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Kenya Power

ALUMINIUM CONDUCTOR COMPOSITE CORE (ACCC) — SPECIFICATION

A Document of the Kenya Power & Lighting Company Plc.

January 2024

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0.1 Circulation List

COPY NO.	COPY HOLDER
1	Manager, Standards
Electronic copy (pdf) on Kenya Power server (http://172.16.1.40/dms/browse.php?fFolderId=23)	

REVISION OF KPLC STANDARDS

In order to keep abreast of progress in the industry, KPLC standards shall be regularly reviewed. Suggestions for improvements to approved standards, addressed to the Manager, Standards Department, are welcome.

0.2 Amendment Record

Rev No.	Date (YYYY-MM-DD)	Description of Change	Prepared by (Name & Signature)	Approved by (Name & Signature)
Issue No. 1 Rev. No. 0	2024-01-09	New	Eng. B. Dianga Rotich Benard	Dr. Eng. P. Kimemia

FOREWORD

This specification has been prepared by the Standards Department in collaboration with Transmission Network, both of the Kenya Power and Lighting Company Limited, and it lays down requirements for Energy Efficient High Ampacity Aluminum Conductor Composite Core (ACCC) Conductors herein called 'conductors'.

This is necessitated by the need for efficiency and increased current carrying capacity conductors to deliver more power with less losses on equal conductor size and weight.

In this specification for high ampacity conductors, the core shall be created by a pultrusion process (uni-directional) composite, wherein all of glass and carbon fibers run parallel and shall offer the tensile strength required for overhead conductors running over long span distances; highways ,rivers and between mountain peaks.

This specification stipulates the minimum requirements for ACCC acceptable for use in the company and it shall be the responsibility of the suppliers and manufacturer to ensure that the offered design is of the highest quality and guarantees excellent service to KPLC, good workmanship and good engineering practice in the manufacture of the Aluminium Conductor Composite Core for KPLC.

Users of this KPLC specification are responsible for its correct interpretation and application.

The following are members of the team that developed this specification:

Name	Division
Eng. Benson Dianga	Standards
Eng. Dedan Njoroge	Transmission
Rotich Benard	Standards

1. SCOPE

The specification is for Aluminium Conductor Composite Core (ACCC) conductors for use in overhead power lines of voltage above 10kV, and covers the following conductor sizes:

a) 223mm² Aluminium Conductor Composite Core (ACCC)
b) 236mm² Aluminium Conductor Composite Core (ACCC)
c) 421mm² Aluminium Conductor Composite Core (ACCC)

2. NORMATIVE REFERENCES

The following standards contain provisions, which, through reference in this text, constitute provisions of this specification. Unless otherwise stated, the latest edition of the referenced documents (including any amendments) applies

ISO 10119:	Carbon Fibers- Determination of densities.
ASTM B857:	Standard specification for shaped wire compact concentric lay stranded Aluminium Conductors, Coated Steel Supported (ACSS/TW).
ASTM B609:	Standard specification for Aluminium 1350 round wire annealed and intermediate Temper for Electrical Purpose.
ISO/IEC 17025:	General requirements for the competence of testing and calibration laboratories.
IEC 61010-1:	Safety requirements for electrical equipment for measurement, control and laboratory use.
IEEE 738:	Standard specification for Calculating the Current-Temperature of Bare Overhead Conductors.
ASTM B987-20:	Standard Specification for Carbon Fiber Composite Core (CFC) for Use in Electrical Overhead Conductors.
ASTM B609:	Standard specification for Aluminium 1350 round wire annealed and Intermediate Temper for Electrical Purposes.
ASTM B557:	Standard Test Methods of Tension Testing Wrought and Cast Aluminum- and Magnesium-Alloy Products.
ASTM B1008:	Standard Test Method for Stress-Strain Testing for Overhead Electrical Conductors.
ASTM B193:	Standard Test Method for Resistivity of Electrical Conductor Materials
ASTM B263:	Standard Test Method for Determination of Cross-Sectional Area of Stranded Conductors.

