

Date: 02.11.2022
Rev: 00

PROJECT	400 kV D/C Khandukhal (Srinagar) – Rampura (Kashipur) line (Twin HTLS*)
SUPPLIER	Sterlite Power Transmission Ltd / Icomm Tele Ltd/JSK Industries
CLIENT	Central Transmission Utility of India Limited
CONTRACTOR	Khandukhal Rampura Transmission Limited
TITLE OF DRG.	Guaranteed Technical Particulars
DRG. NO.	HTLS -ACSS 494/74

GUARANTEED TECHNICAL PARTICULARS OF HTLS CONDUCTOR			
Sl.No	Description	Unit	Value guaranteed by the Bidder
1	Name & address of Manufacturer		Sterlite Power Transmission Ltd / Icomm Tele Ltd/ JSK Industries Pvt. Ltd
2.1	Type of HTLS Conductor (HTLS Technology)		ACSS – 494/74
2.2	Construction of conductor/ Designation of conductor as per IEC: 1089		Outer – Annealed aluminum (RW+TW) RW LAYER –15/ 4.997 mm TW LAYER– 10/ 5.048*mm Inner – Extra high strength steel core, Class A Zinc coated - 19/2.22 mm
3	PARTICULARS OF RAW MATERIALS		
3.1	Outer Layers		
	a) Applicable Standard (if any)		ASTM B 609/ B 233
	b) Type of Aluminum alloy		Annealed Al. (1350-O Temper)
	c) Minimum purity of aluminum	%	99.50%
	d) Maximum Copper content	%	0.04 %
	e) Zirconium content		
	i) Maximum	%	N/A
	ii) Minimum	%	N/A
	e) Other elements		ASTM B 233
	i) -----	%	Si: 0.10 (max)
	ii) -----	%	Fe :0.40 (max) Mn:0.01 (max) Cr:0.01 (max) Zn:0.05 (max) B:0.05(max) G:0.03(max) Va +Ti:0.02(max) Other element, each, 0.03(max) Other element, total:0.1(max)
3.2	Inner Core		
	a) Applicable Standard (if any)		a) ASTM B 957-08
	b) Material of core		b) Extra High Strength Grade Zinc, Class A Coated
	c) Chemical composition of core		c)
	i) C	%	0.50 to 1.00
	ii) Mn		0.40 to 1.30
	iii) P		0.035, Max
	iv) S		0.045, Max
	v) Si		0.15 to 0.60

3.3	Zinc used for galvanization of inner core (if applicable) a) Minimum purity of zinc	%	99.95	
3.4	Chemical Composition of Misch Metal coating on core wires (if applicable) i) Zinc	%	NA	
	ii) Aluminium	%	NA	
	iii) Other elements	%	NA	
3.5	Aluminium used for Aluminium Cladding (if applicable)			
	a) Minimum purity of aluminium	%	NA	
	b) Maximum Copper content	%	NA	
4	OUTER STRANDS AFTER STRANDING			
4.1	Number of outer layers	Nos.	02	
4.2	Number of strands			
	a) 1st Layer from core	Nos	10 (Trapezoidal wire)	
	b) 2nd Layer from core	Nos	15 (Round wire)	
	c) 3rd Layer from core	Nos	NA	
4.3	Diameter of strands		10 TW	15 RW
	a) Nominal	mm	5.048*	4.997
	b) Maximum	mm	5.098*	5.047
	c) Minimum	mm	4.998*	4.947
4.4	Minimum Breaking load of strand a) Before stranding b) After stranding	kN kN	10 TW 1.20 1.14	15 RW 1.18 1.12
4.5	Resistance of 1 m length of strand at 20 deg. C	Ohm	10 TW 1.395 X 10 ⁻³	15 RW 1.424 X 10 ⁻³
4.6	Final Modulus of elasticity	Kg/m m2	5608	
4.7	Final Coefficient of linear expansion	Per°C	23 x 10 ⁻⁶	
5	INNER CORE STRANDS/ INNER CORE AFTER STRANDING			
5.1	Number of layers in inner core (excluding central wire)		02	
5.2	Number of strands a) 1st Layer from center (excluding central wire) b) 2nd Layer from center c) 3rd Layer from center	Nos Nos Nos	06 12 NA	

