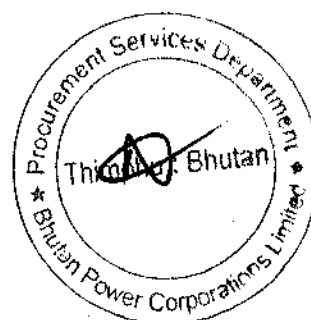


**TECHNICAL SPECIFICATION OF THE LOTS**



**Lot 1-XLPE Cables and Lot 2- PVC Cables.**

**1.0 Scope**

This specification covers the design, manufacture and testing of cables at manufacture's work before dispatch, packing and transportation to BPC stores.

**2.0 Design Criteria**

**2.1 Standards**

The cables under this specification shall comply with the requirements of latest edition of the following standards including amendments:

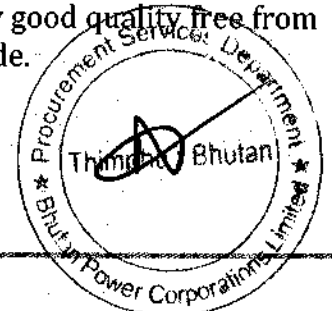
IEC: 60183, 60227,60502, 60885, 50480 IS (Indian standards): 1554 (Part-I) IS: 1753 IS: 3961 Part-II IS: 3975 IS: 4905, IS:5831, IS: 7098 (Part- III), IS: 7098 (Part-II), IS: 7098 (Part-I), IS: 8130, IS: 10418, IS: 10810, ASTM D 2863, IEEE-383, IEC-332 (Part-I), IEC-754 (Part-I), ASTM D - 2843, SS-4241475, (Swedish standard)

**2.2 Cable Design**

- i) The cables shall be suitable for installation in a monsoon area having 100% relative humidity and low temperature which is likely to accelerate rusting in steel. However for the reference ambient temperature may be taken as 40° C with the relative of 100%. The galvanizing of steel armour has to be of the highest quantity for such an ambient condition.
- ii) The cable shall operate with the following requirements.
  - a) Maximum continuous conductor temperature and allowable conductor temperature during short circuit shall be taken as 70°C and 160°C respectively for PVC insulated and 90°C and 250°C respectively in case of XLPE insulated cable.
  - b) Frequency variation  $\pm 5\%$ , voltage variation  $\pm 10\%$  and combined frequency and voltage variation of  $\pm 10\%$ .
- iii) Amongst the various standards given above, for design, stringent conditions specified in the above standards shall be applicable.

**2.3 General Technical Requirement**

- i) The cables shall be suitable for laying in racks, ducts, covered trenches, conduits and underground buried installation with chances of flooding by water.
- ii) Cables shall be designed to withstand mechanical, electrical and thermal stresses developed under steady state and transient operating conditions.
- iii) The aluminium/copper wires used for manufacturing the cables shall be true circular in shape before stranding and shall be of uniformly good quality free from defects. All aluminium used in the cables shall be of H2 grade.



## Section VII- Schedule of Supply

- iv) Aluminium conductor used in power cables shall have tensile strength of more than 100N/sq. mm. The conductor of control cables shall be manufactured from plain annealed copper. All the conductors shall be multi-stranded.
- v) PVC insulation shall be suitable for continuous conductor temperature of 70°C and short circuit conductor temperature of 160°C. XLPE insulation shall be suitable for continuous conductor temperature of 90°C and short circuit conductor temperature of 250°C.
- vi) The cable cores shall be laid up with fillers between the cores wherever necessary. It should not stick to insulation and inner sheath. All the cables, other than single core un-armoured cable shall have distinct extruded PVC inner sheath black in colour as per IS 5831.
- vii) The fillers and inner sheath shall be of non-hygroscopic flame retardant material shall be softer than insulation and outer sheath shall be suitable for the operation temperature of the cable.
- viii) The armouring shall be of galvanized steel as follows:

Calculated nominal size & diameter of cable under armour	Type of armour
a) Upto 13 mm	1.4 mm dia GS wire
b) Above 13 up-to 25 mm	0.8 mm thick GS strip/1.6 mm dia GS wire
c) Above 25 up-to 40 mm	0.8 mm thick GS strip/2.0 mm dia GS wire
d) Above 40 up-to 55 mm	1.4 mm thick GS strip/2.5 mm dia GS wire
e) Above 55 up-to 70 mm	1.4 mm thick GS strip/3.15 mm dia GS wire
f) Above 70 mm	1.4 mm thick GS strip/4 mm dia GS wire

The gap between armour wire/strip shall not exceed one armour wire/strip space and there shall be no cross over/over-riding of armour wire/strip. The minimum area of coverage of armouring shall be 90%. The breaking load of armour joint shall not be less than 95% of that of armour wire/strip. Zinc rich paint shall be applied on armour joint surface.

- ix) Suitable chemicals shall be added to the outer sheaths of all cables to protect them from rodent and termite attack. These chemicals shall not have any harmful effect on the human being.
- x) The normal current rating of all PVC insulated cables shall be as per IS-3961 and should suit the duty requirements for which it is intended.
- xi) Outer sheath shall be of PVC black in colour for power cables and grey in colour for control cables.
- xii) Cores of the cables of up-to 5 cores shall be identified by colouring of insulation. Following colour scheme shall be adopted:

- 1 core - Red, Black, Yellow & Blue
- 2 core - Red & Black
- 3 core - Red, Yellow & Blue
- 4 core - Red, Yellow, Blue & Black
- 5 core - Red, Yellow, Blue, Black & Grey

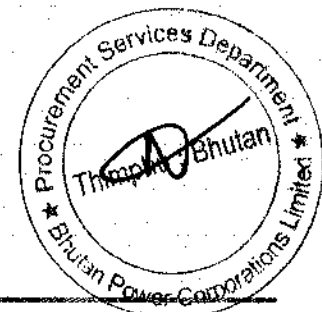
- xiii) For reduced neutral conductors the core shall be black.
- xiv) For cables having more than 5 cores, core identification shall be done by numbering insulation of core sequentially, starting by number 1 in the inner layer (e.g. say for 10 core cable, core numbering shall be from 1 to 10). All the numbers shall be of same colour, which shall contrast with the colour of insulation. The colour of the insulation for all the cores shall be grey only. The numerals shall be legible and indelible. The numbers shall be repeated at regular intervals along the core, consecutive numbers being inverted in relation to each other. When number is a single numeral, a dash shall be placed underneath it. If the number consists of two numerals, these shall be disposed one below the other and a dash placed below the lower numeral. The spacing between consecutive numbers shall not exceed 50 mm.
- xv) In addition to manufacturer's identification on cables as per IS/IEC, following marking shall also be embossed over outer sheath.
  - a) Cable size and voltage grade.
  - b) Sequential marking of length of the cable in meters at every one meter. The embossing shall be progressive, automatic, on line and marking shall be legible and indelible.
- xvi) Allowable tolerance on the overall diameter of the cables shall be  $\pm 2$  mm maximum, over the declared value in the technical data sheets.
- xvii) In plant repairs to the cables shall not be accepted.
- xviii) Identification of cores - the insulated cores of HT and LT power cables shall be identified by coloured code. The control cables shall have identification by means of indelible printing of numbers on its cores at intervals not more than 75 mm. At least 20% cores shall be kept as spares in the multi core control cables.

### **3.0 General Constructional Requirements**

#### **3.1 General**

The power cables, control cables, PVC cables are required for the power supply, control and protection of various equipment.

#### **3.2 Type Of Cable**



The cable shall be multi core/single core (XLPE), PVC and any polymeric/elastomeric insulation type as specified in the Price Schedule.

### 3.3 Conductor

The cable conductor shall be made from stranded copper/aluminium to form compact conductor having a resistance within the limits specified in IS: 8130.

All the cables of size 25mm<sup>2</sup> and above shall have sector shaped conductors. The minimum no. of strands in conductor shall be 7 (seven) except as otherwise specified. Power cables shall be of stranded aluminium conductor with a minimum size 6 mm<sup>2</sup> and the control cables shall be stranded copper (electrolytic) conductor with a minimum size of 2.5 mm<sup>2</sup>.

### 3.4 Conductor (Shield)

The conductor having a semi-conducting screen shall ensure perfectly smooth profile and avoid stress concentration. The conductor screen shall be extruded in the same operation as the insulation; the semi-conducting polymer shall be cross-linked for XLPE cables.

### 3.5 Insulation

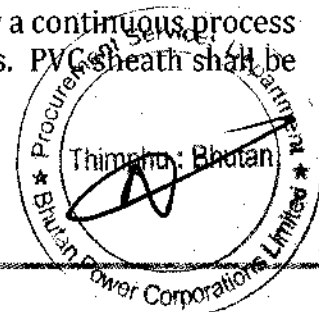
The insulation of the cable shall be extruded type and shall be designed and manufactured for the specified system voltage. The manufacturing process shall ensure that insulation shall be free from voids. The insulation shall withstand mechanical and thermal stresses under steady state and transient operating conditions. The extrusion method should give very smooth interface between semi-conducting screen and insulation. The insulation of the cables shall be of high standard quality. The minimum volume resistivity of the PVC insulation of all the PVC insulated cables shall be  $1 \times 10^{14}$  ohm cm at 27<sup>o</sup> C and  $1 \times 10^{11}$  ohm cm at 70<sup>o</sup> C.

### 3.6 Insulation Shield

In cables to confine electrical field to the insulation, a non-magnetic semi-conducting shield shall be put over the insulation. The insulation shield shall be extruded in the same operation as the conductor shield and the insulation by triple extrusion/process. The cable insulation shield shall be strippable. Metallic screening of appropriate size as per the cable fault level given in this specification shall be provided. Copper tape shall be wrapped helically with 100% coverage. Appropriate shall be 0.04mm.

### 3.7 Sheath

The sheath shall be suitable to withstand the site conditions and the desired temperature. It shall be of adequate thickness and applied by a continuous process to produce a sheath of consistent quality free from all defects. PVC sheath shall be extruded.



- i) The conductor screen, XLPE insulation and insulation screen shall all be extruded in one operation by 'Triple Extrusion' process to ensure perfect bonding between the layers. The core identification shall be by coloured strips or by printed numerals.
- ii) The inner sheath shall be applied over the laid up cores by extrusion and shall conform to the requirements of type ST2 compound of IS: 5831. The extruded inner sheath shall be of uniform thickness.
- iii) The outer sheath of the cables shall be applied by extrusion over the armouring and shall be of PVC compound conforming to the requirements of type ST2 compound of IS: 5831. The thickness of outer sheath shall be as per amendment no.1 of table 5 of IS: 7098 Part-2 (Column 3 & 5 for both armoured and un-armoured cables).
- iv) The dimensions of the insulation, inner sheath and armour materials shall be governed by values given in Tables 2, 3 & 4 (Method 3) of IS: 7098 Part-II.

### 3.8 Armour

Hard drawn aluminium wire armouring/galvanized steel tape/wire armouring shall be used for single core and multi core cable, respectively. The hard drawn aluminium wire for armour shall be of H4 grade, as per IS: 8130 (having tensile strength above 150 N/mm<sup>2</sup>). The diameter of the aluminium wire shall be as per the table for the dimensions of the galvanized steel wire armour given in the relevant standard.

### 3.9 Serving/Cutter Sheath

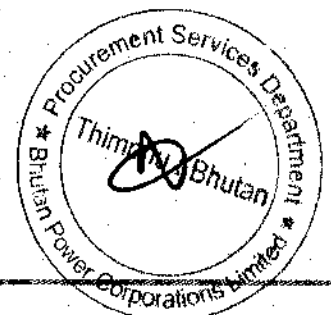
Extruded PVC serving as per IS: 5831 or as specified otherwise shall be applied over the armouring with suitable additives to prevent attack by rodent and termites. All serving must be given anti-termite treatment.

### 3.10 Construction

Cable shall have suitable fillers laid up with the conductors to provide a substantially circular cross section before the sheath is applied. Fillers shall be suitable for the operating temperature of the cable and compatible with the insulating material. All materials shall be new, unused and of finest quality. Workmanship shall be neat, clean and of highest grade.

#### (a) 33kV and 11 kV System – Power Cable

The cable shall be 33 kV and 11 kV (earthed system) grade, heavy duty, stranded aluminium conductor, XLPE insulated, provided with conductor screening and insulation screening, galvanized steel wire/strip armoured, extruded PVC of Type ST2 outer sheathed, as per system requirement, wherever these cables are needed. The cables shall conform to IS: 7098 (Part II) or IEC 60502-2.



(b) 415V System

The cable shall be 1.1 kV, grade, heavy duty, stranded aluminium conductor, PVC Type-A Insulated galvanized steel, wire/strip armoured, extruded PVC type STI outer sheathed.

(c) Control Cables

The cable shall be 1.1 kV grade, heavy duty, multi core stranded (7 wires) tinned copper (annealed) conductor, PVC Type-A insulated, galvanized steel wire/strip armoured, flame retardant low smoke (FPLS) extruded PVC of type-ST1 outer sheathed. The following sizes shall be used.

**4.0 Cable Drums**

4.1 LV and control cables shall be supplied in non-returnable wooden drums. HV cables shall be supplied in a steel drum. The covers with wood is acceptable. The wood used for construction for the drum shall made from hard wood, be properly seasoned, sound and free from defects. Wood preservative shall be applied to the entire drum.

4.2 Bidder shall indicate in the offer the standard length for each size of power and control cable which can be furnished on one drum. The cable length per drum shall be subject to tolerance of  $\pm 0.5\%$  of the standard drums length. The bidders shall take into consideration the wastages in the pricing and quote accordingly. IS tolerance shall not be applicable.

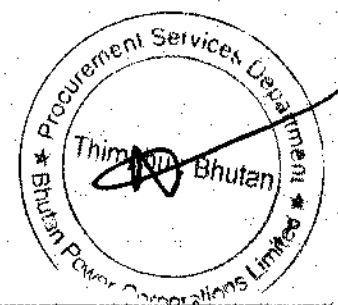
However the cable drums shall be selected so those through joints are eliminated. Typical drum lengths shall be as follows:

a)	33/11kV grade Power Cables up to 300 sq.mm	250 m
b)	1.1 kV grade cables:	
--	Including and above 240 mm <sup>2</sup>	250 m
--	Below 240 mm <sup>2</sup> size and up to 150 sq.mm	500 m
--	Below 150 mm <sup>2</sup> size and up to 50 sq.mm	1000 m
--	Below 35 mm <sup>2</sup> sizes	2000 m

4.3 A layer of PVC sheet shall be applied to the surfaces of the drums and over the outer most cables layer. A clear space of at least 40 mm shall be left between the cables and the logging.

4.4 Each drum shall have the following information stencilled on it in indelible ink:

- i. Contract/specification No.
- ii. Name and address of the consignee
- iii. Makers name and address
- iv. Drum No.
- v. Size of cable, code name and length of cable in meter



- vi. Gross weight of the drum with protective lagging including cable
- vii. Weight of the empty drum with protective lagging.
- viii. Net weight of the cable.
- ix. Arrow marking of unwinding position of the cable end, lot number.

4.5 Packing shall be sturdy and adequate to protect the cables from any injury due to mishandling or other conditions encountered during transportation handling and storage. Both cable ends shall be sealed with PVC/Rubber caps so as to eliminate ingress of water during transportation, storage and erection.

## 5.0 Minimum Technical Requirements.

### 5.1 Underground Distribution Cable

The standard 33 kV & 11 kV cable for underground distribution is cross-linked polyethylene insulated, PVC sheathed, cable manufactured to IS 7098 Part II or IEC 60502-2. Cables shall be steel wire or steel tape armoured for more than 1 core whereas for single core, armouring shall be aluminium wire or aluminium tape.

The current carrying capacity of buried cables depends on the installation conditions, such as the thermal resistance of the soil and the presence of other cables. Manufacturers provide cable ratings for cable installed under defined conditions, which may not reflect the actual installation conditions in a particular situation. In order to provide for these uncertainties, the maximum design current for any underground cable should generally be limited to 90% of the ratings.

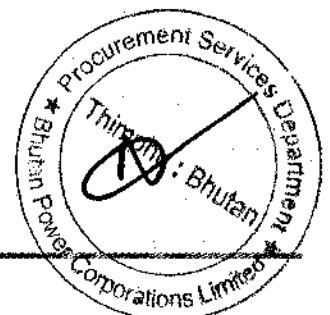
### 5.2 400 V Cable

BPC's standard 400 V underground cable is aluminium conductor, PVC insulated, PVC sheathed, manufactured to IS 1554 (Part I). Cables are four or two core with the neutral conductor having the same cross sectional area as the phase conductors. Cables shall be steel wire or steel tape armoured for more than 1 core whereas for single core, armouring shall be aluminium wire or aluminium tape.

### 5.3 Low Voltage Overhead Service Cable

Low voltage overhead service cable shall be 650/1100 V two core or four core stranded copper conductor, PVC insulated, with high conductivity hard drawn copper conductors. The cable shall have an extruded PVC sheath in accordance with IEC 60502-1.

Single core copper cable with a neutral screen is an acceptable alternative to the twin conductor cable currently used. For three phase supplies three core plus neutral screen cable may be used. Neutral screen cable is considered safer for overhead service drops because the neutral conductor completely surrounds the phase conductor.





## Lot 3: ACSR Conductors

### 1.0 General

#### 1.1 Scope of Supply

This section covers the requirements for the design, manufacture, testing, delivery and unloading at BPC stores of overhead ACSR conductors.

#### 1.2 Standards

The latest edition of the international standards shall apply, in particular:

- BS 215 Aluminium conductors steel reinforced for overhead power transmission
- IEC 888 Zinc coated steel wires for stranded conductors
- IEC 889 Hard drawn aluminium wire for overhead line conductors
- IEC 1089 Round wire concentric lay overhead electrical stranded conductors
- IS 398 (Part II)

### 1.3 ACSR Conductor

#### 1.3.1 General

Bare aluminium conductors, steel reinforced (ACSR) are proposed to be used for MV overhead distribution lines. ACSR conductor consists of seven or more aluminium and galvanized steel wires built up in concentric layers. The centre wire is of galvanized steel and the outer layer is of aluminium as per IS: 398 (Part II).