3. DEFINITIONS

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

4. REQUIREMENTS

4.1. SERVICE CONDITIONS

The Aluminium Conductor Composite Core conductor shall be suitable for continuous outdoor operation in tropical areas and harsh climatic conditions including areas exposed to:-

a) Altitudes of up to 2200m above sea level
b) Humidity of up to 90%
c) Average ambient temperature of +30°C with a minimum of -1°C and a maximum of +40°C, in direct sunlight
d) *Isokeraunic levels* of up to 180 thunderstorm days per year.
e) Pollution (IEC 60815)Very Heavy: Class IV

4.2. MATERIAL

4.2.1 Fully Annealed Aluminium Wires

4.2.1.1 Properties of the aluminum wires before stranding shall meet the minimum tensile strength requirements of ASTM B609, but also exhibit a minimum IACS % value of 63% with a maximum resistivity of the aluminum wires that shall not exceed 0.027367mm2/m at 20°C.

4.2.1.2 Wires must be drawn in a trapezoidal shape and be designed to allow them to fit together during stranding in concentric layers.

4.2.1.3 Before and after stranding, the aluminum wires shall be capable of meeting a 20% minimum elongation.

4.2.1.4 The surface of the aluminum wires shall be smooth, without foreign particles, copper dust or any other material that can cause aluminum corrosion. Wires shall not have cosmetic defects, irregular surface (scales), breaks or any other defects visible to the bare eye.

4.2.1.5 In an effort to reduce the propensity for the surface of the conductor to collect dust, or other surface contaminants from accumulating on the surface of the conductor, the conductor manufacturer shall minimize the amount of stranding lubricant utilized in the manufacture of the conductor.

4.2.2 **Composite core**

4.2.2.1 The glass/carbon fiber composite used in the construction of the conductor composite core shall be of ASTM B987-20 High Strength or Extra High Strength Grade, with a combination of glass and carbon fibers arranged such that the glass fibers is concentrated in a ring outside the carbon and bonded together by a polymer matrix.

4.2.2.2 The glass fibers make up the galvanic protection layer and the thickness of this glass layer shall meet the galvanic protection barrier requirements in ASTM B987-20.

4.2.2.3 The Carbon Fiber Composite (CFC) core shall be formed through a pultrusion (uni- directional) process whereby all the fibers (carbon and fiberglass) shall run parallel so as to offer the required tensile strength suitable for overhead conductors used for long span distances over highways, rivers and between mountain peaks.

4.2.2.4 The manufacturer of the CFC (Carbon Fiber Composite) must have successfully conducted Design Validation tests, in accordance with ASTM B987-20 standard, on the core's specified strength grade before submitting a bid. These tests should include a 52-week positive temperature endurance test at temperatures equal to or above 200°C.

4.2.2.5 In addition to ASTM B987-20 52-week Heat Exposure Test. the composite core supplier shall supply an accelerated Arrhenius heat aging study with temperature exposure 60-degrees above the maximum rated operating temperature that demonstrated product longevity greater than 40-years.

4.3 CONSTRUCTION

4.3.1 The overall conductor shall be manufactured as per ASTM B857.

4.3.2 The conductor shall be a hybrid carbon and a glass fiber composite core which is wrapped with a trapezoidal shaped aluminium strands.

4.3.3 The core shall be of high strength and shall carry most of the mechanical load, with the fully annealed aluminium strands carrying all of the conductor's electrical current.

4.3.4 The conductor shall be concentrically stranded, with successive layers in opposite lay, but such that the outermost layer shall be in the right hand spiral (Z).

4.3.5 The wires in each layer shall be evenly and closely stranded. The complete conductor and its layers shall be firm and solid.

4.3.6 It shall be demonstrated during factory inspection/tests that good design and workmanship has been exercised in the manufacture of the complete conductor and that caging problems shall not arise during stringing.

4.3.7 The completed conductor shall be free from dirt, grit, excessive amounts of drawing oil and other foreign deposits. No grease shall be accepted on the outer layer.