5.3	Diameter		
	a) Nominal	mm	2.220
	b) Maximum	mm	2.258
	c) Minimum	mm	2.195
5.4	Minimum Breaking load of strand/core		
	a) Before stranding.	kN	7.06
	b) After stranding	kN	6.71
5.5	Resistance of 1 m length of strand at 20 deg. C	Ohm	53.60 X 10 ⁻³
5.6	Final Modulus of elasticity	Kg/sq. mm	19374
5.7	Final coefficient of linear expansion	Per° C	11.5 x 10 ⁻⁶
5.8	Minimum elongation of strand for a gauge length of 250 mm	%	3.0
5.9	Min. number of torsions	Nos	12 before stranding
			10 after stranding
5.10	Aluminum cladding of steel core		
	a) Thickness of cladding		
	i) Maximum	mm	NA
	ii) Minimum	mm	NA
	b) Minimum no. of twists in a guage length equal to 100 times diameter of wire which the strands can withstand in the torsion test	-	NA
	c) Minimum elongation of strand for a gauge length of 250 mm	%	NA
	d) Resistance of 1m length of strand at 20 deg. C	Ohm	NA
5.11	Galvanising (if applicable)		
	a. Minimum mass of zinc / ~~Misch metal coating~~ per sqm. of uncoated wire surface.	g/m ²	214
	b) Minimum mass of Misch metal coating per sqm. of uncoated wire surface (if applicable).	Nos	NA
	c) Min. no. of twists which a single strand shall withstand during torsion test for a length equal to 100times dia of wire after stranding.	Nos	NA
	d) Minimum elongation of strand for a gauge length of 250 mm	%	NA
6	FILLER (if applicable)		
6.1	Type & Designation of Filler		NA
6.2	Chemical composition of Filler		NA
6.3	Mass of Filler	Kg/Km	NA

7	COMPLETE HTLS CONDUCTOR	EN 50540		
7.1	Cross section drawing of the offered conductor enclosed	Yes/No	Yes (ANNEXURE A)	
7.1.1	Cross section area of annealed aluminium	mm ²	494.29	
7.1.2	Cross section area of Core	mm ²	73.54	
7.1.3	Cross section area of the complete conductor	mm ²	567.83	
7.2	Diameter of conductor			
	a) Nominal	mm	29.98	
	b) Maximum	mm	30.28	
	c) Minimum	mm	29.68	
7.3	UTS (minimum) of Conductor	KN	162.7	
7.3.1	UTS (minimum) of Core	kN	134.2	
7.3.2	UTS (Minimum) of conductor at elevated temp.	KN	113.9	
7.4	Lay ratio of conductor		Max.	Min.
	a) 1 st layer from center (excluding central wire) 6 wire layer		26	16
	b) 2 nd Layer 12 wire steel layer		22	14
	c) 3 rd Layer – 10TW Wire Annealed Aluminium Layer		16	10
	d) 4 th Layer – 15 Wire Aluminium Layer		14	10
7.5	DC resistance of conductor at 20°C	Ohm/km	0.05552	
7.6	Calculated Final Modulus of elasticity			
	a) Upto transition temperature	Kg/sq. mm	7389	
	b) Above transition temperature	Kg/sq. mm	19374	
7.7	Coefficient of linear expansion			
	a) Up-to transition temperature	Per deg C	19.10 x 10 ⁻⁶	
	b) Above transition temperature	Per deg C	11.50 x 10 ⁻⁶	
7.8	Calculation for transition temperature enclosed	Yes/ No	Yes	
7.9	Transition temperature (corresponding to 400 m ruling span and tension at ruling condition as per 7.19)	DegC	85	
7.10	Minimum Corona Extinction Voltage (line to ground) under Dry condition	kV(rms)	320	
7.11	RIV at 1MHz and 305 kV (rms) under dry conditions	Micro-volts	Below 1000 micro volts	

