WEST BENGAL STATE ELECTRICITY DISTRIBUTION COMPANY LIMITED

(A Govt. of West Bengal Enterprise)

TECHNICAL SPECIFICATION OF ALUMINIUM CONDUCTOR COMPOSITE CORE HIGH TEMPERATURE LOW SAG (ACCC-HTLS) CONDUCTOR WITH DIMENSIONAL COMPATIBILITY TO ACSR PANTHER

1.0 SCOPE OF WORK

This specification covers the design, manufacture, testing, supply, delivery, and erection of Composite Aluminium HTLS Conductor for WBSEDCL 33 kV / 11 kV overhead distribution lines on 11–13 m Rail / H-poles. The scope includes all required hardware fittings, accessories, special tools, and any other items necessary for complete, safe, and satisfactory installation and maintenance under the climatic conditions of West Bengal. No extra claim shall be entertained for any item required for proper execution of the work.

Stringing shall be carried out with controlled sag and minimum mechanical stress to avoid damage to poles and conductor. Where normal stringing is not possible due to site conditions (road crossings, congested areas, waterways, uneven terrain, etc.), suitable controlled or manual methods may be adopted with prior approval of the Engineer-in-Charge.

All erection work shall comply with the latest statutory provisions including:

Central Electricity Authority (Measures relating to Safety and Electric Supply) Regulations, 2023 (as amended),

Indian Electricity Rules (as applicable),

Relevant IS/IEC standards, and

Applicable labour safety regulations and electrical work safety guidelines.

The Bidder shall be solely responsible for safety of personnel, public, and property during execution.

Mid-span compression joints shall not be allowed in normal spans. Conductor drum lengths shall match surveyed section lengths to avoid such joints. Only dead-end joints at strain locations shall be permitted as per approved design.

Where a mid-span joint becomes unavoidable due to site conditions such as way-leave issues or last-minute route changes, the adoption of a mid-span joint may be permitted with prior approval of the Controlling Officer.

The Bidder shall submit detailed technical particulars, including conductor construction, material properties, ampacity as per IEEE 738 or relevant standard, sag–tension calculations for 55 m average spans (Rail poles) and 300 m average span length (tower line, if applicable), loading conditions, maximum working tension, factor of safety, stringing charts, sag templates, and drawings of fittings. The design shall confirm compatibility with existing WBSEDCL structures and ensure statutory

clearances and permissible mechanical loading limits.

2.0 WARRANTY AND GUARANTEE

The HTLS conductor and all associated hardware fittings shall carry a comprehensive warranty of 5 (five) years from the date of commissioning or energization, whichever is earlier, against any manufacturing defect, material failure, or abnormal deterioration under normal operating conditions. In addition, a Section-to-Section Replacement Guarantee of 1 (one) year from the date of commissioning shall be provided. If any conductor snapping or mechanical failure due to manufacturing or design defect occurs within this period, the successful bidder shall replace the complete affected section between two dead-end points at no extra cost to WBSEDCL, including dismantling, supply, re-stringing, and replacement of required hardware fittings.

3.0 LINE BREAKDOWN RESPONSE AND MAXIMUM PERMISSIBLE DOWNTIME

The successful Bidder shall ensure prompt restoration of the HTLS overhead line in the event of any breakdown attributable to the conductor or associated hardware fittings supplied under this contract. The successful Bidder shall maintain adequate emergency manpower, tools, tackles, and essential spare materials to attend any fault or mechanical failure immediately after receiving intimation from WBSEDCL.

The **maximum permissible response and restoration time** shall be as follows:

Response time: Within **2 (two) hours** from the time of intimation by WBSEDCL or as specified in the relevant Service Purchase Order.

Restoration of the affected line section: Within **12 (twelve) hours** under normal site conditions or as specified in the relevant Service Purchase Order.

If the successful Bidder fails to restore the line within the above permissible time, **downtime penalty may be imposed**. The financial implication of the downtime shall be calculated based on the **average load of the line during the preceding 15 days**, multiplied by the duration of the outage (in hours or minutes), and further multiplied by the **prevailing average industrial tariff of WBSEDCL applicable for the concerned financial year**.

However, downtime penalty shall **not be imposed** in cases where the breakdown occurs due to **external causes beyond the control of the** successful Bidder, such as cyclone, storm, flood, lightning, or other natural calamities, which shall be treated as **Force Majeure conditions**. In such cases, the successful Bidder shall still make all reasonable efforts to restore the line at the earliest possible time.

Note:

WBSEDCL reserves the right to restore the line departmentally or through any other agency at the risk and cost of the successful Bidder if the successful Bidder fails to take necessary action within the stipulated response time.

4.0 DEVIATIONS:

Normally the offer should be as per Technical Specification without any deviation. But any deviation felt necessary to improve performance, efficiency and utility of equipment must be mentioned in the

'Deviation Schedule' with reasons duly supported by documentary evidences and advantages of such deviation. Such deviation suggested may or may not be accepted. But deviations not mentioned in 'Deviation Schedule' will not be considered afterwards.

5.0 GENERAL REQUIREMENTS

5.1 CONDUCTOR CONSTRUCTION

CORE:	SINGLE, POLYMER MATRIX COMPOSITE (PMC) CORE (CARBON-FIBRE COMPOSITE IN RESIN / EPOXY MATRIX). THE CORE MADE OF MULTIPLE STRANDS ARE NOT ACCEPTABLE.
CORROSION PROTECTION ENCAPSULATION:	ONE OF THE FOLLOWING, VALIDATED BY MANUFACTURER TEST DATA: GLASS-FIBRE ANNULAR SLEEVE IN RESIN MATRIX ALUMINIUM-ALLOY WELDED/CLAD TUBE POLYMERIC / THERMOPLASTIC OVERWRAP EQUIVALENT PROVEN SYSTEM
OUTER LAYER STRANDS:	FULLY ANNEALED ALUMINIUM OR THERMAL-RESISTANT ALUMINIUM ALLOY STRANDS (ROUND, TRAPEZOIDAL, OR Z-SHAPED).

