PARTICULAR TECHNICAL SPECIFICATION FOR ALUMINIUM CONDUCTOR CARBON FIBER REINFORCED (ACFR)

1. SCOPE

This specification is for aluminium conductor carbon fiber reinforced (ACFR), (low sag) conductors for use on 132KV Overhead transmission line at 50 Hz.

1.1. The conductor is for use in highly saline and humid coastal environment.

1.2. The conductor shall meet climatic condition for the 11kV overhead line across the strait to supply Manda Island from the mainland as given in the issued tender document.

1.3. The conductor shall be used on overhead power transmission system with nominal voltage of 132kv and highest system voltage of 145kv

1.4. This specification covers the following conductor size:

a) 175mm^2 Aluminium Conductor with Carbon Fiber Core, referred to as Aluminum conductor carbon fiber reinforced (ACFR).

1.5 The specification also covers inspection and test of the conductors as well as schedule of Guaranteed Technical schedules to be filled, signed and submitted for tender evaluation.

1.6 The specification stipulates the minimum requirements for Specification for ACFR Overhead Conductors acceptable for use in the corporation and it shall be the responsibility of the Manufacturer to ensure adequacy of design, good workmanship and good engineering practice in the manufacture of the conductors for REREC/KPLC.

The specification does not purport 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 and shall be complied with by the manufacturer/ supplier.

ISO 10119: Carbon fibres – Determination of densities

IEEE 738: Standard specification for Calculating the Current-Temperature of Bare Overhead Conductors

ABS 5354: Carbon fibre reinforced bismaleimide pre-pregnation - Fabric /

Mediumtoughness BMI -Structural Materials - Material Specification

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 Purposes.

3. TERMS AND DEFINITIONS

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

4. REQUIREMENTS

4.1. SERVICE CONDITIONS

The conductors shall be suitable for continuous outdoor operation in tropical areas at altitudes of up to 2200m above sea level, humidity of up to 100%, average ambient temperature of +34ºC with a minimum of -1ºC and a maximum of +40ºC heavy saline conditions along the coast and Isokeraunic levels of up to 180 thunderstorm days per year.

4.2. MATERIALS

4.2.1. Hard aluminium alloy wires of resistant up to 150°C shall be used in the construction of the conductor. They shall also be 1350 “0” temper TW aluminium strand wires as per ASTM B609.

4.2.2. The carbon fiber composite cable used in the construction of the conductor core shall be of medium toughness bismaleimide (BMI) resin reinforced with five-harness (5H) satin standard modulus carbon fiber fabric as per ISO 10119 and ABS 5354 standards.

4.2.3. The carbon fiber 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.

4.3. CONSTRUCTION

4.3.1. The overall conductor shall be manufactured as per ASTM B857 standard. It shall be a hybrid carbon and a glass fiber core wrapped with a trapezoidal shaped aluminium strands.

4.3.2. 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.

4.3.3. 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).

4.3.4. The lay ratio for the outer layer of aluminum wires shall have a minimum value of 10 and a maximum value of 13 with the preferred outer layer of 172mm. The inner layer of aluminum wires shall have a minimum value of 10 and a maximum value of 16 lay ratio.

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.

4.3.8. The general shape and layout of the conductor shall be as shown in Fig. 01.

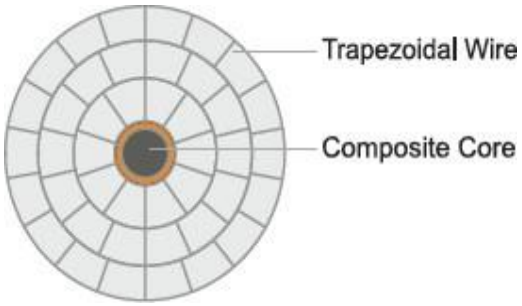

Fig. 01: Concentric Lay Stranded Trapezoidal Conductor.

4.4. **Conductor sizes and characteristics**

4.4.1. The sizes for the aluminum and carbon fiber core used in the construction of the conductors and their sizes shall be as shown in Table 1:

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

Properties		Ratings
Total Cross section of Area (mm^2)		175
Continuous current capacity		464
Calculated maximum current at 120^0C		644
Conductor Diameter (mm)		18.2
Core Diameter (mm)		7.8
No. of aluminIum layers		2
Mass per unit length of conductor, kg/km		502
Mass per unit length of core, kg/km		61
Stranding configuration	No. & diameter of core , mm	1 x 7.8
	No. of Aluminium Layers,	2
	No. & diameter of Aluminium, mm	30/2.6
Coefficient of thermal expansion	Above thermal knee point, $/^0C$	1.1×10^{-6}
	Below thermal knee point, $/^0C$	15.5×10^{-6}
Modulus of elasticity (N/mm^2	Transitional temperature or under	76,000
	Above transitional temperature	137,000
Ultimate Tensile Strength, KN*		68.9
DC Resistance at 20^0C, Ω/km.		0.182
Continuous operating temperature (^0C)		90
Short time temperature (^0C)		120

4.4.2. Variation in diameter shall not exceed ±1.5% for aluminium wires and ±2% of core material.

5. TESTS AND INSPECTION

5.1. The conductors shall be inspected and tested in accordance with the requirement of ASTM B857, ASTM B609, ISO 10119, IEEE 738 and ABS 5354 standards and this specification. It shall be the responsibility of the manufacturer to perform or to have performed all the tests specified and whatever other tests he normally performs at works.