#### 1.3.2 Construction

Construction of conductors shall be as per BS 215. The sizes and properties of the ACSR conductors shall be as given in the table below. The code names given are only for the purpose of easy identification. Conductors with equivalent or superior parameters to those specified herein will be considered acceptable. However, no credit will be given for the same.

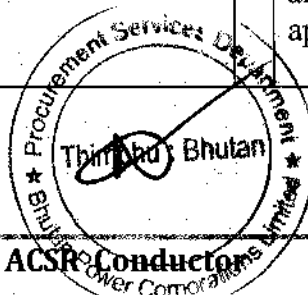
**Table 1: Characteristics of Bare Overhead Line Conductors**

Parameter	WOLF	DOG	RABBIT
Conductor Type	ACSR		
Nominal area (mm <sup>2</sup> )	150	100	50
Aluminium area (mm <sup>2</sup> )	158	105	53
Equivalent copper area (mm <sup>2</sup> )	96	64	32
Stranding and wire dia (mm)	30/2.59 Al.	6/4.72 Al.	6/3.35 Al.
	7/2.59 Steel	7/1.57 Steel	1/3.35 Steel
Conductor diameter (mm)	18.1	14.2	10.1

## Section VII- Schedule of Supply

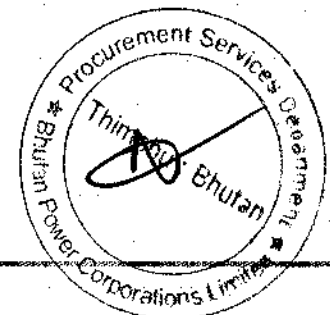
Approximate mass (kg/km)	730	390	210
Minimum breaking load (kN)	69.2	32.7	18.4
DC resistance at 20°C (ohms/km)	0.1831	0.2745	0.5449
AC resistance at 75°C (ohms/km)	0.22	0.33	0.66
Approx inductive reactance (ohms/km)	0.257	0.276	0.397
Approximate voltage drop (mV/A/m) <sup>1</sup>	0.586	0.745	1.334
Full load current - (A) <sup>2</sup>	405	291	190

1.	<b>Type of conductor</b>	:	<b>ACSR Panther Conductor.</b>
2.	Applicable standards	:	IS - 398/ IEC 1089, IEC 888, IEC 189.
3.	<b>Nominal area of aluminum</b>	:	<b>200 Sq.mm.</b>
4.	Sectional area of aluminum	:	212.10 Sq.mm.
5.	Total sectional area of aluminum	:	261.50 Sq.mm.
6.	Number of stranding and wire diameter	:	
	a. Aluminum	:	30/3.00 mm.
	b. Steel	:	7/3.00 mm.
7.	Overall diameter of Al + Steel	:	21 mm.
8.	Weight mass of ACSR conductor	:	
	a. Overall weight	:	976.00 Kg/Km.
	b. Weight of Aluminum	:	588.50 Kg/Km.
	c. Weight of steel	:	387.50 Kg/Km.
9.	<b>Calculated resistance at 20°C (maximum.)</b>	:	<b>0.1400 Ohms/Km.</b>
10.	Ultimate tensile strength (minimum).	:	86.58 kN.
11.	<b>Conductor current carrying capacities</b>	:	
	a. Current carrying at 65°C.	:	395 Amps. (Approx.)
	b. Current carrying at 75°C.	:	487 Amps. (Approx.)
12.	<b>Joints in strands</b>	:	
	a. Steel.	:	Not permitted.
	b. Aluminum wires.	:	No joint shall be permitted in the Aluminum wires in outer most layer of ACSR conductor. But permitted in the inner layer such that no two such joints are within 15 meters of each other in the complete stranded conductor.
13.	Materials for construction of ACSR conductor.	:	The conductor shall be constructed of hard-drawn aluminum and aluminized steel wires as per above applicable IS & IEC standards.



Section VII- Schedule of Supply

Sl.	Technical Particulars:	
1.	Type of conductor	: ACSR Zebra Conductor.
2.	Applicable standards	: IS – 398/ IEC 1089, IEC 888, IEC 189.
3.	Nominal area of aluminum	: 420 Sq.mm.
4.	Sectional area of aluminum	: 428.90 Sq.mm.
5.	Total sectional area of aluminum	: 484.50 Sq.mm.
6.	Number of stranding and wire diameter	:
	a. Aluminum	: 54/3.18 mm.
	b. Steel	: 7/3.18 mm.
7.	Overall diameter of Al + Steel	: 28.62 mm.
8.	Weight mass of ACSR conductor	:
	a. Overall weight	: 1621 Kg/Km.
	b. Weight of Aluminum	: 1182 Kg/Km.
	c. Weight of steel	: 439 Kg/Km.
9.	Calculated resistance at 20°C (maximum.)	: 0.06915 Ohms/Km.
10.	Ultimate tensile strength (minimum).	: 121.45 kN.
11.	Conductor current carrying capacities	:
	a. Current carrying at 65°C.	: 590.00 Amps. (Approx.)
	b. Current carrying at 75°C.	: 737.00 Amps. (Approx.)
12.	Joints in strands	:
	a. Steel.	: Not permitted.
	b. Aluminum wires.	: No joint shall be permitted in the Aluminum wires in outer most layer of ACSR conductor. But permitted in the inner layer such that no two such joints are within 15 meters of each other in the complete stranded conductor.
13.	Materials for construction of ACSR conductor.	: The conductor shall be constructed of hard-drawn aluminum and aluminized steel wires as per above applicable IS & IEC standards.



Note:

1. Phase to phase voltage drop on a balance three phase circuit.
2. Ambient temperature 40°C, conductor temperature of 75°C and wind speed of 1m/sec.

While it is noted that all the above details such as conductor code names, sizes and other parameters given may not be covered by IEC standards, all other requirements applicable to individual wire/strand and the whole conductor shall conform to these standards.

### 1.3.3 Galvanizing

The zinc content in the slab zinc and the method of zinc coating shall be as per IEC standards.

The mass of zinc coating shall correspond to Class 1 of IEC 888.

### 1.3.4 Greasing

The steel cores and the inner layers of aluminium wires (where more than one aluminium layer exists) shall be protected with special grease in order to provide additional protection against corrosion. The grease shall fill the whole space between wires within circumscribed cylinder at inner aluminium layer or at steel core, if the conductor has only one aluminium layer. The application of grease shall correspond to Case 1 of IEC 1089.

The grease shall be chemically neutral with respect to aluminium, zinc and steel. It shall withstand severe weather conditions prevailing in Bhutan and a temperature of 85°C continuously without alteration of its properties. It shall have a drop point of not less than 120°C.

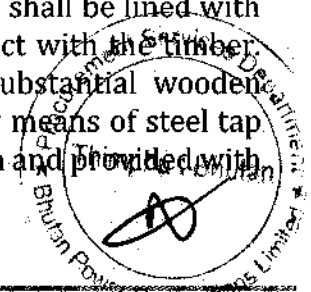
### 1.3.5 Conductor Drums

Conductors shall be supplied on drums in one continuous length. Maximum length of conductor on each drum shall be 4500 m for Rabbit and 2500 m for Dog and 2000 m for Wolf conductor.

The conductor shall be supplied on non-returnable wooden drum generally conforming to IS: 1778-1961 except where otherwise specified hereafter.

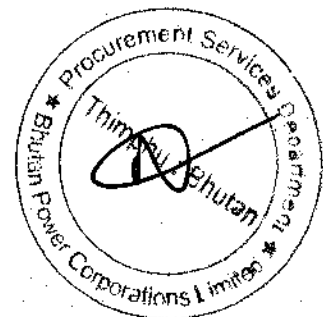
After reeling the conductor, the exposed surface of the outer layer of the conductor shall be wrapped with plastic sheet to protect the conductor from dirt, grit and damaged during transport and handling.

The wooden drums should be treated to an approved international standard by vacuum impregnation with copper-chrome-arsenate (CCA) preservative to resist rotting and termite and fungus attacks. The interior of the drums shall be lined with bituminous paper to prevent the conductor from being in contact with the timber. Drums shall be adequately protected by securely fastening substantial wooden battens around the periphery. These battens shall be secured by means of steel tap bindings. The drums shall be of seasonal hardwood strong enough and provided with



lagging of adequate thickness and strength constructed to protect the conductor against all damages and displacement during transit, storage and subsequent handling at site. Spindle plates to be mounted/fixed on all the conductor drums offered. The conductor ends shall be properly sealed and secured with the help of U-nails or bolts on side of the flanges to avoid loosening of the conductors during transit handling. Each drum shall have the following information stencilled on it in indelible ink:

- a. Contract/specification No.
- b. Name and address of the consignee
- c. Makers name and address
- d. Drum No.
- e. Size of conductor, code name and length of conductor in mtr.
- f. Gross weight of the drum with protective lagging including conductor.
- g. Weight of the empty drum with protective lagging.
- h. Net weight of the conductor.
- i. Arrow marking of unwinding position of the conductor end, lot number.



## Technical Specification for ACSR Moose

### 1. Details of Conductor

The ACSR Moose Conductor shall generally conform to IEC: 1089/ IS: 398 except where otherwise specified herein.

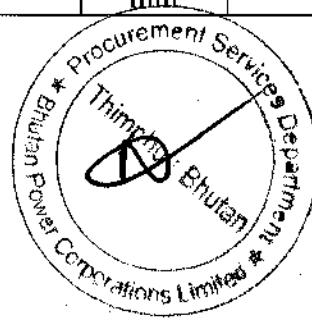
#### 1.1 The salient parameters of the ACSR Conductor are indicated below.

SL#	Description	Value
a)	Stranding and wire diameter	54/3.53 mm Al. Alloy + 7/3.53 mm steel
b)	Number of Strands	
	Steel Core	
	1 <sup>st</sup> Steel Layer	1
	2 <sup>nd</sup> Steel layer	6
	1 <sup>st</sup> Aluminium Alloy Layer	12
	2 <sup>nd</sup> Aluminium Alloy layer	18
	3 <sup>rd</sup> Aluminium Alloy Layer	24
c)	Sectional area of Aluminium Alloy	528.5
d)	Total sectional area	597.0
e)	Overall diameter (mm)	31.77

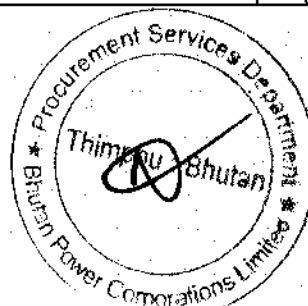
#### 1.2 Standard Technical Particulars

The standard Technical Particulars (STP) of the ACSR conductor are as below. The values indicated in the STP are the minimum and/ or maximum values required to be met by the supplier.

Sl.	Description	Unit	Value
<b>1.0</b>	<b>Raw Materials</b>		
<b>1.1</b>	<b>Aluminium</b>		
a)	Minimum purity of Aluminium	%	99.50
b)	Maximum copper content	%	0.04
<b>1.2</b>	<b>Steel wires/rods</b>		
a)	Carbon	%	0.50 to 0.85
b)	Manganese	%	0.50 to 1.10
c)	Phosphorous	%	Not more than 0.035
d)	Sulphur	%	Not more than 0.045
e)	Silicon	%	0.10 to 0.35 (max)
<b>1.3</b>	<b>Zinc</b>		
a)	Minimum purity of zinc	%	99.95
<b>2.0</b>	<b>Aluminium strands after stranding</b>		
<b>2.1</b>	<b>Diameter</b>		
a)	Nominal	mm	3.53
b)	Maximum	mm	3.55



C)	Minimum	mm	3.51	
2.2	Minimum breaking load of strand			
a)	Before stranding	kN	1.57	
b)	After stranding	kN	1.49	
2.3	Maximum resistance of 1 m length of strand at 20 deg. C	Ohm	0.002921	
<b>3.0</b>	<b>Steel strand after stranding</b>			
3.1	Diameter			
a)	Nominal	mm	3.53	
b)	Maximum	mm	3.59	
c)	Minimum	mm	3.47	
3.2	Minimum breaking load of strand			
a)	Before stranding	kN	12.63	
b)	After stranding	kN	11.99	
<b>3.3</b>	<b>Galvanizing</b>			
a)	Minimum weight of zinc coating per sq. mm	gm	250	
b)	Minimum number of dips that the galvanized strand can withstand in the standard preece test.	No.	2 dips of 1 minute and 1 dip of half minute	
c)	Minimum number of twist in guage length equal 100 times the dia. of wire which the strand can withstand in torsion test (after stranding)	No.	16	
<b>4</b>	<b>Stranded Conductor</b>			
4.1	UTS of the Conductor	kN	161.20 (Min.)	
4.2	Lay length of outer steel layer		Max.	Min.
a)	Outer steel layer	mm	18	16
b)	12 wire Al. Alloy layer	mm	14	12
c)	18 wire Al. Alloy layer	mm	13	11
d)	24 wire Al. Alloy layer	mm	12	10
4.3	DC resistance of the conductor at 20°C	$\Omega$ /km	0.05552	
4.4	Minimum corona extinction voltage (line to phase) under dry condition	kV (rms)	320	
4.5	RIV at 1 Mhz at 305 Amp (line to phase) under dry condition	Micro Volts	Below 1000	
4.6	Standard length of the conductor	m	1800	
4.7	Tolerance on standard length	%	(+/-)5	
4.8	Direction of lay of outer layer		Right Hand	
4.9	Linear mass of the conductor			
a)	Standard	Kg/km	2004	
b)	Minimum	Kg/km	1969	
c)	Maximum	Kg/km	2040	



### **1.3 Workmanship**

All the Aluminium Alloy and steel strands shall be smooth, uniform and free from all imperfections, such as spills and splits, die marks, scratches, abrasions, etc., after drawing and also after stranding.

The finished conductor shall be smooth, compact, uniform and free from all imperfections including kinks (protrusion of wires), wires cross over, over riding, looseness (wire being dislocated by finger/hand pressure and /or unusual bangle noise on tapping), material inclusions, white rust, powder formation or black spot (on account of reaction with trapped rain water etc.), dirt, grit etc.

The steel strands shall be hot dip galvanized and shall have a minimum zinc coating as indicated in the STP. The zinc coating shall be smooth, continuous, of uniform thickness, free from imperfections and shall withstand number of dips in standard preece test as indicated in STP. The steel wire rods shall be of such quality and purity that, when drawn to the size of the strands specified and coated with zinc, the finished strands and the individual wires shall be of uniform quality and have the same properties and characteristics as prescribed in IEC: 888.

The steel strands shall be preformed and post formed in order to prevent spreading of strands in the event of cutting of composite core wire. Care shall be taken to avoid, damages to galvanization during pre-forming and post-forming operation.

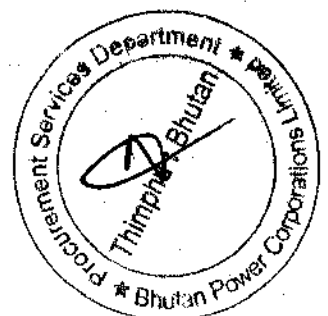
### **1.4 Joints in Wires**

#### **1.4.1 Aluminium alloy Wires**

During stranding, no aluminium alloy wire welds shall be made for the purpose of achieving the required conductor length.

No joints shall be permitted in the individual wires in the outer most layer of the finished conductor. However, joints are permitted in the inner layer of the conductor unavoidably broken during stranding, provided such breaks are not associated with either inherently defective wire or with the use of short lengths of aluminium alloy wires. Such joints shall not be more than four (4) per conductor length and shall not be closer than 15 meters from joint in the same wire or in any other aluminium alloy wire of the completed conductor.

Joints shall be made by cold pressure butt welding and shall withstand a stress of not less than the breaking strength of individual strand guaranteed.





#### **1.4.2 Steel Wires**

There shall be no joint of any kind in the finished wire entering into the manufacture of the strand. There shall also be no strand joints or strand splices in any length of the completed stranded steel core of the conductor.

#### **1.5 Tolerances**

The manufacturing tolerances to the extent indicated in the STP shall be permitted in the diameter of individual alloy and steel strands and lay-ratio of the conductor.

#### **1.6 Materials**

##### **1.6.1 Aluminium**

The aluminium strands shall be hard drawn from electrolytic aluminium rods having purity not less than 99.5% and a copper content not exceeding 0.04%. The materials shall have the same properties and characteristics as prescribed in IEC: 889.

##### **1.6.2 Steel**

The steel wire strands shall be drawn from high carbon steel wire rods produced by either the acid or the basic open-hearth process, the electric furnace process, or the basic oxygen process and shall conform to the chemical composition indicated in the STP.

The Steel wire strands shall have the same properties and characteristics as prescribed for regular strength steel wire in IEC: 888.

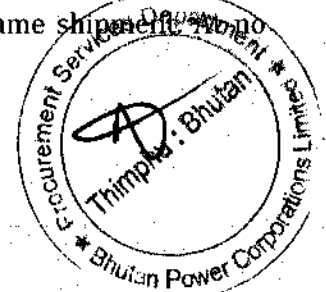
##### **1.6.3 Zinc**

The zinc used for galvanizing shall be electrolytic high grade zinc of 99.95% purity as per IS 209. It shall conform to and satisfy all the requirements of IS 209.

#### **1.7 Standard Length**

The standard length of the conductor shall be as indicated in the STP. All lengths outside this limit of tolerance shall be treated as random lengths.

Random lengths will be accepted provided no length is less than 70% of the standard length and the total quantity of such random lengths shall not be more than 10% of the total quantity ordered. When one number random length has been manufactured at any time, five (5) more individual lengths each equivalent to the above random length with tolerance of +/- 5% shall also be manufactured and all the above six random lengths shall be dispatched in the same shipment.



point, the cumulative quantity supplied of such random lengths shall not be more than 12.5% of the total cumulative quantity supplied including such random lengths. However, the last 20% of the quantity ordered shall be supplied only in standard lengths as specified.