4.3.8 The general shape and layout of the conductor shall be as shown in per fig. 1.

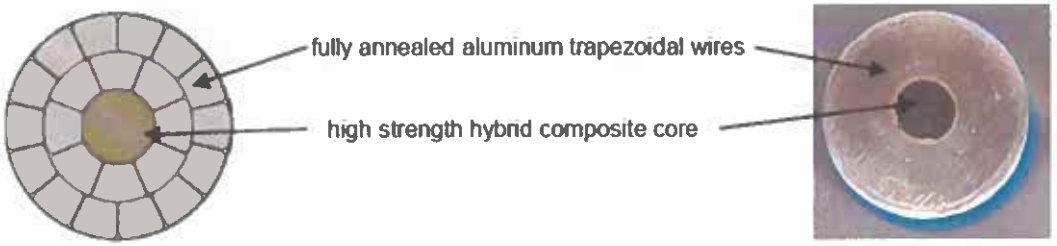

Figure 1: ACCC Conductor

4.4 Conductor Sizes and Characteristics

4.4.1 The sizes for the aluminium and Fiber wires used in the construction of the conductors and the conductor's sizes shall be as shown in Table 1: -

DESCRIPTION		TYPE OF ACCC CONDUCTOR		
ALUMINIUM				
Normal Cross sectional area	mm^2	223.1	236.7	421.4
Diameter	mm	18.82	19.53	25.15
Mass per unit length -kg/km	Kg/km	616	657	1166
Rated Strength	kN	97.5	114.3	134.5
DC Resistance @20°C	Ω/Km	0.1256	0.1184	0.0666
Current Capacity @85°C	A	479	497	696
CORE				
Normal Cross-sectional area	mm^2	39.7	47.1	51.9
Diameter	mm	7.11	7.75	8.13
Weight	Kg/km	76	86	98
Rated Strength	kN	85	101	110.8

Table 1: Technical data for the conductor as per ASTM B857 and ASTM B609

Note: Currents have been calculated at wind velocity 0.6 m/s; solar radiation: 1000 W/m²; emissivity coefficient: 0.5 & absorptivity: 0.5 as per ASTM B857.

Variation in diameter shall not exceed ±1% for aluminium wires and ±2% of core material.

4.5 Conductor Installation Accessories

4.5.1 The tenderer shall provide the following conductor joints and terminations accessories equivalent to ten (10) each per 1000 m length of conductor appropriate for sections and dead-end joints. Some of the accessories are shown in Fig. 2.

a) Dead-end joints and terminations
b) Mid Span Joints/Splices
c) Jumper Terminals
d) Jumper Connectors
e) Repair Sleeves
f) Mechanical connectors
g) Clamps
h) Guy Grips

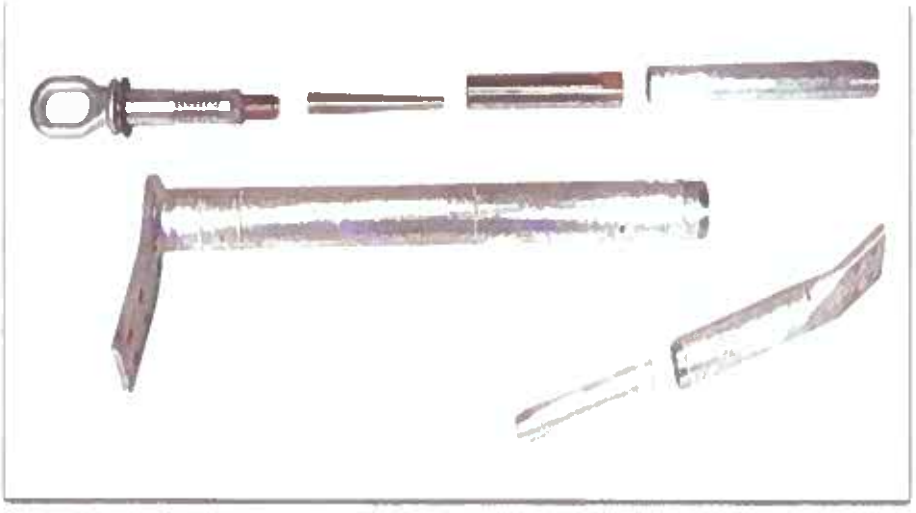

Fig. 2: Dead-end fittings hardware used for ACCC conductor

4.5.2 Collet and housing design (Fig 3) should be used on Dead-end joints and Mid Span Joints/Splices. No compression fitting designs should be used on any composite core conductors.

