be given at every one meter interval to assist field personal in cutting required length.

#### 4.3. STANDARD SIZES AND CHARACTERISTICS

4.3.1 The standard sizes and characteristics of the cables shall be as follows:

Conductor nominal cross-sectional area	mm <sup>2</sup>	185	300	400	630	800
Voltage Designation U <sub>o</sub> /U(U <sub>m</sub> )	kV	19.05/33(36)				
Voltage Designation U <sub>o</sub> /U(U <sub>m</sub> )	kV	76.2/132(145)				
Conductor shape	Stranded, compacted round					



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Maximum resistance of conductor at 20oC	Ω/km	0.0991	0.060	0.047	0.0283	0.0221
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**Note:** *The thickness of insulation, thickness of metallic sheath, thickness of oversheath, minimum bending radius of cable, weight per km and the current carrying capacity of the cable underground and in air shall be stated by the manufacturer in the Guaranteed Technical Particulars as per Annex A. The declared values shall be verified during factory testing as per IEC 60840.*

4.3.2 The test voltages shall be as per IEC 60840.

**4.4. QUALITY MANAGEMENT SYSTEM**

4.4.1 The bidder shall submit a quality assurance plan (QAP) that will be used to ensure that the cable design, material, workmanship, tests, service capability, maintenance and documentation, will fulfil the requirements stated in the contract documents, standards, specifications and regulations. The QAP shall be based on and include relevant parts to fulfil the requirements of ISO 9001:2008.

4.4.2 The Manufacturer's Declaration of Conformity to reference standards and copies of quality management certifications including copy of valid and relevant ISO 9001: 2008 certificate shall be submitted with the tender for evaluation.

4.4.3 The bidder shall indicate the delivery time of the cables and accessories, manufacturer's monthly & annual production capacity and experience in the production of the type and size of cable being offered. A detailed list & contact addresses (including e-mail) of the manufacturer's previous customers outside the country of manufacture for exact or similar rating of cables sold in the last five years shall be submitted with the tender for evaluation.

**4.5. CABLE ACCESSORIES**

**4.5.1 General Requirements for Cable Accessories**

Cable accessories for the single core cables covered by this specification shall satisfy all the requirements of IEC 60840 and the following:

- a) Shall be designed and manufactured to ensure that all components and materials shall be suitable for use in the specified service conditions.
- b) The components and materials shall be manufactured to ensure high moisture sealing capacity, resistance to fungal and insect attack.
- c) Shall be supplied complete with all components necessary for intended application.

- d) Provide the necessary level of insulation and stress control.
- e) Electrically connect/terminate the conductor specified.
- f) Shall provide resistance to tracking and erosion of the material.
- g) Ensure the integrity of the cable with regard to water imperviousness/tightness and current carrying capabilities.
- h) Specialized tools that are required during the installation of the accessories shall be stated and the costs quoted for separately.
- i) Outdoor terminations shall be of specific creepage distance of at least 31mm/kV.
- j) The accessories shall be complete with installation procedures and instructions all in English language.

#### **4.5.2 Outdoor Terminations**

Termination insulators shall be manufactured from Porcelain materials and all materials shall be fully factory tested during production. In accordance with IEC 60815 the pollution level specified is 'very heavy'.

The stress control method must allow for the thermal expansion of the cable and the tenderer must state how this is achieved. The sealing ends shall be filled with high viscosity polyisobutylene, silicone oil, or equivalent and expansion devices shall be provided where necessary.

Corona shields and arcing rings or horns shall be provided at the top of each open type termination and a horn or ring at the base. The base itself shall be insulated from supporting steelwork by mounting upon porcelain pedestal type insulators.

#### **4.5.3 Gas Immersed Terminations**

Gas immersed terminations at the SF6 switchgear shall comply with the requirements of the latest version of IEC 60859. The Supplier shall demonstrate that terminations meet the mechanical loading of IEC60859. The terminations may be of "dry type" or "wet type" construction, containing an epoxy resin insulator and an elastomeric stress cone. The insulator shall have a blind-ended construction to eliminate the possibility of SF6 gas leaking into the cable termination via the conductor connection.

The cable glands of the sealing ends shall be insulated from the SF6 switchgear, and transformers.

#### **4.5.4 Transformer Terminations**

The terminations may be of "dry type" or "wet type" construction, containing an epoxy resin insulator and an elastomeric stress cone. The insulator shall have a blind-ended construction to eliminate the possibility of transformer oil leaking into the cable termination via the conductor connection.



The cable glands of the sealing ends shall be insulated from the transformers.

The cable manufacturer will liaise fully with KPLC to ensure that the cable sealing ends will interface correctly with the transformer.

#### **4.5.5 Straight Joints**

The conductor connection will be made using a compression ferrule.

The following types of joint only will be considered for offer;

- Premoulded One – Piece
- Extrusion Moulded
- Prefabricated Three – Piece

The design of joint will accommodate insulation retraction and expansion.

The design of joint will include an internal partial discharge (PD) sensor.

The joint shall be provided with a copper joint shell suitable for a metallic seal to the extruded metallic sheath of the cable.

Cable joints buried in the ground shall be enclosed in a fibreglass casing and the space between the joint and casing shall be completely filled with bituminous compound of approved grade. Alternative methods of insulating and protecting the joint e.g. heat shrink sleeve, rubber tape, may be offered subject to demonstration of development tests and type tests.

## **5. TESTS AND INSPECTION**

5.1 The cable system, cable and accessories shall be inspected and tested in accordance with the requirements of this specification, IEC 60228, IEC 60840 and other applicable IEC standards listed in clause 2. It shall be the responsibility of the manufacturer to perform or to have performed all the relevant tests.