The Employer reserves the right to place orders for the lengths above the standard length on the same terms and conditions applicable for the standard lengths during the pendency of the contract.

## **2.0 Tests and Standards**

### **2.1 Type Tests**

The following tests shall be conducted once on a sample/samples of conductor for every 1500 Kilometers of production from each manufacturing facility:

- a) DC resistance test on stranded conductor
- b) UTS test on stranded conductor
- c) Radio interference voltage test (dry)
- d) Corona extinction voltage test (dry)

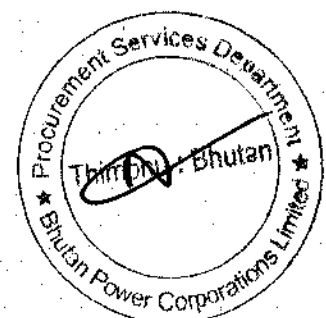
### **2.2 Acceptance Tests**

- a) Visual and dimensional check on drum
- b) Visual check for joints scratches etc. and length measurement of conductor by rewinding
- c) Dimensional check on steel and Aluminium alloy strand
- d) Check for lay-ratios of various layers
- e) Galvanizing test on steel strands
- f) Torsion and Elongation tests on steel strands
- g) Breaking load test on steel and aluminium alloy strands
- h) Wrap test on steel and Aluminium alloy strands as per IEC 888 & 889
- i) DC resistance test on Aluminium alloy strands as per IEC 889
- j) Procedure qualification test on welded joints of Aluminium alloy strands
- k) Barrel Batten strength test

*Note: All the above tests except (j) shall be carried out on Aluminium alloy and steel strands after stranding only*

### **2.3 Routine Test**

- a) Check to ensure that the joints are as per specification
- b) Check that there are no cuts, fins etc., on the strands
- c) Check that drums are as per specification



- d) All acceptance test as mentioned above to be carried out on each coil/drum (as applicable)

#### **2.4 Tests during Manufacture**

- a) Chemical analysis of zinc used for galvanizing
- b) Chemical analysis of Aluminium Alloy used for making Aluminium Alloy strands
- c) Chemical analysis of steel used for making steel strands

#### **2.5 Testing Expenses**

The break-up of the testing charges for the type tests specified shall be indicated separately.

Bidder shall indicate the laboratories in which they propose to conduct the type tests. They shall ensure that adequate facilities are available in the laboratories and the tests can be completed in these laboratories within the time schedule guaranteed by them.

In case of failure in any type test the supplier is either required to manufacture fresh sample lot and repeat all the test successfully once or repeat that particular type test three times successfully on the sample selected from the already manufactured lot at manufacturers/suppliers own expenses. In case a fresh lot is manufactured for testing then the lot already manufactured shall be rejected.

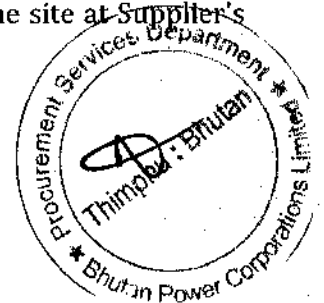
The entire cost of testing for the acceptance and routine tests and tests during manufacture specified herein shall be treated as included in the quoted unit price of conductor, except for the expenses of the inspector/Employer's representative.

In case of failure in any type test, if repeat type tests are required to be conducted, then all the expenses for deputation of inspector/Employers representative shall be deducted from the contract price. Also if on receipt of the supplier's notice of testing, the Employer's representative does not find 'plant' to be ready for testing, the expenses incurred by the employer for re-deputation shall be deducted from contract price.

#### **2.6 Additional Tests**

The employer reserves the right of having at its own expenses any other test(s) of reasonable nature carried out at supplier's premises, at site or in any other place in addition to the aforesaid type, acceptance and routine tests to satisfy that the materials comply with the specification.

The employer also reserves the right to conduct all the tests mentioned in this specification at his own expense on the samples drawn from the site at Supplier's



premises or at any other test centre. In case of evidence of non-compliance, it shall be binding on the part of Supplier to prove the compliance of the items to the technical specifications by repeat tests, or correction of deficiencies, or replacement of defective items all without any extra cost to the Employer.

## **2.7 Sample Batch for Type Testing**

The supplier shall offer material for selection of samples for type testing only after getting Quality Assurance Plan approved from Employer's Quality Assurance department. The sample shall be manufactured strictly in accordance with the Quality Assurance Plan approved by Employer.

The supplier shall offer at least three drums for selection of sample required for conducting all the type test.

The Supplier is required to carry out all the acceptance tests successfully in presence of Employer's representative before sample selection.

## **2.8 Test Reports**

Copies of type test reports shall be furnished in at least six copies along with one original. One copy will be returned duly certified by the Employer only after which the 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 Employer's representative.

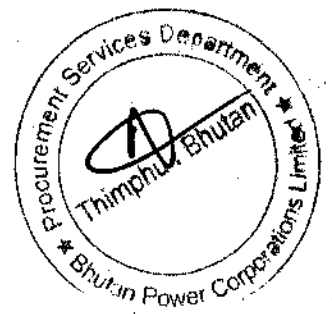
Test Certificates of tests during manufacture shall be maintained by the Supplier. These shall be produced for verification as and when desired by the Employer.

## **2.9 Inspection**

The Employer's representative shall at all times be entitled to have access to the works and all places of manufacture, where conductor shall be manufactured and representative shall have full facilities for unrestricted inspection of the supplier's works, raw materials and process of manufacture for conducting necessary tests as detailed herein.

The supplier shall keep the Employer informed in advance of the time of starting and of the progress of manufacture of conductor in its various stages so that arrangements can be made for inspection.

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



The acceptance of any quantity of material shall no way relieve the Supplier of any of the responsibilities for meeting all requirements of the specification, and shall prevent subsequent reject if such material is later found to be defective.

### 2.10 Test Facilities

The following additional test facilities shall be available at the Supplier's works:

- a) Calibration of various testing and measuring equipment including tensile testing machine, resistance measurement facilities, burette, thermometer, barometer, digital ohm meter etc.
- b) Standard resistance of calibration of resistance bridges.
- c) Finished conductor shall be checked for length verification and surface finish on separate rewinding machine at reduced speed (variable from 8 to 16 meters per minute). The rewinding facilities shall have appropriate clutch system and free of vibrations, jerks etc. with traverse laying facilities.

### 3.0 Packing

The conductor shall be supplied in non-returnable, strong, wooden 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 be responsible for any loss or damage during transportation handling and storage due to improper packing. The drums shall generally conform to IS 1778, except as otherwise specified hereinafter.

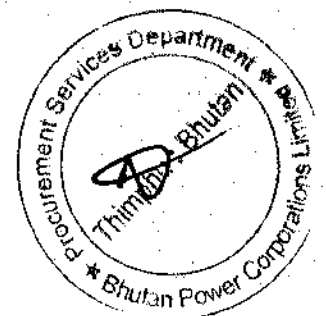
The drums shall be suitable for wheel mounting and for letting off the conductor under a minimum controlled tension of the order of 5 kN.

The bidder should submit their proposed drum drawings along with the bid.

For conductor, one stranded length shall be wound on each drum

All wooden components shall be manufactured out of seasoned soft wood free from defects that may materially weaken the component parts of the drums. Preservative treatment shall be applied to the entire drum with preservatives of a quality which is not harmful to the conductor.

The flanges shall be of two ply construction with each ply at right angles to the adjacent ply and nailed together. The nails shall be driven from the inside face flange, punched and then clenched on the outer face. The thickness of each ply shall not vary by more than 3mm from that indicated in the figure. There shall be at least 3 nails per plank of ply with maximum nail spacing of 75 mm. where a slot is cut in the flange to receive the inner end of the conductor the entrance shall be in line with the periphery of the barrel.



The wooden battens used for making the barrel of the conductor shall be of segmental type. These shall be nailed to the barrel supports with at least two nails. The battens shall be closely butted and shall provide a round barrel with smooth external surface. The edges of the battens shall be rounded or chamfered to avoid damage to the conductor.

Barrel studs shall be used for the construction of drums. The flanges shall be holed and the barrel supports slotted to receive them. The barrel studs shall be threaded over a length on either end, sufficient to accommodate washers, spindle plates and nuts for fixing flanges at the required spacing.

Normally, the nuts on the studs shall stand protruded of the flanges. All the nails used on the inner surface of the flanges and the drum barrel shall be counter sunk. The ends of barrel shall generally be flushed with the top of the nuts.

The inner cheek of the flanges and drum barrel surface shall be painted with a bitumen based paint.

Before reeling, card board or double corrugated or thick bituminized water proof bamboo paper shall be secured to the drum barrel and inside of flanges of the drum by means of a suitable commercial adhesive material. After reeling the conductor, the exposed surface of the outer layer of the conductor shall be wrapped with water proof thick bituminized bamboo paper to preserve the conductor from dirt, grit and damage during transportation and handling.

A minimum space of 75 mm for conductor shall be provided between the inner surface of the external protective tagging and outer layer of the conductor.

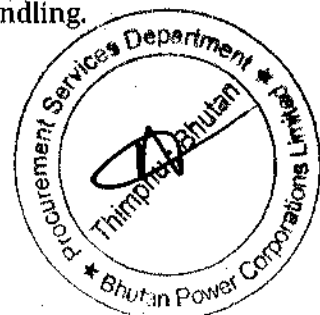
Each batten shall be securely nailed across grains as far as possible to the flange, edges with at least 2 nails per end. The length of the nails shall not be less than twice the thickness of the battens. The nails shall not protrude above the general surface and shall not have exposed sharp, edges or allow the battens to be released due to corrosion.

The nuts on the barrel studs shall be tacked welded on the one side in order to fully secure them. On the second end, a spring washer shall be used.

A steel collar shall be used to secure all barrel studs. This collar shall be located between the washers and the steel drum and secured to the central steel plate by welding.

Outside the protective lagging, there shall minimum of two binder consisting of hoop iron/galvanized steel wire. Each protective lagging shall have two recesses to accommodate the binders.

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.



As an alternative to wooden drum bidder may also supply the conductors in non-returnable painted steel drums. After preparation of steel surface according to IS 9954, synthetic enamel paint shall be applied after application of one coat of primer. Wooden/Steel drum will be treated at par for evaluation purpose and accordingly the bidder should quote in the package.

### 3.1 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 and an arrow marking at the location of the measurement.
- k) Barrel diameter at three locations and an arrow marking at the location of the measurement.
- l) Number of turns in the outer most layer
- m) Gross weight of drum after putting lagging
- n) Tear weight of the drum without lagging
- o) Net weight of the conductor in the drum
- p) CIP/MICC No.

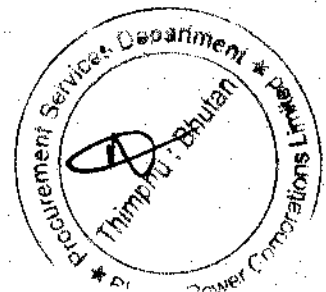
The above should be indicated in the packing list also.

### 3.2 Verification of Conductor length

The Employer reserves the right to verify the length of conductor after unreeling. The quantity for verification shall be between a minimum of five percent (5%) to a maximum of ten percent (10%) of the drums in a lot offered for inspection. The actual quantity will be discussed and mutually agreed to by the supplier and Employer in the Quality Assurance program.

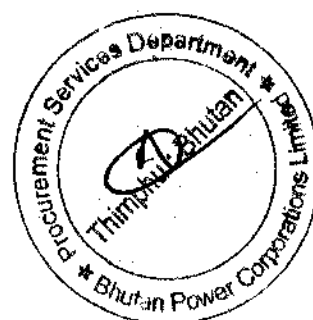
### 4.0 Standards

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



In the event of the supply of the conductor conforming to standards other than specified, the bidder shall confirm in the 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.

SL#	Indian Standard	Title	International Standard
1	IS: 209-1992	Specification for zinc	BS: 3436-1986
2	IS: 398 Part-I-1996	Specification for Aluminium Conductors for overhead Transmission purpose	IEC: 1089-1991 BS: 215-1970
3	IS: 398 Part-II-1996	Aluminium Conductor Galvanised steel Reinforced	BS: 215-1970 IEC: 1089-1991
4	IS: 398 Part-V-1992	Aluminium Conductor Galvanised Steel-Reinforced for extra high voltage (400 kV) and above	IEC: 1089-1991 BS:215-1970
5	IS: 1778-1980	Reels and drums for bare conductors	BS: 1559-1949
6	IS: 1521-1991	Method of tensile testing of steel wire	ISO: 6892-1984
7	IS: 2629-1990	Recommended practice for hot dip galvanizing of Iron and steel	
8	IS: 2633-1992	Method of testing uniformity of coating on zinc coated articles	
9	IS: 4826-1992	Galvanized coating on round steel wires	IEC: 888-1987 BS: 443-1969
10	IS: 6745-1990	Methods of determination of weight of zinc coating of zinc coated iron and steel article	BS:433-1969 ISO: 1460-1973
11	IS: 8263-1990	Method of Radio Interference tests on high voltage insulators	IEC: 437-1973 NEMA:107-1964 CISPR
12	IS: 9997-1988	Aluminium Alloy redraw Rods	IEC: 104-1987
13		Zinc coated steel wires for stranded conductors	IEC: 888-1987
14		Hard drawn Aluminium wire for overhead line conductors	IEC: 889-1987
15	IS: 398 (Part-IV)	Aluminium Alloy stranded conductor	IEC: 208-1966 BS-3242-1970





## Tests on Conductor

### 1. UTS Test on Stranded Conductor

Circles perpendicular to the axis of the conductor shall be marked at two places on a sample of conductor of minimum 5 m length between fixing arrangement suitably fixed on a tensile testing machine. The load shall be increased at a steady rate up to 50% of minimum specified UTS and held for one minute. The circles drawn shall not be distorted due to relative movement of strands. Thereafter, the load shall be increased at steady rate to 100% of the UTS of conductor and held for one minute. The conductor sample shall not fail during this period. The applied load shall then be increased until the failing load is reached and this value shall be recorded.

### 2. Corona Extinction Voltage Test

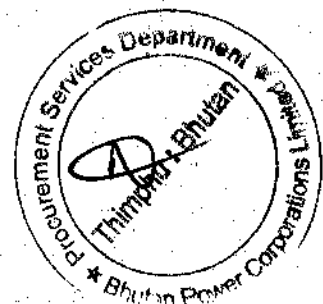
The sample assembly with each conductor of 5 m length shall be strung as per the configuration shown in the Table below;

Line configuration	No. of conductor samples per bundle	Spacing (mm)	Maximum height of the conductor above ground (m)
400 kV with twin ACSR Moose	Two	450	8.84
400 kV with Quad ACSR Moose	Four	457	8.84

The sample assembly when subjected to power frequency voltage shall have a corona extinction voltage of not less than that indicated in the STP. There shall be no evidence of corona on any part of the samples. The test should be conducted without corona control rings. However, small corona control rings may be used to prevent corona in the end fittings. The voltage should be corrected for standard atmospheric conditions.

### 3. Radio Interference Voltage Test

Under the conditions as specified above under "Corona Extinction Voltage Test", the conductor samples shall have radio interference voltage as indicated in the standard technical particulars. This test may be carried out with corona control rings and arcing horns. The test procedure shall be in accordance with IEC-437



#### **4. D.C. Resistance Test on Stranded Conductor**

On a conductor sample of minimum 5 m length two contact-clamps shall be fixed with a predetermined bolt torque. The resistance shall be measured by a Kelvin double bridge or digital ohm-meter of sufficient accuracy by placing the clamps initially zero meter and subsequently one meter apart. The test shall be repeated at least five times and the average value recorded. The value obtained shall be corrected to the value at 20 ° C as per IS: 398. The resistance corrected at 20°C shall conform to the requirements indicated in the STP.

#### **5. Chemical Analysis of Aluminium and Steel**

Samples taken from the Aluminium and steel ingots/coils/strands shall be chemically/spectrographically analyzed. The same shall be in conformity to the requirements stated in this specification.

#### **6. Visual and Dimensional check on drum**

The drums shall be visually and dimensionally checked to ensure that they conform to the requirements of this specification.

#### **7. Visual Check for Joints, Scratches etc.**

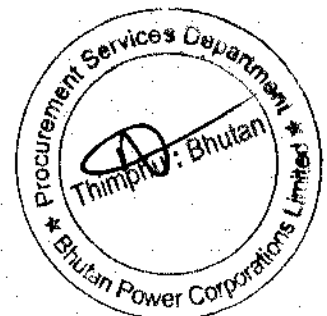
Conductor drums shall be rewound in the presence of the Employer. The Employer shall visually check for scratches, joints etc. and that the conductor generally conform to the requirements of this specification. Five percent (5%) to ten percent (10%) drums from each lot shall be rewound in the presence of the Employer's representative. The actual quantity will be discussed and mutually agreed to by the supplier and employer in the Quality Assurance Programme.

#### **8. Dimensional Check on Steel and Aluminium Strands**

The individual strands shall be dimensionally checked to ensure that they conform to the requirement of this specification.

#### **9. Check for Layer-ratios of Various Layers**

The lay-ratios of various layers shall be checked to ensure that they conform to the requirements of this specification.



#### **10. Procedure Qualification test on welded Aluminium strands**

Two Aluminium wire shall be welded as per the approved quality plan and shall be subjected to tensile load. The breaking strength of the welded joint of the wire shall not be less than the breaking strength of individual strands.

#### **11. Chemical Analysis of Zinc**

Samples taken from the zinc ingots shall be chemically/spectrographically analyzed. The same shall be in conformity to the requirements stated in the specification.

#### **12. Galvanizing test**

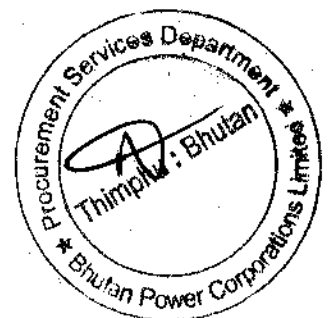
The test procedures shall be as specified in IEC: 888. The material shall conform to the requirements of this specification. The adherence of zinc shall be checked by wrapping around a mandrel four times the diameter of steel wire.