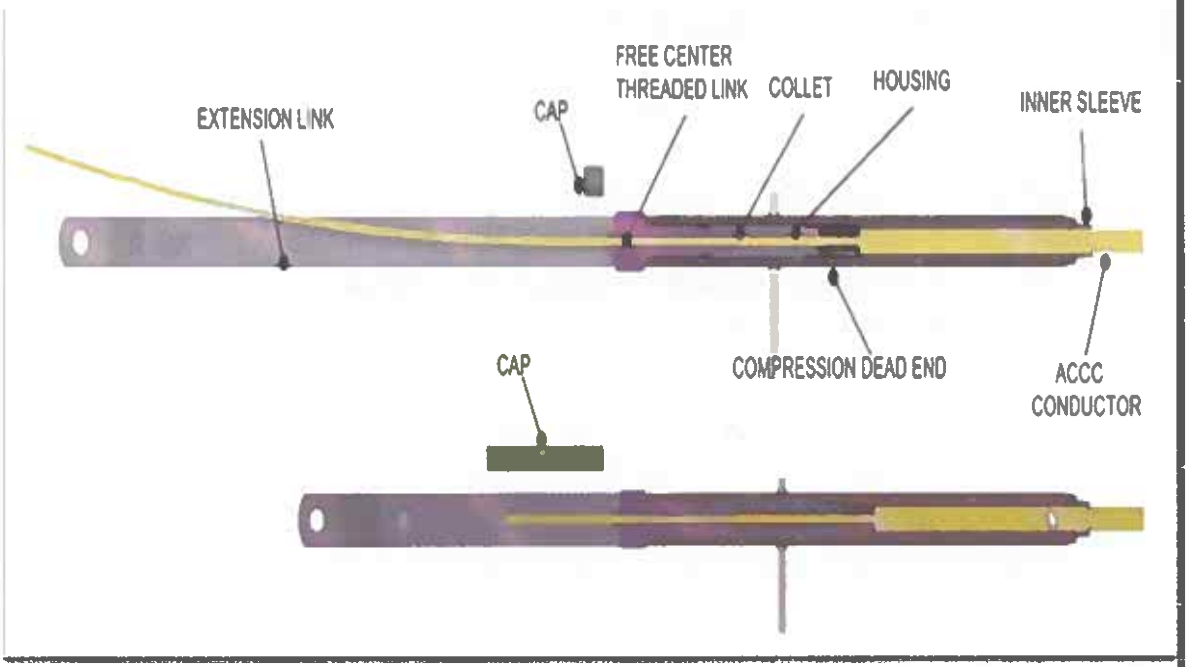

Figure 3: Illustration of Inspectable Deadend for ACCC Conductor Using Collet and Housing

4.5.3 The tender shall provide for special training for at least ten (10) KPLC engineers/technicians on the installation of the conductor, jointing and terminations during construction, operation and maintenance.

4.5.4 A verification is required to confirm the integrity of the composite core before and immediately after conductor installation before energization with the option to re-inspect the composite core during the life cycle of the conductor. Result of the post-install confirmation shall be available to the installing crew within 15 minutes of the inspection test.

4.5.5 The resulting collected field data must be stored in a cloud-based server. The system must permit the Company to independently interrogate the resulting data in real-time, as well as download individual sub-conductor reports.

4.5.6 Technical documentation and manuals to support this system must be included with tender submission.

5. TESTS AND INSPECTION

The conductors shall be inspected and tested in accordance with the requirement of ASTM B357, ASTM B609, ISO 10119 and ABS 5354 standards and this specification.

6. MARKING, LABELLING AND PACKING

6.1. The complete conductor shall be packed on wooden drums such as to prevent damage during transportation and handling. The wooden drums shall be made from treated timber resistant to termite attack The drums shall be firm, with wooden lagging and any collapsed drums shall be rejected during delivery.