5.2 ELECTRICAL & MECHANICAL REQUIREMENTS

AMPACITY:	MINIMUM 800 A AT 33 KV, CALCULATED PER IEEE STD 738.
OPERATING TEMPERATURE:	CONTINUOUS OPERATION AT SPECIFIED TEMPERATURE WITHOUT DETERIORATION.
SHORT-TERM OPERATION:	MANUFACTURER TO SPECIFY PERMISSIBLE TEMPERATURE AND DURATION.
SAG LIMIT:	FOR 55M SPAN AT PERMISSIBLE OPERATING TEMPERATURE AND NIL WIND, SAG ≤ 0.25 M. FOR 300M SPAN AT PERMISSIBLE OPERATING TEMPERATURE AND NIL WIND, SAG ≤ 6 M.

5.3 TEST REPORTS:

Copies of type test reports shall be furnished to WBSEDCL for verification. Only after authentication of GTP & Drawing by WBSEDCL, commercial production of the material shall start.

Record of routine test reports shall be maintained by the Supplier at his works for periodic inspection by the WBSEDCL's representative.

Test Certificates of tests during manufacture shall be maintained by the Bidder. These shall be produced for verification as and when desired by WBSEDCL.

5.4 INSPECTION:

The WBSEDCL's representative shall, at all times, be entitled to have access to the works and to all places of manufacture where the materials are being manufactured. WBSEDCL's representative shall be provided with full facilities for unrestricted inspection of the manufacturing works, raw materials, and manufacturing processes of the successful bidder and/or its approved manufacturing agency, for the purpose of carrying out necessary inspections and tests.

The successful bidder shall keep the WBSEDCL informed in advance of the time of starting and of the

progress of manufacture of material in its various stages so that arrangements can be made for inspection.

No material shall be dispatched from its point of manufacture before it has been satisfactorily inspected and tested, unless the inspection is waived off by the WBSEDCL in writing. In the latter case also the material shall be dispatched only after satisfactory testing for all tests have been completed.

The acceptance of any quantity of material shall in no way relieve the Supplier of any of his responsibilities for meeting all requirements of the Specification, and shall not prevent subsequent rejection it such material is later found to be defective.

PART – I

HTLS CONDUCTOR

1.0 STANDARDS:

The conductor shall conform to the following Indian/International Standards, which shall mean latest revisions, with amendments / changes adopted and published, unless specifically stated otherwise in the Specification.

In the event of the supply of conductor conforming to standards other than specified, the Bidder shall confirm in his bid that these standards are equivalent to those specified. In case of award, salient features of comparison between the standards proposed by the Supplier and those specified in this document will be provided by the Supplier to establish their equivalence.

1.1 GENERAL CONDUCTOR STANDARDS

ISTANDARD	TITLE
IS: 398-1982	ALUMINIUM CONDUCTORS FOR OVERHEAD TRANSMISSION PURPOSES- SPECIFICATION
IS:398-1990 PART-II	ALUMINUM CONDUCTOR GALVANIZED STEEL REINFORCED
IS : 9997-1988	ALUMINIUM ALLOY REDRAW RODS FOR ELECTRICAL PURPOSES- SPECIFICATION
SWEDISH STANDARD (SS) 424 08 13	ALUMINIUM ALLOY WIRE FOR STRANDED CONDUCTORS FOR OVERHEAD LINES – AL 59 WIRE
SS 424 0814	ALUMINIUM ALLOY STRANDED CONDUCTORS FOR OVERHEAD LINES – AL 59 WIRE

1.2 STANDARDS SPECIFIC TO HIGH-TEMPERATURE ALUMINIUM STRANDS

STANDARD	TITLE
IEC 62641	THERMAL-RESISTANT ALUMINIUM ALLOY WIRE FOR OVERHEAD LINE CONDUCTOR
ASTM B 398	STANDARD SPECIFICATION FOR ALUMINUM-ALLOY 6201- T81 AND 6201-T83 WIRE FOR ELECTRICAL PURPOSES
ASTM B 941	STANDARD SPECIFICATION FOR HEAT RESISTANT ALUMINUM-ZIRCONIUM ALLOY WIRE FOR ELECTRICAL PURPOSES
ASTM B 233 – 97 (REAPPROVED 2003)	STANDARD SPECIFICATION FOR ALUMINUM 1350 DRAWING STOCK FOR ELECTRICAL PURPOSE
ASTM B 857-11	STANDARD SPECIFICATION FOR SHAPED WIRE COMPACT CONCENTRIC-LAY-STRANDED ALUMINUM CONDUCTORS

1.3 HTLS COMPOSITE CORE STANDARDS

STANDARD	TITLE
ASTM B 987	STANDARD SPECIFICATION FOR CARBON FIBER THERMOSET POLYMER MATRIX COMPOSITE CORE (CFC) FOR USE IN OVERHEAD ELECTRICAL CONDUCTORS
ASTM B 976	STANDARD SPECIFICATION FOR FIBER REINFORCED ALUMINUM MATRIX COMPOSITE (AMC) CORE WIRE FOR ALUMINUM CONDUCTORS, COMPOSITE REINFORCED (ACCR)

1.4 MECHANICAL, ELECTRICAL & THERMAL TESTING STANDARDS

STANDARD	TITLE
IEC:60468	METHOD OF MEASUREMENT OF RESISTIVITY OF METALLIC MATERIALS
IEEE 738	STANDARD FOR CALCULATING THE CURRENT TEMPERATURE RELATIONSHIP OF BARE OVERHEAD CONDUCTORS