#### **13. Torsion and Elongation Tests on Steel Strands**

The test procedures shall be as per clause No. 10.3 of IEC: 888. In torsion test, the number of complete twists before fracture shall not be less than that indicated in the STP. In case test sample length is less or more than 100 times the stranded diameter of the strand, the minimum number of twists will be proportioned to the length and if number comes in the fraction then it will be rounded off to next higher whole number. In elongation test, the elongation of the strand shall not be less than 4% for a gauge length of 250 mm.

#### **14. Check on Barrel Batten strength of Drums**

The details regarding barrel batten strength test will be discussed and mutually agreed to by the supplier and employer in the Quality Assurance Programme.



## Technical Specification for AACSR Moose Conductor

### 1.1 Details of Conductor

The AACSR Moose Conductor shall generally conform to IEC: 1089/ IS: 398 except where otherwise specified herein.

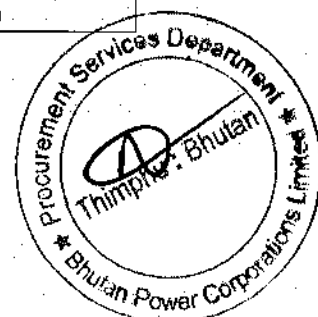
The salient parameters of the AACSR Moose Conductor are indicated below.

SL#	Description	Value	
a)	Stranding and wire diameter	54/3.53 mm Al. Alloy + 7/3.53 mm steel	
b)	Number of Strands		
	<b>Steel Core</b>		
	1 <sup>st</sup> Steel Layer	1	
	2 <sup>nd</sup> Steel layer	6	
	1 <sup>st</sup> Aluminium Alloy Layer	12	
	2 <sup>nd</sup> Aluminium Alloy layer	18	
	3 <sup>rd</sup> Aluminium Alloy Layer	24	
c)	Sectional area of Aluminium Alloy	528.5	
d)	Total sectional area	597.0	
e)	Overall diameter (mm)	31.77	

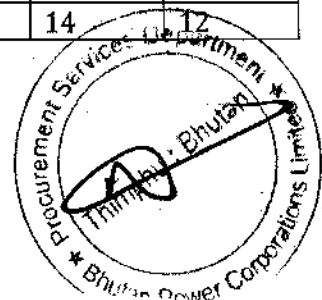
### 1.2 Standard Technical Particulars

The standard Technical Particulars (STP) of the AACSR Moose conductor are as below. The values indicated in the STP are the minimum and/ or maximum values required to be met by the supplier.

Sl.	Description	Unit	Value
1.0	Raw Materials		
1.1	<b>Aluminium Alloy</b>		
a)	Silicon	%	0.5-0.9
b)	Magnesium	%	0.6-0.9
c)	Ferrous	%	0.5 (Max)
d)	Copper	%	0.1 (Max)
e)	Manganese	%	0.03 (Max)
f)	Chromium	%	0.03 (Max)
g)	Zinc	%	0.10 (Max)
h)	Boron	%	0.06 (Max)
i)	Other Elements (each)	%	0.03 (Max)
J)	Other elements (total)	%	0.1 (Max)



<b>1.2</b>	<b>Steel wires/rods</b>		
a)	Carbon	%	0.50 to 0.85
b)	Manganese	%	0.50 to 1.10
c)	Phosphorous	%	Not more than 0.035
d)	Sulphur	%	Not more than 0.045
e)	Silicon	%	0.10 to 0.35 (max)
<b>1.3</b>	<b>Zinc</b>		
a)	Minimum purity of zinc	%	99.95
<b>2.0</b>	<b>Aluminum Alloy strands after stranding</b>		
<b>2.1</b>	<b>Diameter</b>		
a)	Nominal	mm	3.53
b)	Maximum	mm	3.55
c)	Minimum	mm	3.51
<b>2.2</b>	<b>Minimum breaking load of strand</b>		
a)	Before stranding	kN	3.02
b)	After stranding	kN	2.87
<b>2.3</b>	<b>Maximum resistance of 1 m length of strand at 20 deg. C</b>	Ohm	0.003388
<b>3.0</b>	<b>Steel strand after stranding</b>		
<b>3.1</b>	<b>Diameter</b>		
a)	Nominal	mm	3.53
b)	Maximum	mm	3.59
c)	Minimum	mm	3.47
<b>3.2</b>	<b>Minimum breaking load of strand</b>		
a)	Before stranding	kN	12.86
b)	After stranding	kN	12.22
<b>3.3</b>	<b>Galvanizing</b>		
a)	Minimum weight of zinc coating per sq. mm	gm	250
b)	Minimum number of dips that the galvanized strand can withstand in the standard preece test.	No.	2 dips of 1 minute and 1 dip of half minute
c)	Minimum number of twist in guage length equal 100 times the dia. of wire which the strand can withstand in torsion test (after stranding)	No.	16
<b>4</b>	<b>Stranded Conductor</b>		
<b>4.1</b>	<b>UTS of the Conductor</b>	kN	224.64 (Min.)
<b>4.2</b>	<b>Lay length of outer steel layer</b>		Max.    Min.
a)	Outer steel layer	mm	18        16
b)	12 wire Al. Alloy layer	mm	14        12



c)	18 wire Al. Alloy layer	mm	13	11
d)	24 wire Al. Alloy layer	mm	12	10
4.3	DC resistance of the conductor at 20°C	Ω/km	0.0624	
4.4	Minimum corona extinction voltage (line to phase) under dry condition	kV (rms)	320	
4.5	RIV at 1 Mhz at 305 Amp (line to phase) under dry condition	Micro Volts	Below 1000	
4.6	Standard length of the conductor	m	1800	
4.7	Tolerance on standard length	%	(+/-)5	
4.8	Direction of lay of outer layer		Right Hand	
<b>4.9</b>	<b>Linear mass of the conductor</b>			
a)	Standard	Kg/km	1996	
b)	Minimum	Kg/km	1963	
c)	Maximum	Kg/km	2023	

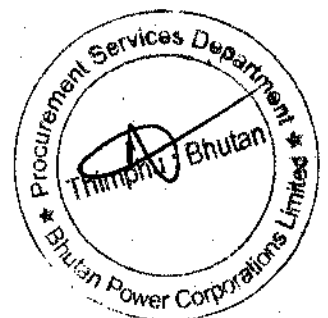
### 1.3 Workmanship

All the Aluminium Alloy and steel strands shall be smooth, uniform and free from all imperfections, such as spills and splits, die marks, scratches, abrasions, etc., after drawing and also after stranding.

The finished conductor shall be smooth, compact, uniform and free from all imperfections including kinks (protrusion of wires), wires cross over, over riding, looseness (wire being dislocated by finger/hand pressure and /or unusual bangle noise on tapping), material inclusions, white rust, powder formation or black spot ( on account of reaction with trapped rain water etc.), dirt, grit etc.

The steel strands shall be hot dip galvanized and shall have a minimum zinc coating as indicated in the STP. The zinc coating shall be smooth, continuous, of uniform thickness, free from imperfections and shall withstand number of dips in standard preece test as indicated in STP. The steel wire rods shall be of such quality and purity that, when drawn to the size of the strands specified and coated with zinc, the finished strands and the individual wires shall be of uniform quality and have the same properties and characteristics as prescribed in IEC: 888.

The steel strands shall be preformed and post formed in order to prevent spreading of strands in the event of cutting of composite core wire. Care shall be taken to avoid, damages to galvanization during pre-forming and post-forming operation.



## **1.4 Joints in Wires**

### **1.4.1 Aluminium alloy Wires**

During stranding, no aluminium alloy wire welds shall be made for the purpose of achieving the required conductor length.

No joints shall be permitted in the individual wires in the outer most layer of the finished conductor. However, joints are permitted in the inner layer of the conductor unavoidably broken during stranding, provided such breaks are not associated with either inherently defective wire or with the use of short lengths of aluminium alloy wires. Such joints shall not be more than four (4) per conductor length and shall not be closer than 15 meters from joint in the same wire or in any other aluminium alloy wire of the completed conductor.

Joints shall be made by cold pressure butt welding and shall withstand a stress of not less than the breaking strength of individual strand guaranteed.

### **1.4.2 Steel Wires**

There shall be no joint of any kind in the finished wire entering into the manufacture of the strand. There shall also be no strand joints or strand splices in any length of the completed stranded steel core of the conductor.

## **1.5 Tolerances**

The manufacturing tolerances to the extent indicated in the STP shall be permitted in the diameter of individual alloy and steel strands and lay-ratio of the conductor.

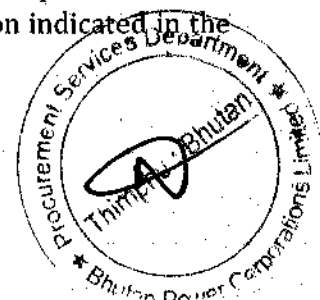
## **1.6 Materials**

### **1.6.1 Aluminium Alloy**

The aluminium alloy strand shall be hard drawn from heat treated aluminium alloy redraw rods conforming to IS: 9997. The strands shall be of Aluminium-Magnesium-Silicon Alloy of electrical conductivity of minimum 53% of IACS.

### **1.6.2 Steel**

The steel wire strands shall be drawn from high carbon steel wire rods produced by either the acid or the basic open- hearth process, the electric furnace process, or the basic oxygen process and shall conform to the chemical composition indicated in the



STP. The Steel wire strands shall have the same properties and characteristics as prescribed for regular strength steel wire in IEC: 888.

### **1.6.3 Zinc**

The zinc used for galvanizing shall be electrolytic high grade zinc of 99.95% purity as per IS 209. It shall conform to and satisfy all the requirements of IS 209.

### **1.7 Standard Length**

The standard length of the conductor shall be as indicated in the STP. All lengths outside this limit of tolerance shall be treated as random lengths.

Random lengths will be accepted provided no length is less than 70% of the standard length and the total quantity of such random lengths shall not be more than 10% of the total quantity ordered. When one number random length has been manufactured at any time, five (5) more individual lengths each equivalent to the above random length with tolerance of +/- 5% shall also be manufactured and all the above six random lengths shall be dispatched in the same shipment. At no point, the cumulative quantity supplied of such random lengths shall not be more than 12.5% of the total cumulative quantity supplied including such random lengths. However, the last 20% of the quantity ordered shall be supplied only in standard lengths as specified.

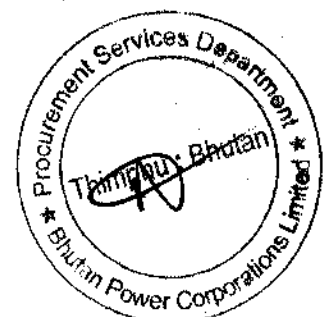
The Employer reserves the right to place orders for the lengths above the standard length on the same terms and conditions applicable for the standard lengths during the pendency of the contract.

## **2.0 Tests and Standards**

### **2.1 Type Tests**

The following tests shall be conducted once on a sample/samples of conductor for every 1500 Kilometers of production from each manufacturing facility:

- a) DC resistance test on stranded conductor
- b) UTS test on stranded conductor
- c) Radio interference voltage test (dry)
- d) Corona extinction voltage test (dry)





## 2.2 Acceptance Tests

- a) Visual and dimensional check on drum
- b) Visual check for joints scratches etc. and length measurement of conductor by rewinding
- c) Dimensional check on steel and Aluminium alloy strand
- d) Check for lay-ratios of various layers
- e) Galvanizing test on steel strands
- f) Torsion and Elongation tests on steel strands
- g) Breaking load test on steel and aluminium alloy strands
- h) Wrap test on steel and Aluminium alloy strands as per IEC 888 & 889
- i) DC resistance test on Aluminium alloy strands as per IEC 889
- j) Procedure qualification test on welded joints of Aluminium alloy strands
- k) Barrel Batten strength test

*Note: All the above tests except (j) shall be carried out on Aluminium alloy and steel strands after stranding only*

## 2.3 Routine Test

- a) Check to ensure that the joints are as per specification
- b) Check that there are no cuts, fins etc., on the strands
- c) Check that drums are as per specification
- d) All acceptance test as mentioned above to be carried out on each coil/drum (as applicable)

## 2.4 Tests during Manufacture

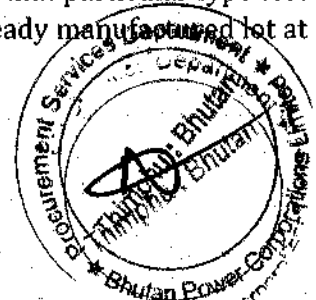
- a) Chemical analysis of zinc used for galvanizing
- b) Chemical analysis of Aluminium Alloy used for making Aluminium Alloy strands
- c) Chemical analysis of steel used for making steel strands

## 2.5 Testing Expenses

The break-up of the testing charges for the type tests specified shall be indicated separately.

Bidder shall indicate the laboratories in which they propose to conduct the type tests. They shall ensure that adequate facilities are available in the laboratories and the tests can be completed in these laboratories within the time schedule guaranteed by them.

In case of failure in any type test the supplier is either required to manufacture fresh sample lot and repeat all the test successfully once or repeat that particular type test three times successfully on the sample selected from the already manufactured lot at



manufacturers/suppliers own expenses. In case a fresh lot is manufactured for testing then the lot already manufactured shall be rejected.

The entire cost of testing for the acceptance and routine tests and tests during manufacture specified herein shall be treated as included in the quoted unit price of conductor, except for the expenses of the inspector/Employer's representative.

In case of failure in any type test, if repeat type tests are required to be conducted, then all the expenses for deputation of inspector/Employers representative shall be deducted from the contract price. Also if on receipt of the supplier's notice of testing, the Employer's representative does not find 'plant' to be ready for testing, the expenses incurred by the employer for re-deputation shall be deducted from contract price.

## **2.6 Additional Tests**

The employer reserves the right of having at its own expenses any other test(s) of reasonable nature carried out at supplier's premises, at site or in any other place in addition to the aforesaid type, acceptance and routine tests to satisfy that the materials comply with the specification.

The employer also reserves the right to conduct all the tests mentioned in this specification at his own expense on the samples drawn from the site at Supplier's premises or at any other test centre. In case of evidence of non-compliance, it shall be binding on the part of Supplier to prove the compliance of the items to the technical specifications by repeat tests, or correction of deficiencies, or replacement of defective items all without any extra cost to the Employer.

## **2.7 Sample Batch for Type Testing**

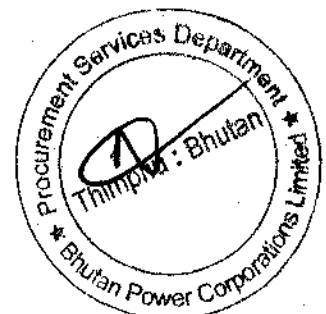
The supplier shall offer material for selection of samples for type testing only after getting Quality Assurance Plan approved from Employer's Quality Assurance department. The sample shall be manufactured strictly in accordance with the Quality Assurance Plan approved by Employer.

The supplier shall offer at least three drums for selection of sample required for conducting all the type test.

The Supplier is required to carry out all the acceptance tests successfully in presence of Employer's representative before sample selection.

## **2.8 Test Reports**

Copies of type test reports shall be furnished in at least six copies along with one original. One copy will be returned duly certified by the Employer only after which the 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 Employer's representative.

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

### **3.0 Inspection**

The Employer's representative shall at all times be entitled to have access to the works and all places of manufacture, where conductor shall be manufactured and representative shall have full facilities for unrestricted inspection of the supplier's works, raw materials and process of manufacture for conducting necessary tests as detailed herein.

The supplier shall keep the Employer informed in advance of the time of starting and of the progress of manufacture of conductor in its various stages so that arrangements can be made for inspection.

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

The acceptance of any quantity of material shall no way relieve the Supplier of any of the responsibilities for meeting all requirements of the specification, and shall prevent subsequent reject it such material is later found to be defective.

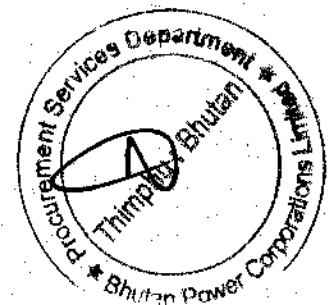
### **3.1 Test Facilities**

The following additional test facilities shall be available at the Supplier's works:

- a) Calibration of various testing and measuring equipment including tensile testing machine, resistance measurement facilities, burette, thermometer, barometer, digital ohm meter etc.
- b) Standard resistance of calibration of resistance bridges.
- c) Finished conductor shall be checked for length verification and surface finish on separate rewinding machine at reduced speed (variable from 8 to 16 meters per minute). The rewinding facilities shall have appropriate clutch system and free of vibrations, jerks etc. with traverse laying facilities.

### **4.0 Packing**

The conductor shall be supplied in non-returnable, strong, wooden 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 be responsible for any loss or



damage during transportation handling and storage due to improper packing. The drums shall generally conform to IS 1778, except as otherwise specified hereinafter.

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.

For conductor, one stranded length shall be wound on each drum

All wooden components shall be manufactured out of seasoned soft wood free from defects that may materially weaken the component parts of the drums. Preservative treatment shall be applied to the entire drum with preservatives of a quality which is not harmful to the conductor.

The flanges shall be of two ply construction with each ply at right angles to the adjacent ply and nailed together. The nails shall be driven from the inside face flange, punched and then clenched on the outer face. The thickness of each ply shall not vary by more than 3mm from that indicated in the figure. There shall be at least 3 nails per plank of ply with maximum nail spacing of 75 mm. where a slot is cut in the flange to receive the inner end of the conductor the entrance shall be in line with the periphery of the barrel.