6.2. The actual length of conductor on a drum shall not be less than the length indicated on the drum.

6.3. Both ends of every drum length of conductor shall have been sealed 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 (in a permanent manner) on one flange of the reel:

a) Direction of rotation of the reel
b) Type of conductor and size (cross-sectional areas in mm^2)
c) The length of the conductor, in meters
d) Gross weight and net weight (kg)
e) Manufacturer's name
f) Year of manufacture
g) KPLC Order Number
h) The instructions for handling and use (in English Language)
i) The words "PROPERTY OF KENYA POWER & LIGHTING COMPANY PLC."

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APPENDICES

APPENDIX A: TESTS AND INSPECTION (NORMATIVE)

A.1 Copies of previous Type Tests Reports issued by a third party testing laboratory that is accredited to ISO/IEC 17025 shall be submitted with the tender for the purpose of technical evaluation. The accreditation certificate to ISO/IEC 17025 for the same third party testing laboratory used shall also be submitted with the tender document (all in English Language).

A.2. Copies of Test Reports to be submitted for tender evaluation shall include following **type tests,** among others, as tested in accordance with ASTM B857, ASTM B609, ISO 10119, IEEE 738 and ABS 5354 standards:

A. **Mechanical Conductor Testing:**

i. Stress Strain Testing
ii. Creep Testing
iii. Aeolian Vibration Testing
iv. Galloping Tests
v. Self-Damping Tests
vi. Radial Impact and Crush Tests
vii. Turning Angle Tests
viii. Torsion Tests
ix. High Temperature Sag Tests
x. High Temperature Sustained Load
xi. High Temp. Cyclic Load Tests
xii. Cyclic Ice Load Tests
xiii. Sheave Wheel Tests
xiv. Ultimate Strength Tests
xv. Cyclic Thermo-Mechanical Testing
xvi. Combined Cyclic Load Testing
xvii. xvii Conductor Comparison Testing

B. Core Testing:

i. Tensile Testing
ii. Flexural, Bending & Shear Tests
iii. Sustained Load Tests
iv. Impact and Crush Testing
v. Torsion Testing
vi. Moisture Resistance Testing
vii. Long Term Thermal Testing
viii. Sustained Load Thermal Testing
ix. Cyclic Thermal Testing

x. Specific Heat Capacity Testing
xi. High Temp. Short Duration
xii. High Temperature Core Testing
xiii. Thermal Oxidation Testing
xiv. Brittle Fracture Testing
xv. UV Testing
xvi. Salt Fog Exposure Tests
xvii. Creep Tests
xviii. Stress Strain Testing
xix. Low & High Temp. Shear Testing

C. Electrical Conductor Testing:

i. Resistivity Testing
ii. Power Loss Comparison Testing
iii. Ampacity
iv. EMF Measurements
v. Impedance Comparison Testing
vi. Corona Testing
vii. Radio Noise Testing
viii. Short Circuit Testing
ix. Lightning Strike Testing
x. Ultra High Voltage AC & DC Testing

A.3. After manufacture, KPLC shall nominate three engineers to witness acceptance tests at the factory. The following tests shall be done at the manufacturer's works in the presence of KPLC Engineers during Factory Acceptance Test and in accordance with ASTM B857, ASTM B609, ISO 10119, IEEE 738 and ABS 5354 standards and shall include:

A. Mechanical Conductor Testing:

i. Stress Strain Testing
ii. Creep Testing
iii. Radial Impact and Crush Tests
iv. Turning Angle Tests
v. Torsion Tests
vi. Sheave Wheel Tests
vii. Ultimate Strength Tests
viii. Conductor Comparison Testing
ix. Lay ratio test
x. Dimensional checks
xi. Wrapping tests

B. Core Testing:

i. Tensile Testing

ii. Flexural, Bending & Shear Tests
iii. Sustained Load Tests
iv. Impact and Crush Testing
v. Torsion Testing
vi. Thermal Oxidation Testing
vii. Brittle Fracture Testing
viii. Creep Tests
ix. Stress Strain Testing
x. Dimensional checks

C. Electrical Conductor Testing:

i. Resistivity Testing
ii. Power Loss Comparison Testing
iii. Ampacity testing
iv. EMF Measurements
v. Impedance Comparison Testing

D. Construction/Workmanship:

i. The Manufacturer shall demonstrate during factory inspection/tests that the complete conductor is of good workmanship and that caging problems shall not arise during stringing.