1.5 DRUMS

STANDARD	TITLE
IS : 1778-1980	SPECIFICATION FOR REELS AND DRUMS FOR BARE CONDUCTORS

1.6 ALLIED, IF REQUIRED

STANDARD	TITLE
IS:398 (PART-IV)	ALUMINIUM ALLOY STRANDED CONDUCTORS (ALUMINIUM-MAGNESIUM-SILICON TYPE) - SPECIFICATION
ASTM B 388	STANDARD SPECIFICATION FOR THERMOSTAT METAL SHEET AND STRIP
ASTM B 753	STANDARD SPECIFICATION FOR THERMOSTAT COMPONENT ALLOYS
ASTM A 856	STANDARD SPECIFICATION FOR ZINC-5% ALUMINUM MISCHMETAL ALLOY-COATED CARBON STEEL W
ASTM A 857	STANDARD SPECIFICATION FOR STEEL SHEET PILING, COLD FORMED, LIGHT GAGE
ASTM B 230	STANDARD SPECIFICATION FOR ALUMINUM 1350–H19 WIRE FOR ELECTRICAL PURPOSES
ASTM B 609	STANDARD SPECIFICATION FOR ALUMINUM 1350 ROUND WIRE, ANNEALED AND INTERMEDIATE TEMPERS, FOR ELECTRICAL PURPOSES
IEC TS 62818-1:2024	CONDUCTORS FOR OVERHEAD LINES - FIBER REINFORCED COMPOSITE CORE USED AS SUPPORTING MEMBER MATERIAL - PART 1: POLYMERIC MATRIX COMPOSITE CORES
IEC TS 62818-2:2024	CONDUCTORS FOR OVERHEAD LINES - FIBER REINFORCED COMPOSITE CORE USED AS SUPPORTING MEMBER MATERIAL - PART 2: METALLIC MATRIX COMPOSITE CORES
IEC 61089:1991 SUPERSEDES IEC 60208:1966	ROUND WIRE CONCENTRIC LAY OVERHEAD ELECTRICAL STRANDED CONDUCTORS
IS: 6745	METHOD FOR DETERMINATION OF MASS OF ZINC COATING ON ZINC COATED IRON AND STEEL ARTICLES
IEC 63248:2022 (SUPERSEDES IEC 61232, IEC 60888)	CONDUCTORS FOR OVERHEAD LINES - COATED OR CLADDED METALLIC WIRE FOR CONCENTRIC LAY STRANDED CONDUCTORS
IEC 62641:2022 (SUPERSEDES IEC 60889)	CONDUCTORS FOR OVERHEAD LINES - ALUMINIUM AND ALUMINIUM ALLOY WIRES FOR CONCENTRIC LAY STRANDED CONDUCTORS (IS VERSION IS IS :9997)

2.0 DESCRIPTIONS AND TECHNICAL REQUIREMENT:

The offered composite core HTLS Conductor shall be capable of carrying the minimum specified current 800 Amps for conductor equivalent to ACSR Panther at a continuous operating conductor temperature not exceeding the maximum permissible operating temperature of the offered composite core aluminium alloy HTLS Conductor without exceeding the level of maximum permissible sag as indicated in following clauses.

The physical and operating performance requirements of the transmission line with HTLS conductor are mentioned below. The bidder shall offer HTLS conductor complying with the specified requirements. The Bidder shall indicate particulars of the proposed conductor in the relevant GTP schedule along with calculations to establish compliance with the specified requirements.

3.0 CURRENT CARRYING CAPACITY / AMPACITY REQUIREMENTS

Each conductor / sub conductor in the bundle of HTLS conductor shall be suitable to carry minimum specified 50 Hz alternating current of 800 Amps for ACSR Panther equivalent under the ambient conditions & maximum conductor sag specified below while satisfying other specified technical requirements/parameters:

ELEVATION ABOVE SEA LEVEL	1000 M
AMBIENT TEMPERATURE	45^0C
SOLAR ABSORPTION COEFFICIENT	0.8
SOLAR RADIATION	1045 WATT/SQ.M
EMISSIVITY CONSTANT	0.45
WIND VELOCITY	0.6 M/SEC
EFFECTIVE ANGLE OF INCIDENCE OF SUN'S RAYS	90 DEGREE

Maximum permissible conductor sag shall be limited as follows:

- ✓ ***For a maximum span of 55 m (Rail Pole / H-Pole):*** ***≤0.25 m***
- ✓ ***For a maximum span of 300 m (Tower Line):*** ***≤6 m***

The above sag values shall be at steady-state conductor temperature, under **nil wind condition**, and corresponding to **800 Amps per conductor at 50 Hz AC supply**, considering the specified ambient conditions.

Ampacity calculation shall be carried out as per **IEEE Standard 738**. The bidder shall submit detailed ampacity calculations for the proposed HTLS conductor in accordance with this standard.

The **AC resistance and DC resistance** of the HTLS conductor shall be calculated as per the relevant applicable standards shall be calculated as follows:

3.1 CALCULATION OF AC RESISTANCE (R_{Ac})

$$R_{\{ac\}} = R_{\{dc\}} \times [\,1 + 0.00519 \times (m_r)^n \times k_1 + k_2]$$

Where,

R_{ac} = AC resistance of conductor at operating temperature, ohms / km

R_{dc} = DC resistance of conductor at operating temperature, ohms / km

3.2 CALCULATE M_R

$$m_r = \frac{0.3544938}{\sqrt{R_{\{dc\}}}}$$

Determination of Exponent n

If $m_r < 2.8$ then $n = 4 - 0.0616 + 0.0896\, m_r - 0.0513\, m_r^2$

If $\mathbf{2.8 \le mr \le 5.0}$ then $n = 4 + 0.5363 - 0.2949\, m_r + 0.0097\, m_r^2$.

Calculation of $k_1 = \left[\cos\left(90\left(\frac{d}{D}\right)^p\right)\right]^{\{2.35\}}$

Where $p = 0.7 + 0.11 m_r - 0.04 m_r^2 + 0.0094 m_r^3$

Value of k_2 = 0 for carbon fibre composite core type HTLS conductor

Geometrical parameter,

D= conductor outer diameter in metres

d = conductor inner diameter in metres

The bidder shall submit detailed ampacity calculations for the proposed HTLS conductor based on the specified ambient conditions. The calculations shall clearly demonstrate that the conductor is capable of carrying the specified AC current of 800 Amps at steady-state operating conditions.

The conductor design shall ensure safe and reliable operation at the calculated steady-state temperature corresponding to 800 Amps under the given ambient conditions.

The bidder shall clearly state the maximum permissible conductor temperature for continuous operation without any deterioration in electrical, mechanical, or metallurgical properties.

The bidder shall also specify the maximum permissible conductor temperature for short-term operation, along with the allowable duration for such operation.

The Ultimate Tensile Strength (UTS) of the conductor, as indicated in the GTP, shall remain valid up to the declared maximum design temperature.

4.0 TECHNICAL PARTICULARS OF HTLS CONDUCTOR:

The HTLS conductor shall meet the following minimum requirements: ACSR Panther equivalent

Overall diameter of complete conductor: Not more than 21 mm and not less than 19 mm (shall match the existing conductor size).

Approximate mass of complete conductor (kg/km): Shall be less than or equal to 974 kg/km (existing conductor weight per km).