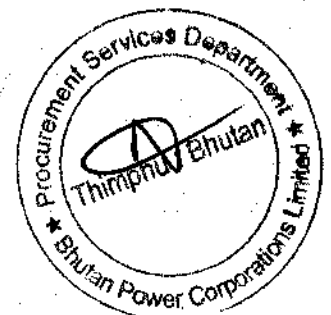
The wooden battens used for making the barrel of the conductor shall be of segmental type. These shall be nailed to the barrel supports with at least two nails. The battens shall be closely butted and shall provide a round barrel with smooth external surface. The edges of the battens shall be rounded or chamfered to avoid damage to the conductor.

Barrel studs shall be used for the construction of drums. The flanges shall be holed and the barrel supports slotted to receive them. The barrel studs shall be threaded over a length on either end, sufficient to accommodate washers, spindle plates and nuts for fixing flanges at the required spacing.

Normally, the nuts on the studs shall stand protruded of the flanges. All the nails used on the inner surface of the flanges and the drum barrel shall be counter sunk. The ends of barrel shall generally be flushed with the top of the nuts.

The inner cheek of the flanges and drum barrel surface shall be painted with a bitumen based paint.

Before reeling, card board or double corrugated or thick bituminized water proof bamboo paper shall be secured to the drum barrel and inside of flanges of the drum by means of a suitable commercial adhesive material. After reeling the conductor, the exposed surface of the outer layer of the conductor shall be wrapped with water proof thick bituminized bamboo paper to preserve the conductor from dirt, grit and damage during transportation and handling.



A minimum space of 75 mm for conductor shall be provided between the inner surface of the external protective tagging and outer layer of the conductor.

Each batten shall be securely nailed across grains as far as possible to the flange, edges with at least 2 nails per end. The length of the nails shall not be less than twice the thickness of the battens. The nails shall not protrude above the general surface and shall not have exposed sharp, edges or allow the battens to be released due to corrosion.

The nuts on the barrel studs shall be tacked welded on the one side in order to fully secure them. On the second end, a spring washer shall be used.

A steel collar shall be used to secure all barrel studs. This collar shall be located between the washers and the steel drum and secured to the central steel plate by welding.

Outside the protective lagging, there shall minimum of two binder consisting of hoop iron/galvanized steel wire. Each protective lagging shall have two recesses to accommodate the binders.

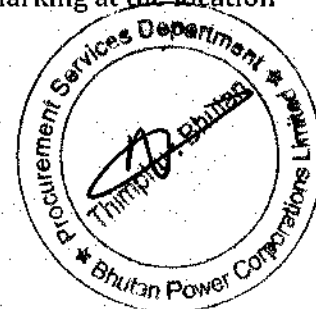
The conductor ends shall be properly sealed and secured on the side of one of the flanges to avoid loosening of the conductor layers during transit and handling.

As an alternative to wooden drum bidder may also supply the conductors in non-returnable painted steel drums. After preparation of steel surface according to IS 9954, synthetic enamel paint shall be applied after application of one coat of primer. Wooden/Steel drum will be treated at par for evaluation purpose and accordingly the bidder should quote in the package.

#### 4.1 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 and an arrow marking at the location of the measurement.
- k) Barrel diameter at three locations and an arrow marking at the location of the measurement.
- l) Number of turns in the outer most layer



- m) Gross weight of drum after putting lagging
- n) Tear weight of the drum without lagging
- o) Net weight of the conductor in the drum
- p) CIP/MICC No.

The above should be indicated in the packing list also.

#### 4.2 Verification of Conductor length

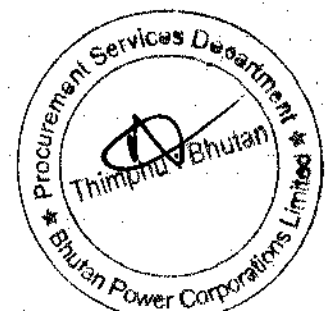
The Employer reserves the right to verify the length of conductor after unreeling. The quantity for verification shall be between a minimum of five percent (5%) to a maximum of ten percent (10%) of the drums in a lot offered for inspection. The actual quantity will be discussed and mutually agreed to by the supplier and Employer in the Quality Assurance program.

#### 5.0 Standards

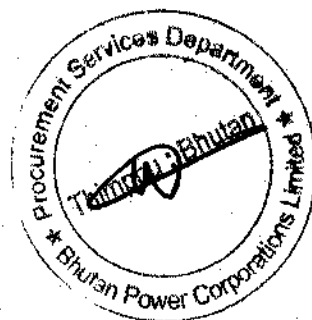
The conductor shall conform to the following India/International standards, which shall mean latest revisions, with amendments/changes adopted and published, unless specifically stated otherwise in in the specification.

In the event of the supply of the conductor conforming to standards other than specified, the bidder shall confirm in the 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.

SL#	Indian Standard	Title	International Standard
1	IS: 209-1992	Specification for zinc	BS: 3436-1986
2	IS: 398 Part-I-1996	Specification for Aluminium Conductors for overhead Transmission purpose	IEC: 1089-1991 BS: 215-1970
3	IS: 398 Part-II-1996	Aluminium Conductor Galvanised steel Reinforced	BS: 215-1970 IEC: 1089-1991
4	IS: 398 Part-V-1992	Aluminium Conductor Galvanised Steel-Reinforced for extra high voltage (400 kV) and above	IEC: 1089-1991 BS:215-1970
5	IS: 1778-1980	Reels and drums for bare conductors	BS: 1559-1949
6	IS: 1521-1991	Method of tensile testing of steel wire	ISO: 6892-1984
7	IS: 2629-1990	Recommended practice for hot dip galvanizing of Iron and steel	
8	IS: 2633-1992	Method of testing uniformity of coating on zinc coated articles	
9	IS: 4826-1992	Galvanized coating on round steel wires	IEC: 888-1987 BS: 443-1969



10	IS: 6745-1990	Methods of determination of weight of zinc coating of zinc coated iron and steel article	BS:433-1969 ISO: 1460-1973
11	IS: 8263-1990	Method of Radio Interference tests on high voltage insulators	IEC: 437-1973 NEMA:107-1964 CISPR
12	IS: 9997-1988	Aluminium Alloy redraw Rods	IEC: 104-1987
13		Zinc coated steel wires for stranded conductors	IEC: 888-1987
14		Hard drawn Aluminium wire for overhead line conductors	IEC: 889-1987
15	IS: 398 (Part-IV)	Aluminium Alloy stranded conductor	IEC: 208-1966 BS-3242-1970



## Tests on Conductor

### 1. UTS Test on Stranded Conductor

Circles perpendicular to the axis of the conductor shall be marked at two places on a sample of conductor of minimum 5 m length between fixing arrangement suitably fixed on a tensile testing machine. The load shall be increased at a steady rate up to 50% of minimum specified UTS and held for one minute. The circles drawn shall not be distorted due to relative movement of strands. Thereafter, the load shall be increased at steady rate to 100% of the UTS of conductor and held for one minute. The conductor sample shall not fail during this period. The applied load shall then be increased until the failing load is reached and this value shall be recorded.

### 2. Corona Extinction Voltage Test

The sample assembly with each conductor of 5 m length shall be strung as per the configuration shown in the Table below;

Line configuration	No. of conductor samples per bundle	Spacing (mm)	Maximum height of the conductor above ground (m)
400 kV with twin AACSR Moose	Two	450	8.84

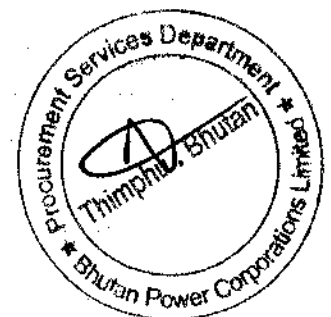
The sample assembly when subjected to power frequency voltage shall have a corona extinction voltage of not less than that indicated in the STP. There shall be no evidence of corona on any part of the samples. The test should be conducted without corona control rings. However, small corona control rings may be used to prevent corona in the end fittings. The voltage should be corrected for standard atmospheric conditions.

### 3. Radio Interference Voltage Test

Under the conditions as specified above under "Corona Extinction Voltage Test", the conductor samples shall have radio interference voltage as indicated in the standard technical particulars. This test may be carried out with corona control rings and arcing horns. The test procedure shall be in accordance with IEC-437

### 4. D.C. Resistance Test on Stranded Conductor

On a conductor sample of minimum 5 m length two contact-clamps shall be fixed with a predetermined bolt torque. The resistance shall be measured by a Kelvin double bridge or digital ohm-meter of sufficient accuracy by placing the clamps initially zero meter and subsequently one meter apart. The test shall be repeated at least five times and the average value recorded. The value obtained shall be corrected to the value at





20 ° C as per IS: 398. The resistance corrected at 20°C shall conform to the requirements indicated in the STP.

**5. Chemical Analysis of Aluminium and Steel**

Samples taken from the Aluminium and steel ingots/coils/strands shall be chemically/spectrographically analysed. The same shall be in conformity to the requirements stated in this specification.

**6. Visual and Dimensional check on drum**

The drums shall be visually and dimensionally checked to ensure that they conform to the requirements of this specification.

**7. Visual Check for Joints, Scratches etc.**

Conductor drums shall be rewound in the presence of the Employer. The Employer shall visually check for scratches, joints etc. and that the conductor generally conform to the requirements of this specification. Five percent (5%) to ten percent (10%) drums from each lot shall be rewound in the presence of the Employer's representative. The actual quantity will be discussed and mutually agreed to by the supplier and employer in the Quality Assurance Programme.

**8. Dimensional Check on Steel and Aluminium Strands**

The individual strands shall be dimensionally checked to ensure that they conform to the requirement of this specification.

**9. Check for Layer-ratios of Various Layers**

The lay-ratios of various layers shall be checked to ensure that they conform to the requirements of this specification.

**10. Procedure Qualification test on welded Aluminium strands**

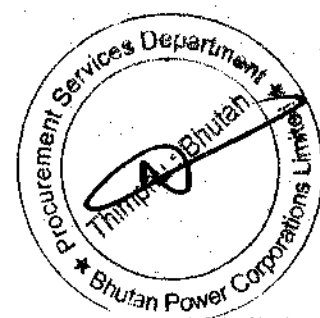
Two Aluminium wire shall be welded as per the approved quality plan and shall be subjected to tensile load. The breaking strength of the welded joint of the wire shall not be less than the breaking strength of individual strands.

**11. Chemical Analysis of Zinc**

Samples taken from the zinc ingots shall be chemically/spectrographically analyzed. The same shall be in conformity to the requirements stated in the specification.

**12. Galvanizing test**

The test procedures shall be as specified in IEC: 888. The material shall conform to the requirements of this specification. The adherence of zinc shall be checked by wrapping around a mandrel four times the diameter of steel wire.

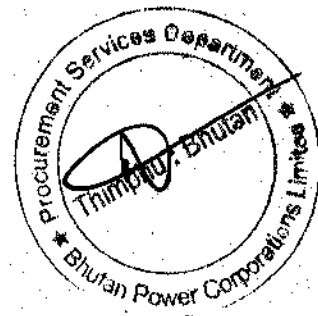


**13. Torsion and Elongation Tests on Steel Strands**

The test procedures shall be as per clause No. 10.3 of IEC: 888. In torsion test, the number of complete twists before fracture shall not be less than that indicated in the STP. In case test sample length is less or more than 100 times the stranded diameter of the strand, the minimum number of twists will be proportioned to the length and if number comes in the fraction then it will be rounded off to next higher whole number. In elongation test, the elongation of the strand shall not be less than 4% for a gauge length of 250 mm.

**14. Check on Barrel Batten strength of Drums**

The details regarding barrel batten strength test will be discussed and mutually agreed to by the supplier and employer in the Quality Assurance Programme.



## Lot 4: HV ABC Cables and Lot 5: LV ABC Cables

### 1.0 General

#### 1.1 Scope of supply

This section covers the requirements for the design, manufacture, testing, and delivery and unloading at BPC stores of ABC Cables.

### 2.0 High Voltage Aerial Bundled Conductor

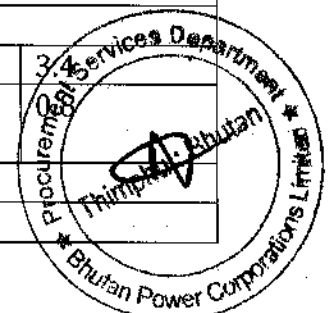
HV ABC consists of XLPE insulation. It has bearer wire (Messenger wire) which is either of aluminium alloy or steel wire (bare or insulated). The design of ABC shall comprise compacted, stranded, hard drawn aluminium phase conductors with dry cured cross linked polyethylene insulation. The main advantages of HV ABC over bare ACSR conductors are as follows:

- Offers relative resistance to short circuits caused by external forces (wind, fallen branches), unless they abrade the insulation.
- Can stand in close proximity to trees and branches will not generate sparks if it in contact
- Simpler installation, as cross arms and insulators are not required.
- Less cluttered appearance than bare conductors.
- It can be installed in a narrower right-of-way.

However the disadvantages were additional cost for the cable itself and shorter spans and maximum use of poles due to increased weight of the cable. The Insulation of the cable also degrades due to direct exposure to sun. Following are minimum technical requirement of HV Aerial Bundled Cable.

#### The Minimum Technical Requirement of the HV ABC

Sl. No.	Parameters	Unit	Minimum Requirement	
1	Applicable Standards	IEC 60502-2, IEC 60228 or equivalent standards		
2	Rated Voltage	kV	6.35/11(12)	
3	<b>Conductor</b>			
	Nom. Area of core Conductor	mm <sup>2</sup>	50	95
	Conductor Screen Material	Extruded cross-linked semi-conductive		
	Min. Thickness of Conductor Screen	mm	0.3	0.3
4	<b>Insulation</b>			
	Insulation material	XLPE		
	Min. Thickness of Insulation	mm	3.4	3
	Min. Thickness of insulation Screen	mm	0.8	
5	<b>Metallic Screen</b>			
	Material	Plain Annealed Copper Wire		



## Section VII- Schedule of Supply

	Size for Conductor Screen	No./mm	26/0.85	26/0.85
<b>6</b>	<b>Sheath</b>			
	Material	Black, High Density Polyethylene (HDPE)		
	Min. Thickness of sheath	mm	1.8	1.8
<b>7</b>	<b>Support Catenary</b>			
	Support Catenary size	No./mm	19/2	19/2
	Material	Aluminium-Clad Steel without insulation		
8	Max. D.C Resistance of cable at 20°C	Ohm/km	0.641	0.320
9	Max. A.C Resistance of cable at 90°C	Ohm/km	0.822	0.411
10	Inductive Reactance of cable at 50Hz	Ohm/km	0.144	0.134
11	Voltage drop (three phase)	mV/A.m	1.45	0.746
12	Continuous current carrying capacity per phase at 90°C conductor tempt & 30°C ambient tempt	Amps	184	280
13	Approximate mass of cable	kg/km	2850	4090
14	Phase cable diameter (Nominal)	mm	25	29

The conductors shall be marked on the external surface with the following:

- Manufacturer's name
- Year of manufacture
- Length in meters marking in sequential numbers at 1 m intervals, with the lowest number at the inner end of the drum.
- Phase marking.

**The Bidder shall submit the UV weathering test of the cable (outer sheath) with type test reports.**

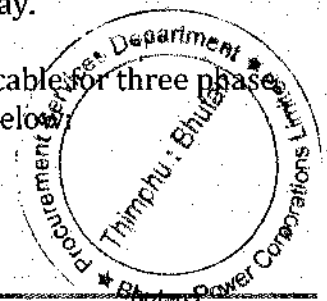
### LV Aerial Bundled Conductor

#### 1 General

The design of aerial bundled conductors shall comprise compacted, stranded, hard drawn aluminium phase conductors with dry cured cross linked polyethylene insulation **The Bidder shall submit the UV Weathering test of the cable (outer sheath) with the type test reports.**

All of the Aerial Bundled Conductors required shall be Fully Supported Cable, where all the equal-sized phase and neutral cores share the mechanical load. The cable shall be XLPE insulated and rated for 0.6/1kV. The bundle shall have a right-hand lay.

Two core cable shall be used for single phase distribution and 4 core cable for three phase. Typical design parameters for the ABC cable used are given in table below.



**The Minimum Technical Requirement of the LV ABC**

Sl. No.	Cable Size (mm <sup>2</sup> ) Parameter	50		95		120
		2 core	4 core	2-core	4-core	4-core
1	Applicable Standard	IEC60502-1 & IEC 60228 OR Equivalent Standards				
2	Rated Voltage (kV)	06/1(1.2)				
3	Nominal conductor diameter (mm)	8.05		11.40		12.90
4	Minimum insulation thickness (mm)	1.5		1.7		1.7
5	Nominal overall diameter (mm)	23.8	28.7	31.8	38.4	42.2
6	Approximate mass (kg/km)	350	700	680	1,350	1660
7	DC resistance at 20°C (ohms/km)	0.641		0.320		0.253
8	AC resistance at 50 Hz 80°C (ohms/km)	0.796		0.398		0.315
9	Inductive reactance at 50 Hz (ohms/km)	0.086	0.093	0.080	0.087	0.0844
10	Voltage drop at 50 Hz, 80°C (mV/A/m)	1.60	1.39	0.81	0.71	0.564
11	Continuous current rating (A)	150	140	230	215	280
	Fault current rating (kA for 1 sec)	4.1		8.3		11.3
	Minimum bending radius core (mm)	65		90		102
	Minimum bending radius cable (mm)	130	160	270	320	352
	Minimum breaking load (kN)	14.0	28.0	26.6	53.2	67.2
	Recommended highest everyday tension (kN)	2.52	5.04	4.79	9.58	12.10
	Recommended maximum working tension (kN)	3.92	7.84	7.45	14.90	18.82

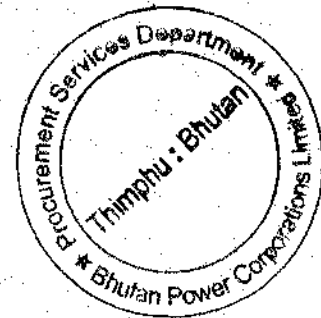
**2 Construction**

The cores shall form a bundle, which comprise four (and two) single cores of insulated aluminium twisted together, for phase and neutral conductors. The total pull of the line shall be distributed among the four (and two) conductors.