5.2 Copies of previous type test reports and type test certificates by the relevant International or National Testing/Standards Authority of the country of manufacture (or ISO/IEC 17025 accredited independent laboratory) shall be submitted with the offer for evaluation. A copy of accreditation certificate for the laboratory shall also be submitted (all in English Language).

5.3 Test reports to IEC 60840 for the cables and accessories to be supplied shall be submitted to KPLC for approval before shipment of the goods. KPLC Engineers (2) will witness the following tests (to IEC 60840) at the factory before shipment:

- a) Conductor examination
- b) Measurement of electrical resistance of conductor
- c) Measurement of thickness of insulation and overshooth
- d) Measurement of thickness of metallic sheath
- e) Measurement of diameters
- f) Hot set test for XLPE
- g) Measurement of capacitance
- h) Partial discharge test
- i) Voltage test
- j) Bending test followed by partial discharge test
- k) Tan delta measurement
- l) Heating cycle voltage test followed by partial discharge measurement
- m) Impulse withstand test followed by a power frequency voltage test
- n) Tests on accessories.

The above tests shall be carried out in accordance with IEC 60840 and this specification.

As per IEC 60840, if the sample from any length selected for the tests fails in any of the tests above, further samples shall be taken from two further lengths of the same batch and subjected to the same tests as those in which the original sample failed. If both additional samples pass the tests, the other cables in the batch from which they were taken shall be regarded as having complied with the requirements of this specification. If either fail, this batch of cables shall be regarded as having failed to comply and shall be rejected.

During acceptance testing, the manufacturer shall demonstrate that the accessories are mechanically and electrically fit for the cable offered. The accessories shall be tested to IEC 60840.

- 5.4 During delivery of the cables and their accessories, KPLC will inspect them and may perform or have performed any of the relevant tests in order to verify compliance with the specification. The manufacturer shall replace/rectify without charge to KPLC, cables/accessories which upon examination, test or use fail to meet any or all of the requirements in the specification.

## **6. MARKING, PACKING AND INSTRUCTIONS**

- 6.1 The finished cable shall be wound on metallic drum such as to prevent damage during transportation and handling. The drums shall be protected against corrosion.

- 6.2 The actual length of cable shall not be less than the length indicated on the drum.
- 6.3 Both ends of every drum length of cable shall have been sealed (with end caps) to prevent the ingress of water during transportation, storage, handling and installation. Both ends shall be secured to the drum to prevent mechanical damage.
- 6.4 The following information shall be marked legibly and in a permanent manner on the flange of the drum:
- a) The manufacturer's name;
  - b) The type and rating of cable;
  - c) The conductor cross-sectional area in mm<sup>2</sup>;
  - d) The length of the cable, in metres;
  - e) The year of manufacture;
  - f) The gross mass and net mass, in kilogram;
  - g) The instructions for handling and use (in English Language);
  - h) The words "**PROPERTY OF KENYA POWER & LIGHTING CO.**"

***Note: The cable itself shall have been marked in accordance with clause 4.2.8.2***

- 6.5 Each accessory shall be marked with information required by IEC 60840.

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**SPECIFICATIONS FOR 132KV AND 33KV SINGLE CORE XLPE INSULATED COPPER CABLES AND ACCESSORIES**

**ANNEX A: Guaranteed technical schedule** (to be filled and signed by the Manufacturer and submitted together with the bid for tender evaluation)

**Tender No.**.....

Description		Bidder's offer
1	Manufacturer	
	Country of manufacture	
2	Service Conditions & application	
3	Applicable Standard(s)	
4	Type and design	
5	Conductor	
6	Conductor screen	
7	Insulation	Material
		Nominal Thickness
		Minimum Thickness
		Nominal overall diameter
		Max continuous operating temperature
		Compound identification reference
8	Insulation screen	
9	Water barriers	
10	Metallic sheath	Type and Material
		Nominal Thickness
		Minimum thickness
		Nominal diameter over screen
		Cross sectional area of the screen
		Short time current density (1sec)
11	Oversheath	Material
		Anti-termite protection
		Fire Resistance
		Marking
12	<b>RATINGS/CHARACTERISTICS</b>	
	Conductor nominal cross-sectional area	
	Voltage designation U <sub>0</sub> /U(U <sub>m</sub> )	
	Conductor shape	
	Thickness of insulation	
	Thickness of screening materials	
	Thickness of metallic sheath	
	Thickness of oversheath	



**SPECIFICATIONS FOR 132KV AND 33KV SINGLE CORE XLPE INSULATED COPPER CABLES AND ACCESSORIES**

	Maximum conductor resistance at 20°C		
	Maximum conductor ac resistance at 90°C		
13	Current carrying capacity	Underground (state conditions) In air (state conditions)	
14	Impulse withstand voltage and power frequency withstand voltage for cable		
15	Impulse withstand voltage and power frequency withstand voltage for cable terminations		
16	Minimum bending radius of cable		
17	Weight per km (kg/km)		
18	Cable accessories (type & design)		
19	Test Voltages (list all as per IEC 60840)		
20	Quality Assurance Program		
21	Copy of ISO 9001:2008 submitted		
22	List of Type Test Reports submitted (indicate Test Report Numbers)		
23	List of Tests to be witnessed by KPLC Engineers at the factory before shipment		
24	Marking on cable (parameters to be indicated and method of marking)		
	Marking on accessories (parameters to be indicated and method of marking)		
	Marking on cable drum (parameters to be indicated and method of marking)		
	Packing	Type of drum Length of cable on drum	
	Installation and technical manuals to be provided during delivery		
25	List of catalogues, brochures, drawings, technical data and customer sales records submitted to support the offer.		
26	Statement of compliance and or deviations from Tender Specifications		
27	Inspection/test by KPLC during delivery before acceptance to stores/site		

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**Manufacturer's Name, Signature, Stamp and Date**