Direction of lay of outer layer: Right Hand.

The bidder shall provide all technical details and construction particulars of the conductor in the relevant schedule of the GTP.

The bidder shall guarantee the DC resistance of the conductor at 20°C. The bidder shall also guarantee the AC resistance at 50 Hz corresponding to the specified current (800 Amps) at the maximum continuous operating temperature under the specified ambient conditions.

Supporting calculations for AC resistance shall be submitted. The calculation shall clearly show the temperature coefficient of resistance and the DC to AC resistance conversion factor, with proper reference to the conductor construction and geometry.

5.0 SAG & TENSION REQUIREMENT

The **HTLS Conductor** (equivalent to ACSR Panther) shall satisfy the following **sag and tension limits** under various loading and temperature conditions for 33 kV distribution lines.

Particulars	Limiting Requirement
Everyday condition (32 °C, no wind)	Conductor tension shall be **≤ 25 % of UTS** of the proposed conductor
Sag at Maximum Continuous Operating Temperature (MCOT) (corresponding to rated current and ambient condition)	Sag shall be **≤ 0.25 m for 55 m span** and **≤ 6.0 m for 300 m span**
32 °C with full wind pressure (203.2 kg/m²)	Tension shall be **≤ 70 % of UTS** of the proposed conductor
Designed Maximum Temperature, no wind	Tension shall be **≤ 25 % of UTS** at designed maximum temperature
Designed Maximum Temperature with full wind	Tension shall be **≤ 70 % of UTS** at designed maximum temperature
Knee-Point Temperature, no wind	Tension shall be **≤ 40 % of UTS of the core*** of the proposed conductor

Notes

* UTS of Core shall be taken as the certified minimum breaking strength of the composite core, as declared by the manufacturer and validated by type test reports.

5.1 SAG–TENSION CALCULATION

After award of the contract, the **Supplier shall submit detailed sag–tension calculations** for all ruling and actual spans, based on **final check survey data**, covering all the loading and temperature conditions specified above.

5.2 CREEP CHARACTERISTICS

The Supplier shall also furnish **creep characteristics** of the HTLS conductor based on **laboratory test results** conducted on similar type conductors, in accordance with **IEE 1138 / IEC 61395**.
The creep data shall include **creep strain values** corresponding to:
1 month, 6 months, 1 year, 10 years and 20 years
at: **Everyday tension**, and **Maximum Continuous Operating Temperature (MCOT)**.

5.3 STRINGING TENSION

The initial stringing tension shall be creep-compensated at minus (–) 18 °C, so that the final design tension limits of the supporting structures (Rail / H poles) are fully satisfied under all specified operating conditions.

6.0 WORKMANSHIP:

All the conductor strands shall be smooth and uniform. They shall be free from any defects such as cracks, splits, scratches, die marks, abrasions, rust, or any other surface damage.
The finished conductor shall be smooth, compact, and properly bound. It shall not have kinks (protruding

wires), wire cross-over, over-riding, or any looseness (wires moving by hand pressure or producing unusual sound when tapped). It shall also be free from material inclusions, white rust, powder formation, black spots (due to trapped rainwater reaction), dirt, grit, or any other visible defects.

7.0 JOINTS IN WIRES

Core: There shall be no joint or splice in any length of the core.

Aluminium Alloy Wires: During stranding, aluminium alloy wires shall not be welded to achieve the required conductor length.

No joint shall be permitted in any wire of the outermost layer of the finished conductor. In the inner layer(s), joints are allowed only if a wire is accidentally broken during stranding. Such breakage shall not be due to defective material or the use of short wire lengths.

The total number of joints shall not exceed four (4) in one conductor length. The distance between any two joints shall be at least 15 metres, whether in the same wire or in different wires of the completed conductor.

The Bidder shall maintain proper records of all joints for each conductor length and submit the same to WBSEDCL for review.

All joints shall be made by cold pressure butt welding. Each joint shall have a tensile strength not less than the guaranteed breaking strength of the individual strand.

8.0 TOLERANCES:

Manufacturing tolerances on the dimensions to the extent of one percent (+/-1%) shall be permitted for individual strands and the complete conductor

9.0 MATERIALS:

The materials used for manufacturing the conductor shall ensure that all technical and performance requirements specified in this document are fully met.

9.1 CORE

For composite core conductors, the core material shall be of proven quality and suitable for long-term operation under tropical environmental conditions similar to existing overhead distribution lines.

The bidder shall submit complete supporting documents, including:

- ✓ Technical specifications
- ✓ Type test reports
- ✓ Details of past operating experience

to establish the suitability and reliability of the offered composite core material.

9.2 OUTER LAYER

The outer layer of the HTLS conductor shall be made of high-temperature resistant aluminium alloy. The alloy shall be produced by adding zirconium or other suitable elements to electrolytic aluminium having a minimum purity of 99.5% and copper content not more than 0.04%.

The aluminium strands shall be manufactured using a controlled and proven process to maintain uniform electrical, mechanical, and metallurgical properties suitable for continuous operation at elevated temperatures.

The bidder shall:

Guarantee the chemical composition in the GTP schedule.

Provide details of the manufacturing process along with the bid.

In case fully annealed (tempered) aluminium/alloy strands are offered, only trapezoidal or Z-shaped wires shall be accepted.

9.3 CONDUCTOR LENGTH:

After survey of the involved section of the line, the pole to pole span schedules, section lengths, special crossing etc. shall be finalized by the supplier/ shall be furnished to the supplier. The supplier shall determine the most appropriate individual conductor lengths to be manufactured & supplied keeping in view the pole to pole span schedules, section lengths, special crossings etc. And the drum schedules shall be submitted to WBSEDCL for review & approval.

The standard length of the conductor shall be indicated in the guaranteed technical particulars of offer.

A tolerance of +5% on the standard length offered by the Bidder shall be permitted.

The bidder shall also indicate the maximum single length of HTLS Conductor; he can manufacture in the guaranteed technical particulars of offer. Such length of conductor may be required for special stretches like river crossing etc.

10.0 OHMIC LOSSES (KWH)–BASED DIFFERENTIAL PRICE EVALUATION:

Based on the conductor parameters guaranteed by the bidders, the **ohmic energy loss (kWh)** of the offered conductor shall be calculated. For **WBSEDCL**, one conductor per phase shall be used (no sub-conductor or bundled conductor is permitted).