A.4. On receipt of the Insulated Platform Tools at stores, KPLC will inspect them for acceptance and may perform or have tests performed in order to verify compliance with this specification. The supplier shall replace without charge to KPLC any tool, accessory or fitting which upon examination, test or use fail to meet any or all of the requirements in the specification.

APPENDIX B: QUALITY MANAGEMENT SYSTEM (Normative)

B.1 The supplier shall submit a Quality Assurance Plan (QAP) that will be used to ensure that the Insulated Platform Tools physical properties, tests 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: 2015.

B.2 The Manufacturer's Declaration of Conformity to applicable standards and copies of quality management certifications including copy of valid and relevant ISO 9001: 2015 certificate shall be submitted with the tender for evaluation.

B.3 The bidder shall indicate the delivery time of the Insulated Platform Tools, manufacturer's monthly & annual production capacity and experience in the production of the type and size of items being offered.

APPENDIX C: DOCUMENTATION (Normative)

C.1 The bidder shall submit its tender complete with technical documents for tender evaluation. The technical documents to be submitted (all in English language) for tender evaluation shall include the following:

a) Fully-filled clause by clause Guaranteed Technical Particulars (GTP) signed by the manufacturer, specific values shall be filled in. Terms like "Yes", "Agree", "Complied" **shall not be acceptable;**

b) Copies of the Manufacturer's catalogues, brochures, drawings and technical data;

c) ISO 9001:2015 Certificate and other technical documents required in the tender.

d) Quality Assurance Plan (QAP) that will be used to ensure that the design, material, workmanship, tests, service capability, maintenance and documentation will fulfil the requirements stated in the contract documents, standards, specifications and regulations.

e) Copies of required type test reports by a third party testing laboratory accredited to ISO/IEC 17025. The test reports shall not be more than five years old;

f) Copy of accreditation certificate to ISO/IEC 17025 for the third party testing laboratory;

g) Contacts and address of third party testing laboratory;

h) Manufacturer's warranty and guarantee; subject to 12 months from the date of delivery to KPLC stores.

C.2 The successful bidder (supplier) shall submit the following documents/details to KPLC for aproval before manufacture:

a) Fully-filled clause by clause Guaranteed Technical Particulars (GTP) signed by the manufacturer, specific values shall be filled in. Terms like "Yes", "Agree", "Complied" **shall not be acceptable;**

b) Design Drawings with details of ACCC to be manufactured for KPLC.

c) Quality Assurance Plan (QAP) that will be used to ensure that the 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 9001:2015.

d) Detailed test program to be used during factory testing;

e) Marking details

f) Packaging details (including packaging materials).

C.3 The supplier shall submit recommendations for use, care, storage and routine inspection/testing procedures, all in the English Language, during delivery of the testers to KPLC stores

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APPENDIX D: GUARANTEED TECHNICAL PARTICULARS(GTP)

To be filled and signed by the Manufacturer and submitted together with relevant copies of the Manufacturer's catalogues, brochures, drawings, technical data, sales records, four customer reference letters, details of manufacturing capacity, the manufacturer's experience and copies of complete type test certificates and type test reports for tender evaluation, all in English Language

Bidder Name.....

Tender No. ....

Clause	Description	KPLC Requirement	Supplier's Details/ Response
	Name of the manufacturer and address	State	
	Country of origin	State	
	Type Reference Number or Model Number	State	
	Type and Size	Specify	
1	Scope	State	
2	Applicable Standards	Specify	
3	Definitions	Specify	
4	**Requirements**		
4.1	Service Conditions	Specify	
4.2	**Materials**		
4.2.1	**Fully Annealed Wire**		
4.2.1.1	Tensile strength of the aluminum wires before stranding	Specify	
	Minimum IACS % value	Specify	
	maximum resistivity of the aluminum wires	Specify	
4.2.1.2	Shape of drawn wires	Specify	
4.2.1.3	Percentage elongation of aluminum wires Before and after stranding, the	Specify	
4.2.1.4	Surface texture of the wires	Specify	
4.2.1.5	Amount of stranding lubricant utilized in the manufacture of the conductor	Specify	
4.2.2	**Composite Cores**		
4.2.2.1	Standard of manufacture of the glass/carbon fiber composite	Specify	
	Grade of glass/carbon fiber composite	Specify	
	Arrangement of the combination of glass and carbon fibers during construction	Specify	
4.2.2.2	Galvanic protection for the fibre	State	
	Thickness of the galvanic protection barrier	State	
4.2.2.3	Process of manufacturing the Carbon Fiber Composite (CFC) core	Specify	