Each core shall be insulated with extruded cross linked polyethylene (XLPE). The three phase conductors shall be indelibly marked with one, two or three, as appropriate or longitudinal ridges formed from the insulation material. The cores shall be twisted together with a right hand lay. The pitch of laying shall be such as to allow easy separation of conductors when making connection but also maintain the bundle cohesion at the splice points on the line route. Cables shall be supplied on drums, in one continuous length.

The conductors shall be marked on the external surface with the following:

- Manufacturer's name
- Year of manufacture
- Length in meters marking in sequential numbers at 1 m intervals, with the lowest number at the inner end of the drum.
- Phase marking.



## Lot 6: Covered AAAC Conductors

### Scope of supply

This section covers the requirements for the design, manufacture, testing, and delivery and unloading at BPC stores of Covered AAAC conductors.

### AAAC covered overhead conductor

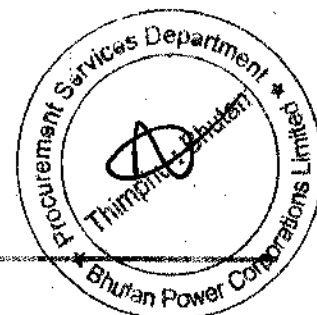
The water blocked covered conductor (CC) should have AAA Conductor material (Alloy 1120) suitable for overhead lines for working voltages 6.35/11 kV and 19/33 kV, 50 Hz. AC system. The cover insulation shall be UV stabilized XLPE insulation. The covered conductors shall be marked on the external surface with the following:

- (a) Manufacturer's name, registered trade name or registered mark
- (b) Year of manufacture
- (c) Length in metres marking in sequential numbers at 1 m intervals, with the lowest number at the inner end of the drum. Any drum length can be started at any integral number with starting metre length is allowed.
- (d) Covered conductor type CC
- (e) Conductor material AAAC, Alloy 1120

### The Minimum Technical Requirement of the AAAC Covered

	Units	Conductor size and type		
Applicable Standard		IEC 60502, IEC 60228		
Rated Voltage	kV	11 kV and 33 kV		
Nominal cross-sectional area	mm <sup>2</sup>	49.5	111	158
Calculated equivalent aluminium area	mm <sup>2</sup>	47.2	106	150
Stranding and nominal wire diameter	No./mm	7/3.00 (Fluorine)	7/4.5 (Hydrogen)	19/3.25 (Krypton)
Conductor Material		Aluminium Alloy 1120		
Cover insulation material		UV stabilized XLPE		
Approximate conductor diameter	mm	9	13.5	16.3
Minimum thickness of XLPE Cover		The thickness of the XLPE insulation shall be specified for each of the nominated working voltages		
Overall diameter of the Cable (approx.)	mm	12.4 - 14	16.9 - 18.5	19.7 - 21.3
Max. Conductor DC resistance at 20°C	Ohm/km	0.641	0.253	0.164
50 Hz Inductive Reactance	Ohm/km	0.312	0.297	0.281
Minimum thickness of XLPE cover	mm	3.4	3.4	
Continuous current rating	Amps	215	290	375
Weight Conductor without insulation	Kg/km	135	304	433
Weight of conductor with insulation	Kg/km	340	500	710

The Bidder shall submit the UV weathering test for XLPE Insulation result with the bid.



## Lot 7: Conductor Hardware Fittings

### 1. Scope

This section covers the requirements for the design, manufacture, testing, and delivery to site of overhead hardware items and fittings

This Specification covers the following items:

- (a) P.G. Connectors
- (b) Preformed Dead End Terminations
- (c) Terminal Lugs
- (d) Tension joints
- (e) Suspension clamp (for shield wire)

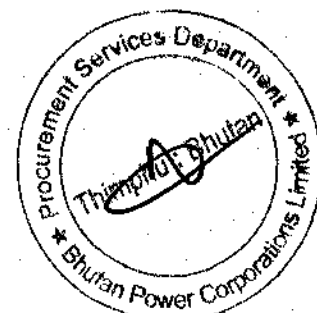
### 2. General

Connectors are required for aluminium to aluminium, aluminium to copper and steel to steel non-tension and tension joints, and for connecting copper and aluminium conductor to terminals of electrical equipment. The connectors shall be complete with any special tools, protective grease, tapes, bolts and washers appropriate for their application. In addition all the connectors shall comply with the following:

- 1) The contact shall be firm so that the current distribution among the strands of the conductors is uniform;
- 2) The conductivity of the connector shall be at least 95% of that of the conductor and it shall be designed to carry continuously the full rated current of the conductor for which it is used;
- 3) The contact pressure shall be maintained throughout its service life; and
- 4) Corona discharge shall be kept to a minimum.

All compression connectors shall be suitable for installation using either manual or hydraulic compression tools. Details of dies and tools required for the compression connectors offered shall be submitted with the bid. Complete instructions for the installation of each type of connector shall be provided by the Supplier.

Oxide inhibiting grease shall be suitable for aluminium to aluminium to copper bolted joints and as a filling compound for aluminium fittings which accept copper conductors. The compound shall be free from zinc particles or grit, shall be high 'drop point' grease based and shall remain stable at high temperatures.





## 2.1 Parallel Groove (PG) Connector

### (1) General

Non-tension type bolted parallel groove connectors (P.G. connector) are required for jumpers, spur take-offs, and drop connections to dropout fuses. The P.G. connector shall be of one or two bolt type (one bolt type shall be used for connection of shield wire SWG 7/2mm only). IEC61238 or other national or international Standards which ensure equal or higher quality shall be applicable.

The edges of the connector barrels shall be rounded to assist stress relief when the connectors are used with covered conductors.

All connectors shall be supplied pre-filled with high quality oxide inhibiting compound and shall be protectively capped to prevent spillage or spoilage of this compound. All connectors shall be clearly and permanently marked with the correct conductor size range and category.

In addition all connectors shall comply with the following:

- The current must be uniformly distributed among the strands of the conductors.
- The connector must have at least the same conductance as the conductor and carry the full continuous current rating of the conductor size they are designed for.
- The original quality of contacts shall be maintained throughout the connector's service life.

Oxide inhibiting grease shall be free from zinc particles or grit, shall be high 'drop point' grease based and shall remain stable at high temperatures.

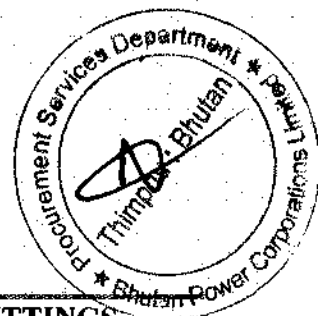
The connectors shall be made of corrosion-resistant alloy with a minimum tensile strength 400 MPa. The resistance of all clamps shall not be more than 50% of the resistance of the conductor itself over the same length as the clamp.

The connectors shall:

- Have serrated conductor grooves,
- Interlocking fingers,
- Be recessed to prevent bolt head turning during tightening,
- Have a one, two, or three bolt pattern to suit conductor size and current rating,
- Have bolts of sufficient length to allow installation without disassembling the connector,
- Have conductor entries of a generous radius to prevent damage to strands, and
- Be pre-filled with joint compound.

The Bidder shall submit type test certificates with the bid to demonstrate compliance with the requirements of this specification.

### (2) Range



The P.G. connector shall be of the same design to suit for connection of conductors' combination, as given in the table below.

Side A ("main")		Side B ("tap")	
Approx. Diameter of Conductor (mm)	Code Name	Approx. Diameter of Conductor (mm)	Code Name
14.15	Dog	14.15	Dog
14.15	Dog	10.05	Rabbit
13.5*	Hydrogen	13.5*	Hydrogen
13.5*	Hydrogen	9.0*	Fluorine
9.0*	Fluorine	9.0*	Fluorine
6.0	SWG 7/14	6.0	SWG 7/14

Note) (\*) Diameter of Hydrogen and Fluorine is indicated in the size of bare conductor. The actual diameter with insulation cover may be the conductor diameter plus 6mm (2 times of 3mm insulation thickness).

### (3) Packaging

Each connector shall be supplied in an individual sealed clear plastic bag or pocket. The bag shall be adequately durable to ensure no grease or oxide inhibiting compound is lost or spoiled prior to the time of installation. The bag shall be labelled with the makers name or trade mark, and the size range of the fitting. Bags shall be further packaged in cardboard or similar containers in quantities of approximately 100 fittings of the identical description.

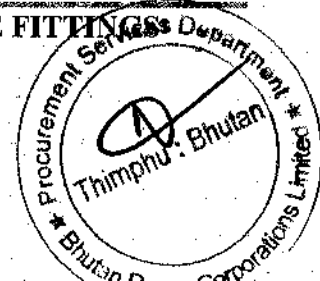
### (4) Insulation Cover (for Covered Conductors Only)

A UV-radiation and weather resistant insulation cover shall be provided for each P.G. connector for covered Hydrogen and Fluorine conductors. The cost of provision of insulation covers shall be included in the unit prices for P.G. clamps for covered conductors in the Price Schedule.

## 2.2 General Requirement for Preformed Fittings

Preformed (Helical) fittings shall be supplied for conductor dead ends, guy dead ends and conductor tie on pin insulator top.

The preformed fittings for bare conductor shall be manufactured from aluminium alloy and shall be compatible with the ACSR conductors, and with AAAC covered conductors including its XLPE insulation in 3 mm thickness without peeling. The preformed fittings



for galvanised steel conductor (shield wire) and stay wire shall be manufactured from galvanised steel and shall be compatible with the conductors and galvanised steel guy wires specified. The Supplier shall ensure that all preformed fittings are compatible for installation with the insulators and thimbles supplied or as required for correct construction.

Preformed fittings shall be the correct size for the conductor to which they are to be fitted and shall be of adequate strength for the purpose for which each is intended. Every fitting shall be such that it is unable to slip whilst in service.

Each fitting shall be colour coded and labelled with the name and diameter of the conductor for which it is to be used. All labelling and instructions shall be in the English language.

Note: The Sub-Clause 2.2 is to state the general requirements for preformed (helical) fittings, so that the Sub-clause 2.3 and 2.4 shall also be applied to the subsequent Sub-Clause 2.2.

### 2.3 Preformed Dead End Terminations

#### (1) Preformed dead end terminations for conductors

The following preformed terminations shall be supplied for termination of the following conductors

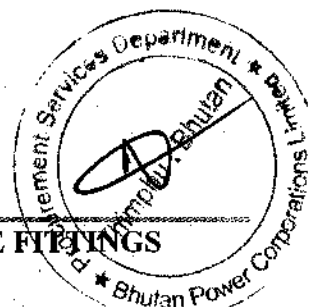
- ACSR Wolf conductor;
- ACSR Dog conductor;
- ACSR Rabbit conductor;
- AAAC Hydrogen covered conductor (with 3 mm thickness XLPE insulation);
- AAAC Fluorine covered conductor (with 3mm thickness XLPE insulation);

Preformed dead end terminations for bare ACSR and covered AAAC shall be manufactured from aluminium alloy. Dead end terminations for galvanised steel conductor shall be manufactured from galvanised steel.

The minimum failing load of the dead end fittings shall be not less than 100% of the breaking load of the matching conductor, as mentioned in the relevant clauses in this Technical Specification. The loop dimensions shall be suitable for the matching thimble fittings. The fittings shall have marks to show the crossover points for correct installation.

For the preformed dead end terminations *for covered conductors, an insulation cap shall be provided one for each preformed termination*, as mentioned in Sub-Clause 2.7.

#### (2) Preformed dead end terminations for shield wire and guy wire



The preformed terminations shall be supplied for termination of the following shield wire and guy wire

- 7/8 SWG G.I. stay wire; and
- 7/2.0 mm G.I. shield wire with accessories

The 7/2.0 mm G.I. shield wire will be terminated by a preformed dead end termination at top cross arm (G.I. Channel 75mm x 50mm x 6mm). *The necessary strain clamp sets for connecting the preformed dead end termination to the top cross arms shall be provided along with the preformed terminations for shield wire (refer to drawing).* The cost for provision of these clamp sets shall be included in the itemized prices for preformed dead end terminations for shield wire.

The minimum failing load of the dead end fittings shall be not less than 100% of the breaking load of the matching conductor, as mentioned in the relevant clauses in this Technical Specification. The loop dimensions shall be suitable for the matching thimble fittings. The fittings shall have marks to show the crossover points for correct installation.

#### 2.4 Helities

Preformed Helities are required for tying the following conductors to the 11kV and 33kV pin insulators.

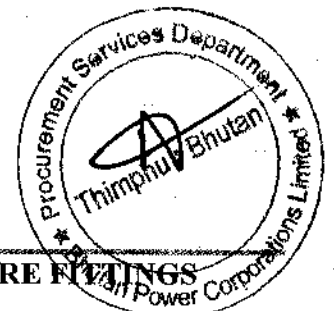
- ACSR Wolf conductor;
  - ACSR Dog conductor;
  - ACSR Rabbit conductor;
  - AAAC Hydrogen covered conductor (with 3 mm thickness XLPE insulation);
  - AAAC Fluorine covered conductor (with 3mm thickness XLPE insulation);
- For covered conductor covered tie wires shall be used.*

Preformed Helities grips shall be of aluminium alloy. The fittings shall be suitable in all respects for the pin insulators. Each tie shall comprise not less than two rods shaped to suit the insulator neck and groove diameter and the conductor diameter. All helical ties shall be supplied with a neoprene pad for insertion over the conductor where it rests in the insulator top or side groove.

#### 2.5 Terminal Lugs

Terminal Lugs shall be heavily tin plated aluminium (for aluminium conductors) or heavily tin plated high purity copper (for copper conductors and SWG wire) and of the compression type, pre-filled with compound and suitable for connection onto plant copper terminals using 12 mm diameter bolts.

The following types of lugs are required.



- (1) Terminal lugs with a 13 mm hole in the palm shall be supplied for Rabbit ACSR conductor and Fluorine AAAC conductor.
- (2) Terminal lugs with a 13 mm hole shall be supplied for termination of LV cables in the transformer LV cable box and LV distribution board. They shall be supplied for the following 600/1000V grade, PVC insulated cables with Aluminium conductor of the following sizes.
  - (a) 2C/4C x 16 mm<sup>2</sup>
  - (b) 2C/4C x 35 mm<sup>2</sup>
  - (c) 2C/4C x 50 mm<sup>2</sup>
  - (d) 2C/4C x 70 mm<sup>2</sup>
  - (e) 4C x 150 mm<sup>2</sup>
- (3) Terminal lugs with a 13 mm hole in the palm shall be supplied for SWG 7/2.00mm.

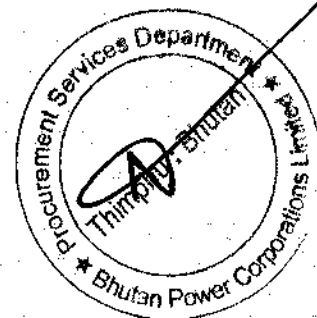
**2.6 Insulated end (termination) caps for AAAC covered conductors**

A UV-radiation and weather resistant end (termination) caps for AAAC covered conductors shall be provided for each preformed dead end termination. The end caps shall be suitable size for fitting with the outer of covered conductors, as specified in Package 4 in this Bidding Documents.

**2.7 G.I. Suspension Clamp for Shield wire**

The galvanized steel suspension clamp for shield wire will be used for installation of shield wire on the top of single telescopic pole. The materials other than galvanized steel shall not be used for the suspension clamp because of shield wire's connectivity to the earthing. The gripping part shall suit for the size of shield wire.

The suspension clamps shall be supplied along with necessary hook bolt (M16), nut and washers by individual packing.



**Lot 8: ABC Fittings**

**1.0 HV ABC Fittings and Accessories**

**1.1 Pole Accessories**

The following accessories are required for the installation of the HV Aerial Bundled Cables.

- a. Pole Bracket assembly
- b. Suspension assembly
- c. Strain Clamp/Dead end assembly
- d. GI support hook
- e. Bundled Restraint assembly
- f. Jointing Sleeves

Each assembly shall be delivered complete with all necessary devices suitable for attachment to round steel poles by stainless steel strap. All metal fitting shall be of good quality galvanized mild steel or cast aluminium alloy. Each of the suspension/angle/dead end assemblies shall be supplied with a 1.75 m stainless steel trap with two buckles.

Bundled end protection shall be provided for protecting cable dead end ends and shall comprise a set of heat shrinkable polymeric terminal caps for fitting on each conductor, together with protective black PVC sleeve of 500 mm length.

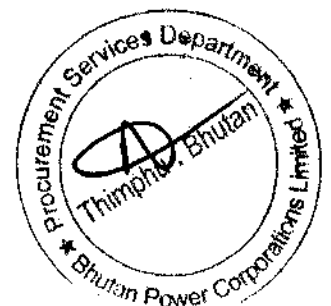
**1.2 HV ABC Connector**

The following connectors are required for the connection of HV aerial bundled conductors.

- a. Insulated tension jointing sleeve
- b. XLPE cable termination Push On Type

The connection shall be insulated and suitable for use on live lines. The teeth of the contact plates shall penetrate the bundled conductor insulation to establish contact with ABC cable without the need to strip the bundled conductor insulation. The connector shall be suitable for copper or aluminium tee-off conductor. The Tee-off shall be capable of removal and subsequent re-installation.

Insulated tension jointing sleeves shall be provided for bundled conductors. These shall be of the compression type, but compression shall not damage or displace the sleeve insulation. The sleeve connectors shall be designed to have the full rate breaking strength of the Aluminium or aluminium alloy cable on which they are fitted.



## 2.0 LV ABC Fittings and Accessories

### 2.1 Pole Accessories

The following accessories are required for the installation of the LV aerial bundled cables.