Average Ohmic Loss (kW) = Loss Load Factor × Line Length × (Continuous Operating Current)^2 × AC Resistance per km at Continuous Operating Current

The AC resistance value corresponding to the continuous operating current, as guaranteed by the bidder, shall be considered for this calculation.

10.1 CONVERSION OF OHMIC LOSS INTO ENERGY LOSS (KWH FOR 15 YEARS)

The average ohmic loss (kW) shall be converted into total energy loss over **15 years** as follows:

Total Energy Loss (kWh) = Average Ohmic Loss (kW) × Annual Operating Hours × 15

(Annual Operating Hours shall be taken as per standard utility practice.)

Differential Price Evaluation

The differential price shall be calculated as follows:

10.2 IDENTIFY BASE CONDUCTOR

Among all technically responsive and qualified bidders, the conductor having the lowest total energy

loss (kWh) over 15 years shall be treated as the Base Conductor.
The corresponding energy loss shall be considered as Base Energy Loss (kWh).

10.3 CALCULATE EXCESS ENERGY LOSS

For each bidder: **Excess Energy Loss (kWh)** = Bidder's Total Energy Loss − Base Energy Loss

10.4 CAPITALIZATION OF EXCESS LOSS (DISCRETION OF TENDERING AUTHORITY FOR NON TURNKEY WORK)

The excess energy loss shall be converted into cost using the applicable energy cost (₹/kWh):
Differential Price (₹) = Excess Energy Loss (kWh) × Energy Cost (₹/kWh)
The calculated differential price shall be **added to the quoted bid price** of the respective bidder for the purpose of price evaluation.

11.0 TESTS AND INSPECTION:

11.1 TYPE TESTS

All specified type tests for the offered HTLS Conductor need not be repeated if valid type test certificates are available. The certificates must be from an accredited laboratory or tests witnessed by a Utility representative and must have been conducted within the last five (5) years from the date of bid opening. If there is any discrepancy in the submitted test report — such as change in design, material, manufacturing process, substitution of any component, or non-compliance with the Technical Specification — the relevant type tests shall be carried out again by the Bidder at no additional cost to WBSEDCL.

Note: If the bidder/manufacturer does not have a valid type test report at the time of bidding and intends to conduct the type test after award of contract, they may do so by submitting an undertaking along with the bid. To avoid delay, material may be supplied before completion of type testing. However, payment will be released only after submission of a successful type test report, or against submission of 100% Bank Guarantee valid until acceptance of the type test results. If the material fails in the type test, the Bidder shall remove the supplied material at their own cost. In such case, the Bank Guarantee shall be invoked, and the Performance Bank Guarantee shall also be encashed.
Type Tests shall be conducted once on samples drawn from each manufacturing facility to establish design conformity.

11.1.1 TESTS ON COMPLETE CONDUCTOR

1. **DC RESISTANCE TEST**: DC resistance is measured on a minimum 5 m long conductor sample using a Kelvin double bridge or micro-ohm meter. The test is repeated at least five times and the average value is taken. The result is corrected to 20°C as per IS 398. The corrected resistance must meet the specification requirement.
2. **UTS TEST (ROOM TEMPERATURE)**: A minimum 5 m conductor sample is fixed in a tensile testing machine. Load is increased gradually up to 50% of UTS and held for 1 minute. Then it is increased to 100% of minimum specified UTS and held for 1 minute. The conductor must not fail. The load is then increased till breaking and the value is recorded. Test is conducted between 0°C and 50°C.

3. **UTS TEST (ELEVATED TEMPERATURE)**: The same procedure as above is followed, but the conductor temperature is kept at its designed maximum temperature.

4. **STRESS–STRAIN TEST (ROOM & ELEVATED TEMPERATURE)**: Stress–strain test is conducted as per IEC 61089. At elevated temperature, the conductor is heated to maximum design temperature and tested up to 80% of guaranteed UTS.

5. **HIGH TEMPERATURE ENDURANCE & CREEP TEST**: Two conductor samples are tested at 25% UTS tension. One sample is kept at 20°C for 1000 hours and elongation is recorded. The other sample is heated step-by-step up to maximum temperature and then kept at maximum temperature +10°C for 1000 hours. Creep and elongation are measured. After the test, the core must withstand 95% of UTS. For polymer core, flexural strength and glass transition temperature should not reduce by more than 10%.

6. **SHEAVES TEST:** A 35 m conductor sample is tensioned at 25% UTS and passed 36 times over pulleys (32 times conductor diameter). After the test, UTS is checked. There should be no damage. Polymer cores are checked by dye penetration test.

7. **AXIAL IMPACT TEST**: The conductor is suspended vertically and a 650 kg weight is dropped from 4 m height. The impact load is recorded. The core must withstand at least its UTS.

8. **RADIAL CRUSH TEST**: A conductor section is crushed between steel plates with 350 kg load for 1 minute. After release, strands are tested. All strands must retain full strength.

9. **TORSIONAL DUCTILITY TEST**: A 10–15 m sample is loaded to 20% UTS and twisted in ±180° steps. It must withstand at least 16 rotations without damage.

10. **AEOLIAN VIBRATION TEST**: The conductor is tensioned at 25% UTS in a minimum 30 m span. It is vibrated at resonance frequency (>10 Hz) for at least 10 million cycles. There must be no broken strands and it must retain 95% UTS.

11. **TEMPERATURE CYCLE TEST**: The conductor is subjected to 100 heating and cooling cycles up to maximum temperature. Then tension is increased to 70% UTS for 24 hours. The cycle is repeated 5 times. After the test, conductor strength must be more than 95% UTS. Polymer core properties must not reduce by more than 10%.

11.1.2 TESTS ON CONDUCTOR STRANDS / CORE

1. **HEAT RESISTANCE TEST (ALUMINIUM ALLOY WIRE)**: Wire is heated in a furnace (temperature depends on conductor rating) for 1 hour. Breaking strength after heating must be at least 90% of original strength.

2. **BENDING TEST**: A 30 cm sample is bent 90° left and right. After cutting at bend point, there should be no separation between core and aluminium.

3. **COMPRESSION TEST**: A 10 mm sample is compressed with 3600 kg load. The strand must not break.