7.12	Maximum permissible conductor temperature for continuous operation	Deg C	180
7.13	Maximum permissible conductor temperature for short term operation	Deg C	200
7.13 a.)	Permissible duration of above short-term operation	Hrs	712 Hrs (Over the life of the conductor)
7.14	Steady state conductor temperature at conductor current of 1516 A and under Ambient conditions detailed in Clause 1.2.1 of Section-II of the Technical Specification (Vol-II)	Deg C	166.83 (ANNEXURE C)
7.14 A.	Conductor core temperature corresponding to the designed maximum temperature of conductor	Deg C	177.98 (ANNEXURE C)
7.15	AC resistance at maximum continuous operating temperature corresponding to specified maximum operating current (1516 A under ambient condition enclosed as per Clause 1.2.1 of Section-II of the Technical Specification)	Ohm/k m	0.0891 (ANNEXURE D)
7.16	Details of Creep characteristic for HTLS conductor enclosed	Yes / No	No (Shall be submitted along with complete test report)
7.19 Sag Tension Calculation (report Attachment 1)			
7.19.1	Sag Tension Calculation enclosed (clause 1.4 of Sec-II of TS)	Yes/ No	YES (ATTACHMENT 1 - for ruling span 400 mtr)
7.19.2	Tension at 32 deg. C & no wind	N	35792
7.19.3	Sag at maximum continuous operating temperature (corresponding to current of 1516 A and Ambient conditions detailed in Clause 1.4 of Section-II of the Technical Specification (Vol-II))	Meters	14.66
7.19.4	Sag of HTLS Conductor for ruling span at minimum temp (0 deg C) and no wind condition (m)	Meters	9.84

7.19.5	Tension at 32°C and full wind condition		-
	180 Kg/m ² wind pressure	N	74241
7.19.6	Tension at transition temperature	N	29655
7.21	Direction of lay for outside layer		Right Hand
7.22	Linear mass of the Conductor		
	a) Standard	Kg/km	1944
	b) Maximum	Kg/km	1983
	c) Minimum	Kg/km	1905
7.23	Standard length of conductor	m	2400
7.24	Maximum length of conductor that can be offered as Single length	m	2520
7.25	Tolerance on standard length of conductor	%	± 5
7.26	Drum is as per specification	Yes/No	Yes
7.27	No. of cold pressure butt welding equipment available at works	Nos.	4

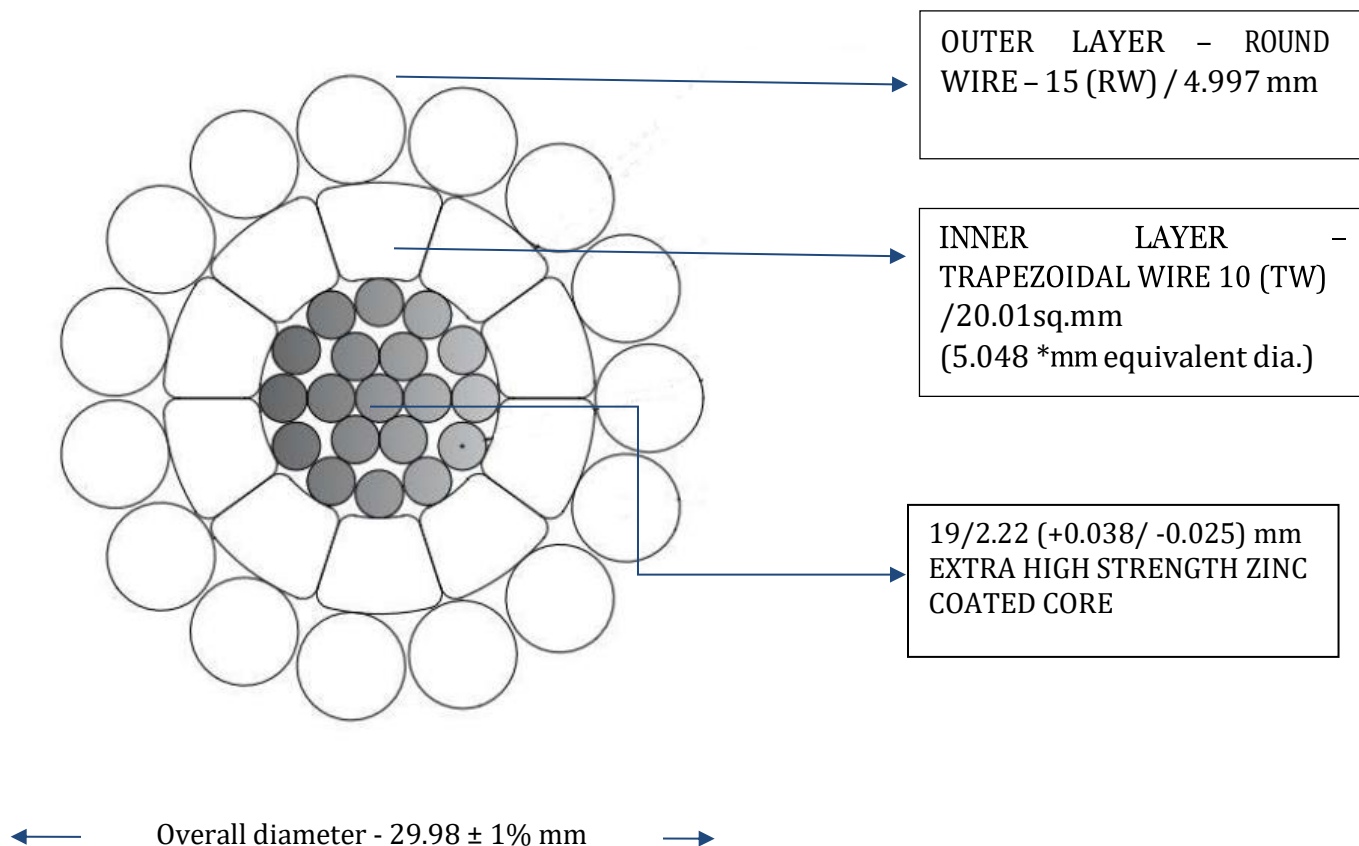
Note: *- TW equivalent diameter of strand can be calculated by complete conductor weight method as per ASTM B-263, based on the total aluminium area, we can calculate individual area/ Diameter of strands. (i.e. TW Al. area / No. of TW Al. strands).