- a. Suspension assembly (including angles up to 30 deg.)
- b. Suspension (Large Angle) assembly (Angles over 30 deg.)
- c. Dead end assembly
- d. End caps

Each assembly shall be delivered complete with all necessary devices suitable for attachment to round steel poles by stainless steel strap. All metal fitting shall be of good quality galvanized mild steel or cast aluminium alloy. Each of the suspension/angle/dead end assemblies shall be supplied with a 1.75 m stainless steel trap with two buckles.

Bundled end protection shall be provided for protecting cable dead end ends and shall comprise a set of heat shrinkable polymeric terminal caps for fitting on each conductor, together with protective black PVC sleeve of 500 mm length.

### 2.2 LV ABC Connectors

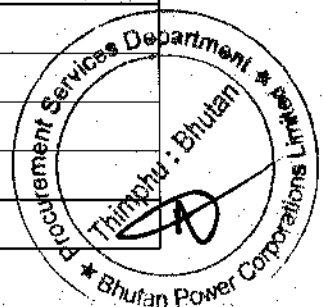
The following connectors are required for connection of LV aerial bundled conductors.

- a. Insulated service/tee-off connection (IPC Connector)
- b. Insulated tension jointing sleeve
- c. Insulated connectors between ABC and PVC cables

Bundled conductor connectors are required for connection of service cables to bundled conductors, for tee-offs of bundled conductors and for connection to PVC cables. The connections shall be insulated and suitable for use on live lines. The teeth of the contact plates shall penetrate the bundled conductor insulation to establish contact with ABC cable without the need to strip the bundled conductor insulation. The connector shall be suitable for copper or aluminium tee-off conductor. Bidder shall describe the method used to ensure that the contact plates make adequate contact with the main conductor. The Tee-off shall be capable of removal and subsequent reinstallation.

The range of connector for ABC to ABC and for ABC to service cable shall be as follows.

Main conductor size (mm <sup>2</sup> )	Tee-off Conductor Size (mm <sup>2</sup> )
120	95, 50
95	95
95	50, 16, 10, 6, 4
50	50
50	10, 6 & 4



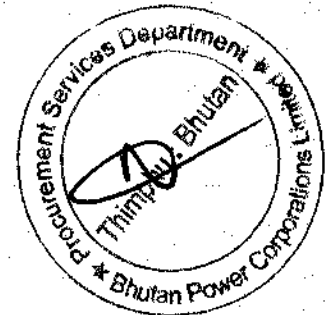
The range of connector for ABC to PVC cable shall be as follows;

LV ABC Cables	LV PVC Cable
50 mm <sup>2</sup> XLPE	4C x 16 mm <sup>2</sup>
	4C x 50 mm <sup>2</sup>

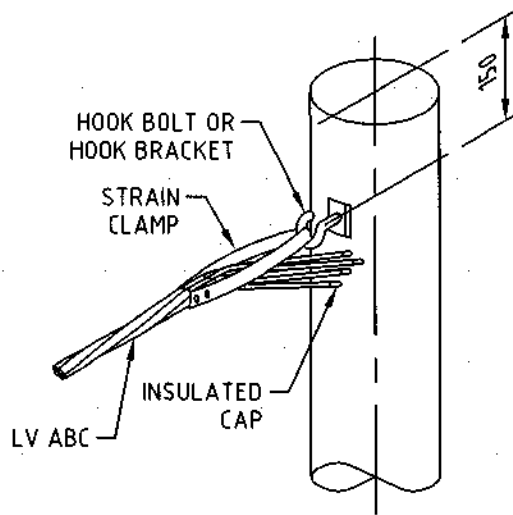
Insulated tension jointing sleeves shall be provided for the bundled conductors and service cables. These shall be of the compression type, but compression shall not damage or displace the sleeve insulation. The sleeve connectors shall design to have the full rate breaking strength of the aluminium or aluminium alloy cable on which they are fitted.

### 2.3 LV Service dead-end Clamps

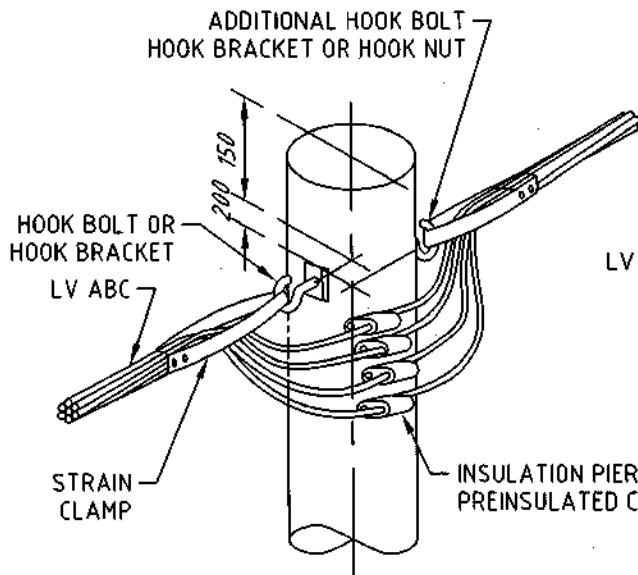
An open sided stainless steel wedge clamp or similar dead-end to be supplied for dead ending two core service conductor cables at the pole and the consumer premises. The clamp shall be suitable for the LV service cables. Above and shall have a pull out tension of not less than 16 kN.



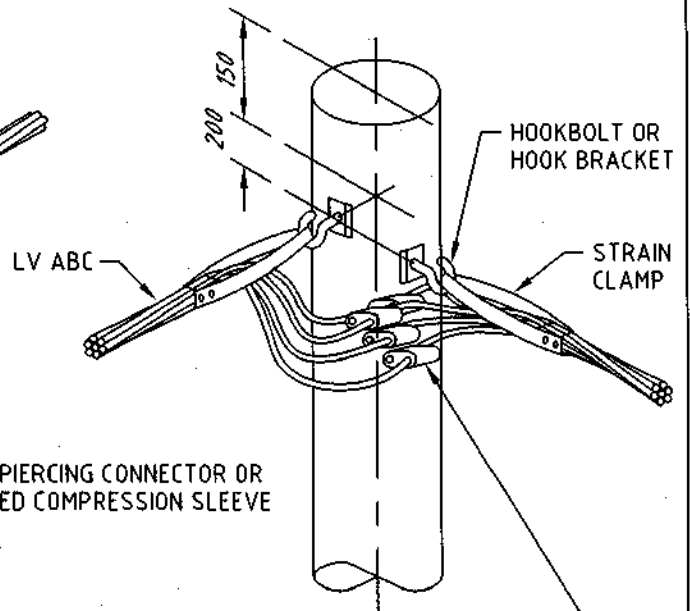




ALLOW SUFFICIENT CABLE TAIL  
TO ALLOW FOR FUTURE EXTENSION



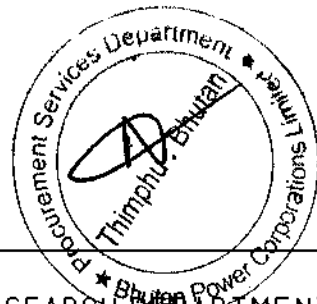
FIELD CONDITIONS MAY ALLOW  
CABLE TO BE CONTINUOUS AT POLE



INSULATION PIERCING CONNECTOR OR  
PREINSULATED COMPRESSION SLEEVE

### NOTES

1. DIMENSIONS AS SHOWN ARE IN mm.
2. DRAWING IS NOT TO SCALE.



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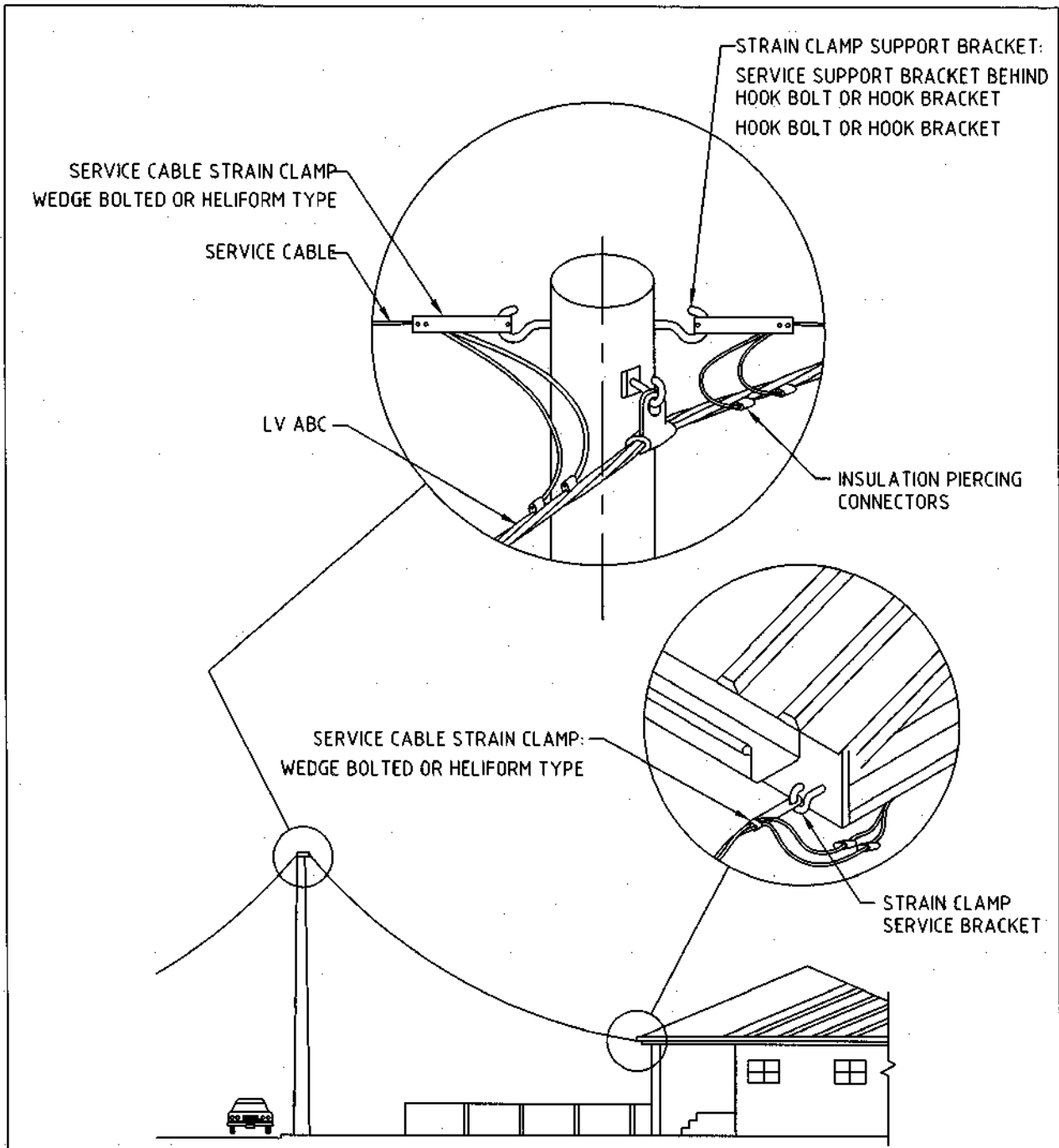
ENGINEERING AND RESEARCH DEPARTMENT

TITLE : DISTRIBUTION DESIGN & CONSTRUCTION STANDARD  
LV ABC TERMINATION & ANCHOR POLES DETAILS

TITLE	NAME	DATE
DESIGNED BY		
CHECKED BY		
APPROVED BY		

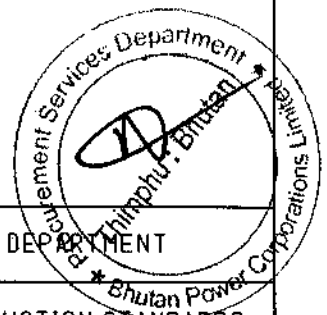
DRAWING NO. BPC - DDCS - 2020-14/3-4

REVISION  
2020



**NOTES**

- 1. DIMENSIONS AS SHOWN ARE IN mm.
- 2. DRAWING IS NOT TO SCALE.



**BHUTAN POWER CORPORATION LIMITED**

**ENGINEERING AND RESEARCH DEPARTMENT**

**DISTRIBUTION DESIGN AND CONSTRUCTION STANDARDS**

**LV ABC TYPICAL SERVICE LAYOUT ARRANGEMENT**

TITLE	NAME	DATE
DESIGNED BY		
CHECKED BY		
APPROVED BY		

DRAWING NO. BPC - DDCS -2020-14/1-4

REVISION  
2020

## Lot 9: Cable Termination and Jointing Kits

### General Specifications

The cable accessories should be suitable for storage without deterioration in properties at temperatures up to 50 deg C and should have unlimited shelf life.

Fluorinated Silicon Grease should be provided for filling up the minor nicks & scratches on the insulation that may occur while removing the Semi conducting screen of the Cable.

#### 1. End Terminations

##### a. Class of Termination:

The End termination should be Class - I as defined by IEEE 48 Standard & latest amendments.

##### b. Stress Control :

- The stress control at the screen cutback should be provided by a Heat Shrinkable tubing having a minimum volume resistivity of  $10^{10}$  Ohms cm. The relative permittivity of the tubing should be at least 15.
- To eliminate voids caused at the step due to semiconducting screen cutback, the manufacturer should provide a high permittivity mastic the permittivity of which should be at least 15.
- The impedance of the stress control tubing should not change over a range of temperature of 0 deg C – 125 deg C, which is the temperature range over which an XLPE cable is expected to operate.

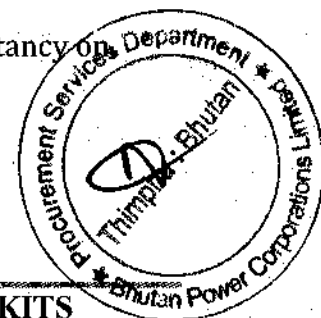
##### c. Protection to Insulation :

A heat shrinkable tubing should be applied over exposed cable dielectric. The material should be:

- (1) Non tracking
- (2) Weather resistant
- (3) Erosion resistant
- (4) U. V. radiation resistant

Test reports conforming that there is no degradation of the material after prolonged exposure to elevated temperatures. This should include

- Thermal endurance- An Arrhenius plot to confirm the life expectancy continuous at a temperature of 90 deg C.



## Section VII- Schedule of Supply

- The materials should pass Tracking & Erosion Resistant test in accordance with ASTM D 2303.
- For weather resistance the materials should be tested on Atlas weather-O- meter test.
- The materials should be tested as per EMMAQUA test procedure for evaluating its resistance to Ultra Violet radiations.

d. Environment sealing:

At the lug end the sealing against ingress of moisture should be provided by non-tracking sealant strips followed by heat shrinkable non tracking, erosion & weather resistant tubing precoated with non tracking sealant.

For 3 core cable the sealing at the crutch area should be provided by a heat shrinkable non tracking erosion & weather resistant breakout internally coated with a non tracking hot melt adhesive.

e. Provision for Earthing

The Copper tape screen and armour of the cable should be earthed by tinned copper braids of appropriate size provided with lug at one end.

## 2. STRAIGHT THROUGH JOINTS

a. Conductor Continuity

Proper conductor continuity should be ensured either by Crimping or by using Shear head bolted connector.

b. Stress Control :

- The stress control at the screen cutback should be provided by a heat shrinkable tubing having a minimum volume resistivity of  $10^{10}$  Ohms cm. The relative permittivity of the tubing should be at least 15.
- To eliminate voids caused at the step due to semiconducting screen cutback, the manufacturer should provide a high permittivity mastic the permittivity of which should be at least 15.
- The impedance of the stress control tubing should not change over a range of temperature of 0 deg C - 125 deg C, which is the temperature range over which an XLPE cable is expected to operate.

c. Reinstatement of Insulation:



- This should be affected by means of a heat shrinkable, flexible, polymeric tubing made from discharge resistant polymer. The tubing after complete recovery should have a minimum wall thickness of 3 mm to ensure provision of adequate insulation in one step.
- To ensure a void free bond between the rebuilt tubing and screen the manufacturer should supply a single dual walled tubing. This enables the final insulating layer to be installed complete with a conductive polymeric screen.
- The kit should be provided with a high permittivity hot-melt mastic for applying over the ferrule to eliminate voids and sharp edges.

d. Armour/ Screen Continuity

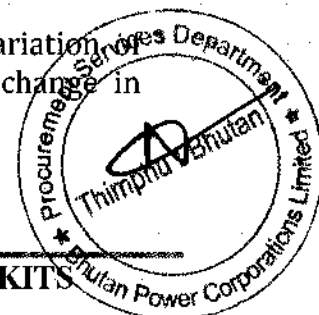
The continuity of the copper tape screen should be affected by tinned copper Mesh and that of the armour by tinned copper braids of adequate cross section.

e. Environment Sealing :

The joints should be protected against ingress of moisture by a polymeric flexible heat shrinkable tubing precoated with hot melt adhesive. This should completely cover metallic sheaths/ earth connections.