Clause	Description	KPLC Requirement	Supplier's Details/ Response
4.2.2.4	The tests submitted for Carbon Fiber Composite (CFC) core	Specify	
4.2.2.5	52-week Heat Exposure Test as per ASTM B987-20 to be submitted	Specify	
4.3	**Construction & Standard**		
4.3.1	Standard of Manufacture	Specify	
4.3.2	Composition of conductor material	Specify	
4.3.3	Manufacturing process for the conductor	Specify	
4.3.4-4.3.5	Design of manufacture of the conductor	Specify	
4.3.6	Workmanship during manufacturing of the conductor	Specify	
4.3.7	Quality of manufacture of the conductor	Specify	
4.3.8	General Shape and construction layout of the conductor	Specify	
4.4	**Conductor sizes and characteristics**		
4.4.1	Type of ACCC Conductor	Specify	
	Total Cross section of Area of aluminum (mm^2)	Specify	
	Total Cross section of Core (mm^2)	Specify	
	Conductor Diameter (mm)	Specify	
	Diameter of Core (mm)	Specify	
	Mass per unit length of conductor, kg/km	Specify	
	Mass per unit length of aluminum, kg/km	Specify	
	Mass per unit length of core, kg/km	Specify	
	Ultimate Tensile Strength of the Aluminium, kN*	Specify	
	DC Resistance at 20^0C, Ω/km.	Specify	
	Calculated maximum current at 85^0C	Specify	
4.5	**Conductor installation accessories**		
4.5.1	Accessories to be supplied with the conductors	List	
4.5.2	Collet and housing design on Dead-end joints and Mid Span Joints/Splices.	Provide	
4.5.3	Training for at least ten (10) KPLC engineers/technicians on the installation of the conductor, jointing and terminations during construction, operation and maintenance.	Provide	
4.5.4	Verification of integrity conformity	Provide	
4.5.5	Online repository/reference for conductor field data	Provide	
4.5.6	Technical documentation and manuals	Provide	
5	**Test and Inspection**		
	Reference Standard of test to be ASTM B857, ASTM B609, ISO 10119 and ABS 5354	State	

Clause	Description	KPLC Requirement	Supplier's Details/ Response
6	**Marking Labelling & Parking**		
6.1	Packing of the complete conductor	State	
6.2	Length of the conductor per drum	State	
6.3	Sealing of both ends of the drum	State	
6.4	Markings on the flange of the drum	State	
	APPENDICES		
A	**TESTS AND INSPECTION**		
A1	Copies of test certificates and certificates be submitted	List	
A2	Lists of tests in the submitted test reports	List	
A3	Factory acceptance tests (FAT) before shipment/delivery of the goods	List	
A4	Supplier shall replace without charge to KPLC items that don't meet specification	State	
B	**Quality Management System**		
B.1	Quality Assurance Plan	*Provide*	
B.2	Manufacturer's ISO 9001:2015	*Provide*	
B.3	Manufacturer's experience and delivery time	*State*	
	Manufacturer's delivery time	*State*	
	Manufacturing Capacity (units per month)	*State*	
	List of previous customers	*State*	
	Customer reference letters	*State*	
C	**Documentation**		
C.1	Documents submitted with tender	*State compliance*	
C.2	Documents to be submitted by supplier to KPLC for approval before manufacture	*State compliance*	
	Statement of compliance to specification (indicate deviations if any & supporting documents)	*State compliance*	

**Note that words like 'agreed', 'confirmed' complied, 'As per KPLC specifications', etc. shall not be accepted and shall be considered non-responsive.*

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Manufacturer's Name, Signature, Stamp and Date