4. **COEFFICIENT OF LINEAR EXPANSION TEST**: Temperature is increased gradually and elongation is measured. Expansion coefficient is calculated from readings.

5. **BRITTLE FRACTURE TEST (POLYMER CORE)**: Core is tensioned to 25% UTS and exposed to nitric acid for 96 hours. It must withstand at least 80% of specified load.

6. **TORSION & ELONGATION TEST (CORE STRANDS/COMPOSITE CORE)**: As per IEC 61232. Strand must withstand specified number of twists and minimum elongation before fracture. Composite core must withstand 100% rated tensile strength after torsion.

7. **BREAKING LOAD TEST**: Breaking load of aluminium alloy strands and core strands is checked as per IEC 888/889. Results must meet specification.

8. **WRAP TEST**: Strand is wrapped around a mandrel (5 times its diameter). After unwrapping, there should be no break.

9. **RESISTIVITY TEST**: Conductivity of aluminium alloy or aluminium clad strands is checked as per IEC:889 standards to confirm minimum conductivity.

10. **WELDED JOINT QUALIFICATION TEST**: Welded aluminium alloy strand is tensile tested. Breaking strength must not be less than individual strand strength.

11. **AGEING TEST ON FILLER (IF APPLICABLE)**: Filler material is heated above operating temperature. Drop point temperature is recorded.

12. **GLASS TRANSITION TEMPERATURE TEST (POLYMER CORE)**: Test is conducted as per ASTM B987. Minimum glass transition temperature must meet specified requirement.

13. **FLEXURAL STRENGTH TEST (POLYMER CORE)**: Test is conducted as per ASTM D7264 / ISO 14125. Flexural strength must meet guaranteed value.

15. **CHEMICAL ANALYSIS (ALUMINIUM ALLOY, CORE & ZINC)**: Samples are chemically analysed to confirm composition as per specification. WBSEDCL reserves the right to conduct all the chemical tests in this specification at his own expense on the samples drawn during manufacturing.

11.1.3 ACCEPTANCE TESTS – HTLS CONDUCTOR

1. **VISUAL AND DIMENSIONAL CHECK ON DRUM**: Each drum is checked visually to confirm that it matches the approved drawing. Drum size, marking, lagging, protection and general condition are inspected. The drum must be strong enough for safe transport and handling.

2. **VISUAL CHECK OF CONDUCTOR BY REWINDING**: Selected drums (normally 10% from each lot) are rewound in the presence of the purchaser. During rewinding, the conductor surface is checked for scratches, damages, loose strands, improper joints or any visible defect. Conductor length is also verified. The conductor must be free from unacceptable defects.

3. **DIMENSIONAL CHECK OF CORE AND ALUMINIUM ALLOY STRANDS**: Samples of individual strands are measured using proper measuring instruments. Strand diameter and construction must be within specified tolerance limits and match the approved technical data.

4. **CHECK OF LAY RATIO OF VARIOUS LAYERS:** The lay ratio of each layer of the stranded conductor is checked. The measured lay ratio must match the guaranteed technical particulars. Stranding must be uniform and proper.

6. **THICKNESS OF ALUMINIUM ON ALUMINIUM CLAD WIRES**: The aluminium cladding thickness is measured using suitable electrical measuring instruments or direct measurement method. The thickness must meet the specified value.

7. **TORSION TEST ON COMPOSITE CORE**: The core strand is twisted for the specified number of turns. It must withstand the required number of twists without cracking or breaking. In case of composite

core, it must also retain full tensile strength after torsion.

8. **ELONGATION TEST ON COMPOSITE CORE**: The strand is subjected to tensile load until fracture. The elongation at breaking point must not be less than the guaranteed value.

9. **BREAKING LOAD TEST ON CORE AND ALUMINIUM ALLOY STRANDS**: Individual strands are tensile tested. The breaking load must not be less than the specified minimum breaking strength.

10. **WRAP TEST ON CORE AND ALUMINIUM ALLOY STRANDS**: The strand is wrapped around a mandrel of specified diameter and then unwrapped. There must be no crack or break in the strand after the test.

11. **RESISTIVITY TEST ON ALUMINIUM / ALUMINIUM ALLOY STRANDS**: Electrical resistivity of strands is measured to confirm required conductivity. The conductivity must meet the specified minimum value.

12. **PROCEDURE QUALIFICATION TEST ON WELDED JOINT OF ALUMINIUM ALLOY STRAND**: Two aluminium alloy wires are welded and tested under tensile load. The welded joint must have breaking strength not less than that of individual strand.

13. **HEAT RESISTANCE TEST ON ALUMINIUM ALLOY STRAND**: The strand is heated in a furnace at specified temperature for one hour. After heating, breaking strength must be at least 90% of original strength.

14. **AGEING TEST ON FILLER (IF APPLICABLE)**: The filler material is heated above the maximum operating temperature. The drop point temperature is recorded. The filler must remain stable up to specified temperature.

15. **RESISTIVITY TEST ON ALUMINIUM CLAD CORE STRAND**: Electrical conductivity of aluminium clad core strand is measured. It must meet the specified conductivity requirement.

16. **GLASS TRANSITION TEMPERATURE TEST (FOR POLYMER COMPOSITE CORE)**: The composite core sample is tested to determine its glass transition temperature. The value must be equal to or higher than the specified minimum temperature.

17. **FLEXURAL STRENGTH TEST (FOR POLYMER COMPOSITE CORE)**: The composite core is tested for bending strength. The measured flexural strength must not be less than the guaranteed value.

18. **COATING TEST ON ZINC–5% ALUMINIUM MISCHMETAL ALLOY (IF APPLICABLE)**: The coating quality and adhesion are checked as per relevant standard ASTM B803 / B958. The coating must be uniform and properly bonded.

19. **CHEMICAL ANALYSIS OF MATERIALS**: Samples of aluminium alloy, core material and zinc used for galvanizing are chemically analysed. The chemical composition must match the specified and guaranteed values.

12.0 PACKING:

The conductor shall be supplied in non-returnable, strong, wooden/painted steel/hybrid (painted steel cum wood) drums provided with lagging of adequate strength, constructed to protect the conductor against all damage and displacement during transit, storage and subsequent handling and stringing operations in the field. The Supplier shall select suitable Bottom of Form drums for supply of conductor and shall be responsible for any loss or damage to conductor and/or drum during transportation

handling and storage due to improper selection of drum or packing.