(Signature).....

(Common Seal)

ANNEXURE - A **CROSS SECTION DRAWING**

ACSS - 479/78



ANNEXURE – B

WIR FILE FOR HTLS - ACSS – 494/74

Cable Data
?
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☐ Linear elastic with permanent stretch due to creep specified as a user input temperature increase

Cross section area (mm²)
 Outside diameter (mm)

Unit weight (N/m)
 Ultimate tension (N)

Default Tension (N)

Temperature at which strand data below obtained (deg C)

Number of independent wires (1 unless messenger supporting other wires with a spacer)

☐ Conductor is a J-Power Systems GAP type conductor strung with core supporting all tension.

Outer Strands

 Final modulus of elasticity (MPa/100)
 Thermal expansion coeff. (/100 deg)

Polynomial coefficients (all strains in %, stresses in MPa)

	a0	a1	a2	a3	a4
Stress-strain		61.161	178.61	-361.996	178.057
Creep		61.161	178.61	-361.996	178.057

Note: Final modulus, stress-strain and creep are actual material values multiplied by ratio of outer strand area to total area.

Core Strands

 Final modulus of elasticity (MPa/100)
 Thermal expansion coeff. (/100 deg)

Polynomial coefficients (all strains in %, stresses in MPa)

	b0	b1	b2	b3	b4
Stress-strain		233.487	47.792	-86.178	-17.633
Creep		222.85	38.949	-46.133	-56.019

Note: Final modulus, stress-strain and creep are actual material values multiplied by ratio of core strand area to total area.

Bimetallic Conductor Model...

Aluminum has a larger thermal expansion coefficient than steel. If Aluminum is used as the outer material over a steel core there is a temperature transition point at which the aluminum is no longer under tension.

Select the behavior you want for temperatures above the transition point

☐ Use behavior from Criteria/Bimetallic Conductor Model
☒ Aluminum does not take compression at high temperature (Bird Cage)
☐ Aluminum can go into compression at high temperature

$$\text{VirtualStress} = \text{ActualStress} * A_o / A_t$$

A_o = cross section area of outer strands
 A_t = total cross section area of entire conductor (outer + inner strands)

Maximum virtual compressive stress (MPa)