5.2. 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)

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5.3. Copies of type test reports for the conductor to be submitted with the tender (by bidder) for evaluation shall be as stated in table 2:

Table 2: Type tests

Mechanical Conductor Testing:	Core Testing:	Electrical Conductor Testing:
Stress Strain Testing	Tensile Testing	Resistivity Testing
Creep Testing	Flexural, Bending & Shear Tests	Power Loss Comparison Testing
Aeolian Vibration Testing	Sustained Load Tests	Ampacity
Galloping Tests	Impact and Crush Testing	EMF Measurements
Self-Damping Tests	Torsion Testing	Impedance Comparison Testing
Radial Impact and Crush Tests	Moisture Resistance Testing	Corona Testing
Turning Angle Tests	Long Term Thermal Testing	Radio Noise Testing
Torsion Tests	Sustained Load Thermal Testing	Short Circuit Testing
High Temperature Sag Tests	Cyclic Thermal Testing	Lightning Strike Testing
High Temperature Sustained Load	Specific Heat Capacity Testing	Ultra-High Voltage AC & DC Testing
High Temp. Cyclic Load Tests	High Temp. Short Duration	
Cyclic Ice Load Tests	High Temperature Core Testing	
Sheave Wheel Tests	Thermal Oxidation Testing	
Ultimate Strength Tests	Brittle Fracture Testing	
Cyclic Thermo-Mechanical Testing	UV Testing	
Combined Cyclic Load Testing	Salt Fog Exposure Tests	
Conductor Comparison Testing	Creep Tests	
	Stress Strain Testing	
	Low & High Temp. Shear Testing	

5.4 The following tests shall be done at the manufacturer's works in the presence of KPLC Engineers (2) and in accordance with ASTM B857, ASTM B609, ISO 10119, IEEE 738 and ABS 5354 standards and this specification as in Table 3.

Table 3: Routine tests

Mechanical Conductor Testing:	Core Testing:	Electrical Conductor Testing:
Stress Strain Testing	Tensile Testing	Resistivity Testing
Creep Testing	Flexural, Bending & Shear Tests	Power Loss Comparison Testing
Radial Impact and Crush Tests	Sustained Load Tests	Ampacity testing
Turning Angle Tests	Impact and Crush Testing	EMF Measurements
Torsion Tests	Torsion Testing	Impedance Comparison Testing
Sheave Wheel Tests	Thermal Oxidation Testing	
Ultimate Strength Tests	Brittle Fracture Testing	
Conductor Comparison Testing	Creep Tests	
Lay ratio test	Stress Strain Testing	
Dimensional checks	Dimensional checks	
Wrapping tests		

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5.5 Workmanship:

5.5.1 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.

6 MARKING, LABELLING AND PACKING

6.1 The actual length of conductor on a drum shall not be less than the length indicated on the drum and the minimum single length per drum shall be 2000m.

Guaranteed Technical Schedules to be filled, signed and submitted together with bid for tender evaluation

	Description		Kplc Requirement	Guaranteed Values
1	Manufacturer and country of origin			
2	Applicable Standards			
3	Type and Size			
4	Service Conditions			
5	Materials	Aluminium		
		Core material		
	No. of aluminlum layers			
6	Total Cross section of Area (mm^2)			
7	Conductor Diameter (mm)			
8	Core Diameter (mm)			
9	Mass per unit length of conductor, kg/km			
10	Mass per unit length of aluminum, kg/km			
11	Mass per unit length of core, kg/km			
12	Stranding configuration	Specify		
		Specify		
13	Trapezoidal wires	Specify		
		Specify		
14	Coefficient of thermal expansion	Above thermal knee point, $/^0C$		
		Below thermal knee point, $/^0C$		
15	Modulus of elasticity	Transitional temperature or under		
		Above transitional temperature		
16	Ultimate Tensile Strength, kN*			
17	DC Resistance at 20^0C, Ω/km.			
18	Rated Breaking Load, kN			
19	Continuous operating temperature at rated current			
20	Short time temperature at maximum current			
21	Continuous current capacity			
22	Maximum current at 120^0C			