The drums shall be suitable for wheel mounting and for letting off the conductor under a minimum controlled tension of the order of 5 KN.

The Bidder should submit their proposed drum drawings along with the bid. One conductor length only shall be wound on each drum.

The conductor ends shall be properly sealed and secured on the side of one of the flanges to avoid loosening of the conductor layers during transit and handling.

13.0 MARKING:

Each drum shall have the following information stenciled on it in indelible ink along with other essential data:

(a) Contract/Award letter number.
(b) Name and address of consignee.
(c) Manufacturer's name and address.
(d) Drum number
(e) Size of conductor
(f) Length of conductor in meters
(g) Arrow marking for unwinding
(h) Position of the conductor ends
(i) Distance between outer-most Layer of conductor and the inner surface of lagging.
(j) Barrel diameter at three locations & an arrow marking at the location of the measurement.
(k) Number of turns in the outer most layer.
(l) Gross weight of drum after putting lagging.
(m) Tear weight of the drum without lagging.
(n) Net weight of the conductor in the drum.
(o) CIP/MICC No.

The above should be indicated in the packing list also.

GUARANTEED TECHNICAL PARTICULARS OF HTLS CONDUCTOR (EQUIVALENT TO PANTHER)

1. NAME & ADDRESS OF MANUFACTURER:

2. NAME OF THE HTLS CONDUCTOR:

3. CONSTRUCTION / DESIGNATION OF HTLS CONDUCTOR AS PER IEC :61089:

4. PARTICULARS OF RAW MATERIALS:

1. OUTER LAYER STRANDS

APPLICABLE STANDARD ON STRANDS:
TYPE OF CONDUCTOR STRANDS MATERIAL:

2. CHEMICAL COMPOSITION OF CONDUCTOR OUTER LAYER STRANDS

DESCRIPTION	UNIT	VALUE GURANTEED BY BIDDER
MINIMUM PURITY OF ALUMINUM	%	
MAXIMUM COPPER CONTENT	%	
MAXIMUM SILICON CONTENT	%	
MAXIMUM ZIRCONIUM CONTENT	%	
MINIMUM ZIRCONIUM CONTENT	%	
MAXIMUM IRON CONTENT	%	
MAXIMUM MANGANESE CONTENT	%	
MAXIMUM CHROMIUM CONTENT	%	
MAXIMUM OTHERS CONTENT (IF ANY)- 1	%	
MAXIMUM OTHERS CONTENT (IF ANY)- 2	%	

3. HTLS CONDUCTOR COMPOSITE CORE

APPLICABLE STANDARD ON CORE:
TYPE OF CORE MATERIAL:

4. CHEMICAL COMPOSITION OF HTLS CONDUCTOR COMPOSITE CORE

Manufacturer's proprietary information. Detailed chemical composition may be furnished by the bidder wherever disclosed by the OEM. Absence of such data shall be acceptable. However, the bidder shall mandatorily indicate the type of composite core material (e.g. carbon fibre / glass fibre based) along with the applicable nationally or internationally accepted standard followed (such as IEC / ASTM / equivalent).

5. HTLS CONDUCTOR CORROSION PROTECTION ENCAPSULATION

APPLICABLE STANDARD ON CORROSION PROTECTION ENCAPSULATION OF CORE:	
TYPE OF CORROSION PROTECTION ENCAPSULATION OF CORE:	

6. CHEMICAL COMPOSITION OF HTLS CONDUCTOR CORROSSION PROTECTION ENCAPSULATION

Manufacturer's proprietary information. Detailed chemical composition may be furnished by the bidder wherever disclosed by the OEM. Absence of such data shall be acceptable. However, the bidder shall mandatorily indicate the type of corrosion protection encapsulation material (e.g. glass fibre annular sleeve or equivalent proven system) along with the applicable nationally or internationally accepted standard followed (such as IEC / ASTM / equivalent).

5. PHYSICAL PARAMETER OF OUTER LAYER STRANDS COUNT:

DESCRIPTION	UNIT	VALUE GURANTEED BY BIDDER
NUMBER OF OUTER LAYERS	NOS	
NO. OF STRANDS 1ST LAYER FROM CORE		

NO. OF STRANDS 2ND LAYER FROM CORE		
NO. OF STRANDS 3RD LAYER FROM CORE		

1. **PHYSICAL PARAMETER OF OUTER LAYER STRANDS DIMENTION:**

DESCRIPTION		VALUE GURANTEED BY BIDDER		
OUTER LAYERS STRANDS DIMENSION	UNIT	LAYER 1	LAYER 2	LAYER 3
NOMINAL	MM			
MAXIMUM	MM			
MINIMUM	MM			

Shaped Aluminium Strands: If the above information is difficult to provide, the bidder shall indicate the total effective aluminium cross-sectional area (mm^2) of the shaped strands offered. The shaped strands shall be manufactured and tested in accordance with the relevant standards specified by the bidder.

Dimensional tolerances and conformity shall be governed by the standards indicated by the bidder.

Compliance with the specified total aluminium area and the applicable standard shall be considered sufficient for technical evaluation.

STANDARD FOLLOWED FOR SHAPE OF STRANDS		
DESCRIPTION	UNIT	VALUE GURANTEED BY BIDDER
COMPLETE ALUMINIUM AREA	SQMM	

2. **MINIMUM BREAKING LOAD OF STRANDS:**

DESCRIPTION	UNIT	VALUE GURANTEED BY BIDDER
BEFORE STRANDING	KN	
AFTER STRANDING	KN	

3. **RESISTANCE OF 1 M LENGTH OF STRAND AT 20 DEG C IN OHM:**
4. **FINAL MODULUS OF ELASTRICITY KG/SQ MM:**
5. **FINAL COEFFICIENT OF LINER EXPANSION OF STRANDS IN PER DEG C:**
6. **PHYSICAL PARAMETER OF CONDUCTOR CORE:**

CORE DIMENSION	UNIT	VALUE GURANTEED BY BIDDER
NOMINAL	MM	
MAXIMUM	MM	
MINIMUM	MM	

1. **MINIMUM BREAKING LOAD OF CORE IN KN:**
2. **FINAL MODULUS OF ELASTRICITY OF CORE IN KG/SQ MM:**
3. **FINAL COEFFICIENT OF LINER EXPANSION OF CORE IN PER DEG C:**
7. **PHYSICAL PARAMETER OF CORROSION PROTECTION ENCAPSULATION:**