ANNEXURE – C AMPACITY CALCULATION SHEET for 1516 amps. (AS PER IEEE 738-2012)			
Description	Symbol	Unit	Value
Conductor Code Name	-	-	ACSS - 494/74
Core diameter of conductor	D _{core}	mm	11.10
Outside diameter of conductor	D _o	mm	29.98
Wind Velocity	V _w	m/s	0.56
Solar absorptivity	α	--	0.80
Emissivity	ε	--	0.45
Ambient air temperature	T _a	°C	45
Conductor Temperature	T_c	°C	166.83
Constant of Mass Temperature Coefficient	α	/°C	0.00403
Total solar and sky radiated heat intensity	Q _s	W/m ²	1045
Elevation of conductor above sea level	He	m	0
Air Film temperature	T _{film}	°C	105.91
Projected area of conductor per unit length	A'	m ² /linear m	0.02998
Air density, $\rho_f = \frac{1.293 - 1.525 \cdot 10^{-4} \cdot H_e + 6.379 \cdot 10^{-9} \cdot H_e^2}{1 + 0.00367 \cdot T_{film}} \quad [kg/m^3]$	ρ _f	Kg/m ³	9.311 x 10 ⁻¹
Dynamic viscosity of air $\mu_f = \frac{1.458 \cdot 10^{-6} \cdot (T_{film} + 273)^{1.5}}{T_{film} + 383.4} \quad [kg/m-s \text{ or } N-s/m^2]$	μ _f	Kg/m-s	2.198 x 10 ⁻⁵
Thermal Conductivity of air	k _f	W/m.°C	3.211 x 10 ⁻²
1. CONVECTIVE HEAT LOSS (q_c)			
Forced convection heat loss rate $q_{c1} = K_{angle} \cdot [1.01 + 1.35 \cdot N_{Re}^{0.52}] \cdot k_f \cdot (T_s - T_a) \quad [watts/ft \text{ or } watts/m]$ $q_{c2} = K_{angle} \cdot 0.754 \cdot N_{Re}^{0.6} \cdot k_f \cdot (T_s - T_a) \quad [watts/m \text{ or } watts/ft]$	q _{c1}	W/m.	164.56
Natural convection $q_{cn} = 3.645 \cdot \rho_f^{0.5} \cdot D_o^{0.75} \cdot (T_s - T_a)^{1.25} \quad W/m$	q _{c2}	W/m	151.69
Since the wind speed is greater than zero, the forced convection heat loss for perpendicular wind is calculated according to above Equation with K angle = 1, direction and compared to the natural convection heat loss. The largest of the heat losses due to both natural and forced heat convection is used to calculate the thermal rating.			
2. RADIATED HEAT LOSS RATE (q_r)			
$q_r = 17.8 \cdot D_o \cdot \varepsilon \cdot \left[\left(\frac{T_s + 273}{100} \right)^4 - \left(\frac{T_a + 273}{100} \right)^4 \right] \quad W/m$	q _r	W/m	65,308
The constant in Equation below include the Stefan – Boltzmann constant and conversion factors to produce a result in the desired units			
3. SOLAR HEAT GAIN (q_s)			
$q_s = \alpha \cdot Q_{se} \cdot \sin(\theta) \cdot A' \quad [W/m \text{ or } W/ft]$ where: $\theta = \arccos [\cos(H_e) \cdot \cos(Z_e - Z_1)]$	q _s	W/m	25.063
Effective Angle of incidence of Sun ray	θ	°	90
STEADY STATE THERMAL RATting $I = \sqrt{\frac{q_c + q_r - q_s}{R(T_{avg})}}$	I	Amp	1516
Radial temperature gradient within the conductor (as per cl. No. 4.4.7)	T _{core}	Deg.C	11.15
Conductor core temperature corresponding to the designed maximum temperature of conductor	T_s	Deg.C	177.98

ANNEXUER – D Rac CALCULATION SHEET			
Resistance at 166.83 °C (R ac) calculated for 1516 Amps			
Description	Symbol	Unit	Value
Conductor Code Name	-	-	ACSS – 494/74
Core diameter of conductor	D _{core}	mm	11.10
Outside diameter of conductor	D _o	mm	29.98
Electrical (DC) Resistance @20C	R _{dc}	Ohm/km	0.05552
Constant of Mass Temperature Coefficient	α	/°C	0.00403
Electrical (DC) Resistance @ Temperature T	R _{t dc}	Ohm/km	0.0884
Conductor Temperature	T _c	°C	166.83
CALULATION			
mr = 0.3544938 / (R _{dc}) ^{1/2}	-	-	1.1925
n = 4 - 0.0616 + 0.0896 X mr – 0.0513 X (mr) ² - If mr < 2.8	-	-	3.9723
n = 4 + 0.5363 - 0.2949 X mr + 0.0097 X (mr) ² - if mr > 2.8 < 5.0	-	-	--
p = 0.7 + 0.11 X mr – 0.04 X mr ² + 0.0094 X mr ³	-	-	0.7902
k1, {cos (90 (d/D) P)} ^{2.35}	-	-	0.5154
K2 = 0.15 for single aluminium layer HTLS conductor = 0.03 for three aluminium layer HTLS conductor = <u>0.003 for two or four aluminium layer HTLS conductor</u> = 0 for composite core type HTLS conductor	-	-	0.003
Rac @ 166.83 °C Temperature =	Rac	Ohm/km	0.0891