ENCAPSULATION DIMENSION	UNIT	VALUE GURANTEED BY BIDDER
NOMINAL THICKNESS	MM	
MAXIMUM THICKNESS	MM	
MINIMUM THICKNESS	MM	

1. **MINIMUM BREAKING LOAD OF PROTECTION ENCAPSULATION IN KN:**
2. **FINAL MODULUS OF ELASTRICITY OF ENCAPSULATION IN KG/SQ MM:**
3. **FINAL COEFFICIENT OF LINER EXPANSION OF ENCAPSULATION IN PER DEG C:**

8. **IF FILLER IS USED, THEN TYPE AND DESIGNATION OF FILLER, CHEMICAL COMPOSITION, MASS OF FILLER IS TO BE NOTED:**
9. **PARTICULARS OF COMPLETE HTLS CONDUCTOR:**

1. **CROSS SECTION DRAWING OF THE OFFERED CONDUCTOR ENCLOSED (YES / NO):**

2. **CALCULATION OF TRANSITION TEMPERATURE ENCLOSED (YES / NO)**

DESCRIPTION	VALUE GURANTEED BY BIDDER		
LAY RATIO OF CONDUCTOR AS PER ASTM B 857	LAYER 1	LAYER 2	LAYER 3
MAXIMUM			
MINIMUM			

3. **OTHER PARAMETER OF THE OFFERED CONDUCTOR:**

DESCRIPTION	UNIT	VALUE GURANTEED BY BIDDER
UTS OF CONDUCTOR	KN	
FINAL MODULUS OF ELASTICITY UPTO TRANSITION TEMPERATURE	KG / SQ MM	
FINAL MODULUS OF ELASTICITY ABOVE TRANSITION TEMPERATURE	KG / SQ MM	
FINAL COEFFICIENT OF LINEAR EXPANSION UPTO TRANSITION TEMPERATURE	PER DEG C	
FINAL COEFFICIENT OF LINEAR EXPANSION ABOVE TRANSITION TEMPERATURE	PER DEG C	
TRANSITION TEMPERATURE (CORRESPONDING TO 55M RULING SPAN AND TENSION AT RULLING CONDITION AS PER SAG TENSION CALCULATION	DEG C	
TRANSITION TEMPERATURE (CORRESPONDING TO 300M RULING SPAN AND TENSION AT RULLING CONDITION AS PER SAG TENSION CALCULATION	DEG C	
MAXIMUM PERMISSIBLE CONDUCTOR TEMPERATURE FOR CONTINUOUS OPERATION	DEG C	
MAXIMUM PERMISSIBLE CONDUCTOR TEMPERATURE FOR SHORT TERM OPERATION	DEG C	
PERMISSIBLE DURATION OF ABOVE SHORT-TERM OPERATION	MINUTES	
STEADY STATE CONDUCTOR TEMPERATURE CORRESPONDING TO SPECIFIED MAXIMUM OPERATING CURRENT 800 A UNDER MAXIMUM AMBIENT CONDITIONS AND ZERO WIND AS PER TECHNICAL SPECIFICATION	DEG	
DC RESISTANCE OF CONDUCTOR AT 20°C	OHM/KM	
AC RESISTANCE AT CONTINUOUS OPERATIONG TEMPERATURE CORRESPONDING TO SPECIFIED OPERATING CURRENT 800 A UNDER MAXIMUM AMBIENT CONDITIONS AND ZERO WIND AS PER TECHNICAL SPECIFICATION	OHM/KM	
AC RESISTANCE AT MAXIMUM CONTINUOUS OPERATIONG TEMPERATURE CORRESPONDING TO SPECIFIED OPERATING CURRENT 800 A UNDER MAXIMUM AMBIENT CONDITIONS AND ZERO WIND AS PER TECHNICAL SPECIFICATION)	OHM/KM	

4. **DETAILED CREEP CHARECTERISTIC OF HTLS CONDUCTOR ENCLOSED (YES / NO)**

5. **DETAILED SAG TENSION CALCULATION OF HTLS CONDUCTOR ENCLOSED (YES / NO)**

SAG TENSION CALCULATION SPAN _____ (55M / 300M)

DESCRIPTION	UNIT	VALUE GURANTEED BY BIDDER
TENSION AT 32 DEG C & NO WIND	KG	

SAG & TENSION AT MAXIMUM CONTINUOUS OPERATIONG TEMPERATURE CORRESPONDING TO SPECIFIED OPERATING CURRENT 800 A UNDER MAXIMUM AMBIENT CONDITIONS AND ZERO WIND AS PER TECHNOCAL SPECIFICATION)	METER & KG	
TENSION FOR 32 DEG C & FULL WIND CONDITION	KG	
TENSION FOR 32 DEG C & NIL WIND CONDITION	KG	
TENSION FOR MINIMUM TEMPERATURE & NIL WIND	KG	
TENSION FOR MINIMUM TEMPERATURE & 36% FULL WIND	KG	
TENSION FOR 32 DEG C & 75% OF FULL WIND CONDITION	KG	
TENSION AT TRANSITION TEMPERATURE	KG	

6. DIRECTION OF LAY FOR OUTSIDE LAYER IN RIGHT HAND SIDE (YES / NO)

DESCRIPTION	UNIT	VALUE GURANTEED BY BIDDER
LINEAR MASS OF CONDUCTOR AS STANDARD	KG / KM	
LINEAR MASS OF CONDUCTOR AS MINIMUM	KG / KM	
LINEAR MASS OF CONDUCTOR AS MAXIMUM	KG / KM	
STANDARD LENGTH OF CONDUCTOR	M	
MAXIMUM LENGTH OF CONDUCTOR THAT CAN BE OFFERED AS SINGLE LENGTH	M	
TOLERANCE ON STANDARD LENGTH OF CONDUCTOR	%	

7. DRUM IS AS PER SPECIFICATION (YES / NO)

8. NO. OF COLD PRESSURE BUTT WELDING EQUIPMENT AVAILABLE AT WORKS:

DATE:

SIGNATURE WITH SEAL