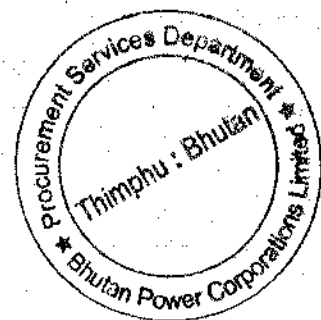
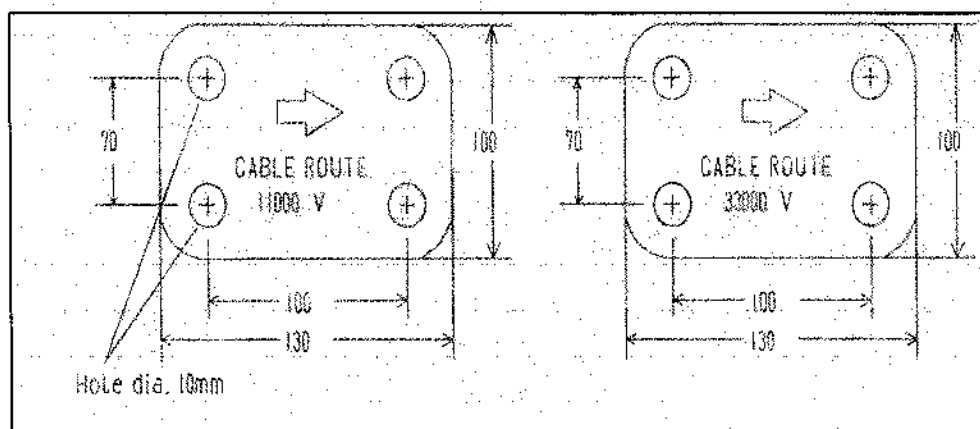
3. **TEST**

- a. The kits should be tested as per test sequence of VDE 0278 or IS: 13573 as per latest amendments
- b. The Joints/ Terminations should be type Tested for series 1 and series 2 along with **SALT FOG TEST** at per testing procedures.
- c. All Heat Shrinkable components should be tested as per ESI-09-13. The bidder shall furnish test reports along with the bid.
- d. The manufacturer should provide life assessment test (accelerated ageing test) reports to prove that the heat shrinkable components are capable of retaining their properties within acceptable limits during the course of long term usage.
- e. TERT (Track Erosion and Resistance test) should be conducted on heat shrinkable tube used in termination to prove that they are non tracking.
- f. The manufacturer should also furnish graphs showing the variation impedance of the stress control tubing with respect to (1) change in temperature and (2) Time (aging at constant temperature).

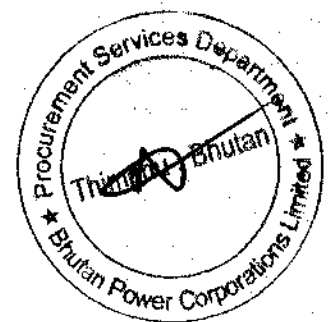


### Cable Route Markers

Cable Route Marker Plate with Nuts & Bolts. The length and breath of the plate should be 130x100 mm. The thickness of the plate should be 10 mm. The diameter of the hole should be 10 mm. The length of the Nut (Nut and Bolt) should be 75 mm and the diameter should be 8 mm as per the below sample drawings.

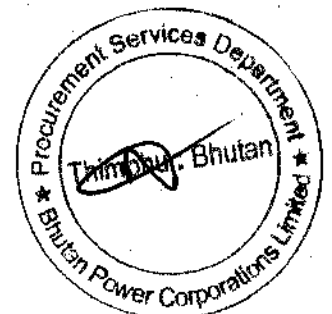


**TECHNICAL SPECIFICATION  
FOR  
LOT 10: ADSS AND OPGW CABLE**



## Technical particulars of 24F DWDM ADSS Optical Fiber Cable

<b>1. Fiber properties</b>			
SI.No	Characteristics	Unit	Value
1	Attenuation @ 1310 nm @1550 nm	dB/km	≤ 0.36 ≤ 0.23
2	Chromatic dispersion between 1270 - 1340 nm 1285 - 1330 nm 1550 nm 1625 nm	ps/(nm <sup>2</sup> km)	≤ 5.3 ≤ 3.5 ≤ 18 ≤ 22
3	Zero dispersion wavelength	Nm	1300 to 1324
4	Zero dispersion slope	ps/(nm <sup>2</sup> km)	≤ 0.092
5	Cut off wavelength	nm	≤ 1320
6	Mode field diameter at 1310 nm	μm	9.3 ± 0.5
7	Core-clad concentricity error	μm	≤ 0.6
8	Cladding non circularity	μm	≤ 1.0%
9	Cladding diameter	μm	125 ± 1.0
10	Coating diameter	μm	245 ± 10
11	Polarization mode dispersion	ps/√km	≤ 0.20
<b>2. Mechanical &amp; Environmental properties</b>			
A	Tensile Strength	KN	13.0
B	Crush resistance	Newton/100mm	2000 (200Kg load on 100x100mm plate for one minute), change in loss ≤ 0.05dB (IEC-60794-1-21-E3 standard)
C	Bending radius	mm	280 (IEC-60794-1-21-E11 standard)
B	Strain Margin	%	≤ 0.25
C	Impact Resistance	N	50, Change in loss ≤ 0.05dB (IEC-60794-1-21-E4 standard)
D	Torsion resistance	N	75, (10 cycles, ±180degree Change in loss ≤ 0.05dB (IEC-60794-1-21-E7 standard) )
E	Max. operating /installation temperature	°C	-30 to +70
<b>3. Physical &amp; dimensions properties</b>			
I	Number of fibers		24F
II	Numbers of loose tubes Number of filler/Dummy Number of fiber per tube		4 2 6
III	Type of fiber		SM G652D
IV	Central strength member		FRP rod
V	Peripheral strength elements		Aramid Yarn – 12.6 kg/km
VI	Sequence of loose tubes (as per EIA/TIA 598)		Blue, Orange, Green, Brown, Slate & White
VII	Color of fiber		Blue, Orange, Green, Brown, Slate, & White
VIII	Inner & Outer sheath material		UV resistant (Black) polyethylene (H.D.P.E)
IX	Inner sheath thickness	mm	≥ 1.2
X	Outer sheath thickness	mm	≥ 2.0





XI	Outer cable diameter	mm	14.8 ± 0.5 mm
XII	Cable weight	Kg/km	165 ± 20
XIII	Printing on cable	<ol style="list-style-type: none"> <li>1. Manufacturer name</li> <li>2. Labelled "24F G652D ADSS OFC"</li> <li>3. Year of manufacture</li> <li>4. Labelled "BPC"</li> <li>5. Sequential length marking in meter</li> <li>6. Two orange colour (UV stabilized) lines of minimum 3 mm width diametrically opposite to each other, continuous over the length of the cable shall be applied (marked) for easy identification of this cable from other cables.</li> </ol>	
XIV	Standard length	2 km + 5%	

**Cross Section diagram of ADSS cable**

ORANGE COLOUR STRIPE

OUTER SHEATH (H.D.P.E.)

INNER SHEATH (H.D.P.E.)

WATER SWELLABLE TAPE

LOOSE TUBE WITH FIBRES

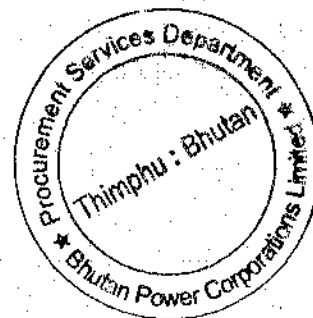
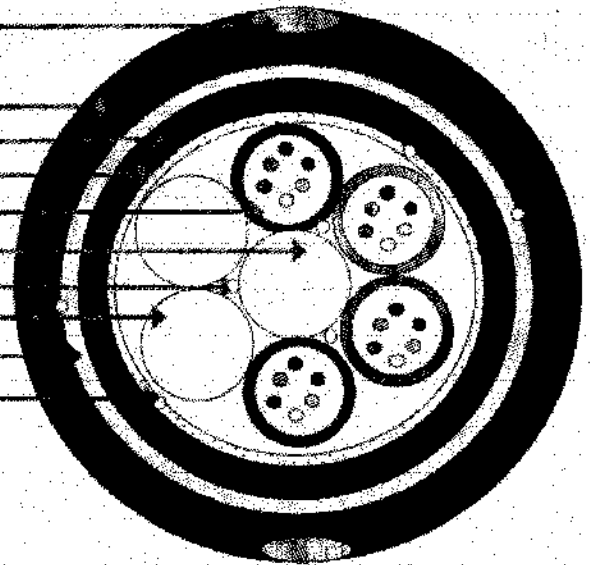
F.R.P. ROD

W.S. YARN

FILLER/DUMMY

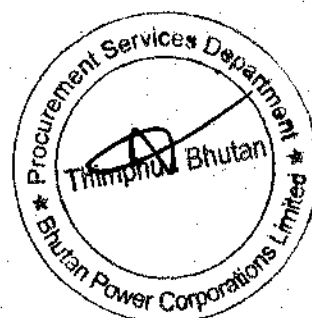
ARAMID YARN

RIP CORDS



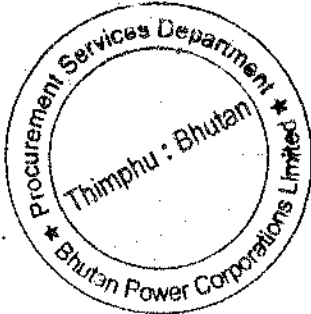
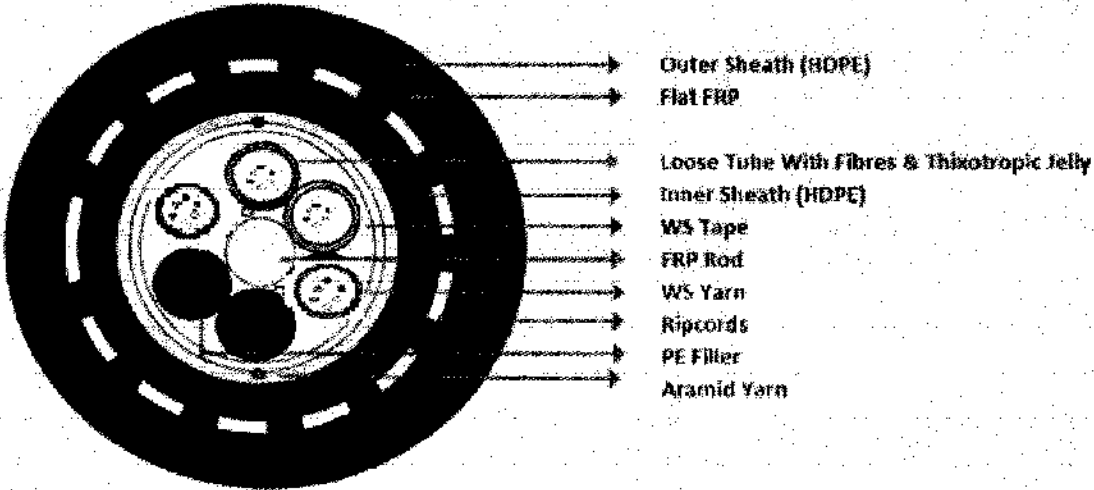
## Technical particulars of 24F SM G652 D FLAT FRP ANTIRODENT ADSS OFC

<b>1. Fiber properties</b>			
SI.No	Characteristics	Unit	Value
1	Attenuation @ 1310 nm @1550 nm	dB/km	≤ 0.36 ≤ 0.23
2	Chromatic dispersion between 1285 – 1330 nm 1550 nm	ps/(nm <sup>2</sup> km)	≤ 3.5 ≤ 18
3	Zero dispersion wavelength	Nm	1300 to 1324
4	Zero dispersion slope	ps/(nm <sup>2</sup> km)	≤ 0.092
5	Cut off wavelength	nm	≤ 1320
6	Mode field diameter at 1310 nm	μm	9.1 ± 0.5
7	Core-clad concentricity error	μm	≤ 0.6
8	Cladding non circularity	μm	≤ 1.0%
9	Cladding diameter	μm	125 ± 1.0
10	Coating diameter	μm	245 ± 10
11	Polarization mode dispersion	ps/√km	≤ 0.20
<b>2. Mechanical &amp; Environmental properties</b>			
A	Tensile Strength	KN	13.0
B	Max. installation tensile	N	3800 N
C	Crush resistance	Newton/10cm	2000 N/ 10 cm
D	Min. Bending radius (static)	mm	12.5 x D mm
E	Min. Bending radius (dynamic)	mm	25 x D mm
F	Max. operating /installation temperature	°C	20 °C to +65 °C
<b>3. Physical &amp; dimensions properties</b>			
I	Number of fibers		24F
II	Loose Tube / Dummy		4/2
III	Number of fiber per tube		6
IV	Type of fiber		SM G652D
V	loose tube Material / Diameter (INNER)		PP (Polypropylene)
VI	Central Strength Member		FRP (Fiber Reinforced Plastic)
VII	Peripheral Strength Members		Flat FRP
VIII	Peripheral Strength Members		High Strength Aramid Yarns
VIII	Color of fiber		Blue, Orange, Green, Brown, Slate & White
IX	Color of loose tube/ dummy		Blue, Orange, Green, Brown, Filler-1 & Filler-2
X	Inner sheath materials		UV resistant (Black)
XI	Inner sheath thickness	mm	0.80 mm NOMINAL
XII	Outer sheath materials		HDPE - BLACK
XIII	Outer sheath thickness	mm	1.70 mm NOMINAL
XIV	Outer Cable Diameter	mm	14.8 ± 0.5 mm
XV	Cable weight	KG	160 kg/km + 15 Kg/Km
XVI	Standard length	KM	2 km + 5%
XVII	Printing on cable		1. Manufacturer name 2. Labelled "24F G652D FRP OFC" 3. Year of manufacture



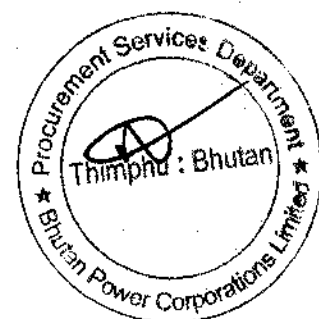
		<p>4. Labelled "BPC"</p> <p>5. Sequential length marking in meter</p> <p>Two orange colour (UV stabilized) lines of minimum 3 mm width diametrically opposite to each other, continuous over the length of the cable shall be applied (marked) for easy identification of this cable from other cables.</p>
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**Cross Section diagram of ADSS cable**



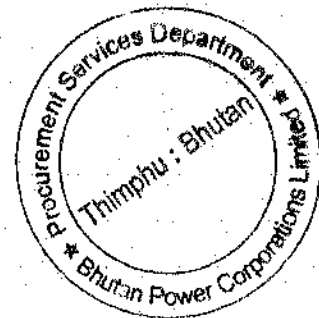
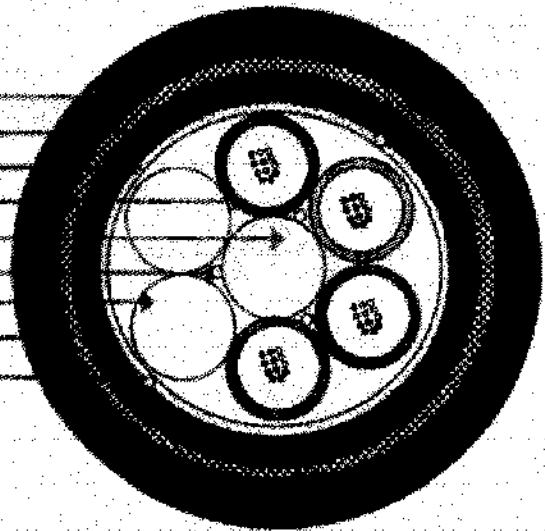
## Technical particulars of 48F SM Armoured Optical Fiber Cable

1. Fiber properties			
Sl.No	Characteristics	Unit	Value
1	Attenuation @ 1310 nm @1550 nm	dB/km	≤ 0.36 ≤ 0.23
2	Chromatic dispersion between 1270 - 1340 nm 1285 - 1330 nm 1550 nm 1625 nm	ps/(nm <sup>2</sup> km)	≤ 5.3 ≤ 3.5 ≤ 18 ≤ 22
3	Zero dispersion wavelength	nm	1300 to 1324
4	Zero dispersion slope	ps/(nm <sup>2</sup> km)	≤ 0.092
5	Cut off wavelength	nm	≤ 1320
6	Mode field diameter at 1310 nm	μm	9.3 ± 0.5
7	Core-clad concentricity error	μm	≤ 0.6
8	Cladding non circularity	μm	≤ 1.0%
9	Cladding diameter	μm	125 ± 1.0
10	Coating diameter	μm	245 ± 10
11	Polarization mode dispersion	ps/√km	≤ 0.20
2. Mechanical Properties			
A	Bending radius	mm	260
B	Tensile Strength	Newton	3000
3. Physical & dimensions properties			
I	Number of fibers		48F
II	Numbers of loose tubes		4
	Number of filler/Dummy		2
	Number of fiber per tube		12
III	Type of fiber		SM G652D
IV	Central strength member		FRP rod
V	Armouring details		Corrugated Steel Tape
VI	Sequence of loose tubes (as per EIA/TIA 598)		Blue, Orange, Green, Brown, Filler-1 & Filler-2
VII	Color of fiber		Blue, Orange, Green, Brown, Grey, White, Red, Black, Yellow, Violet, Pink & Aqua
VIII	Inner & Outer sheath material		UV resistant (Black) polyethylene (H.D.P.E)
IX	Inner sheath thickness	mm	≥ 1.2
X	Outer sheath thickness	mm	≥ 2.0
XI	Outer cable diameter	mm	14.8 ± 0.5 mm
XII	Cable weight	Kg/km	175 ± 20
XIII	Printing on cable	1. Manufacturer name 2. Labelled "48F G652D ARMOURED OFC" 3. Year of manufacture 4. Labelled "BPC" 5. Sequential length marking in meter	
XIV	Standard length	2 km + 5%	



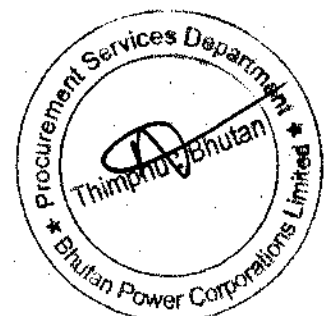
Cross Section diagram of ADSS cable

- OUTER SHEATH (H.D.P.E.)
- INNER SHEATH (H.D.P.E.)
- WATER SWEALLABLE TAPE
- LOOSE TUBE WITH FIBRES
- F.R.P. ROD
- W.S. YARN
- FILLER/DUMMY
- CORRUGATED STEEL TAPE
- RIP CORDS



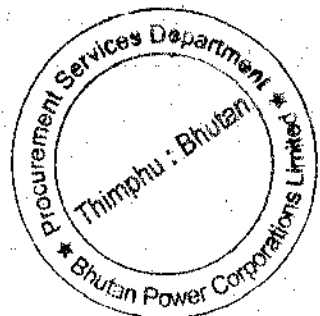
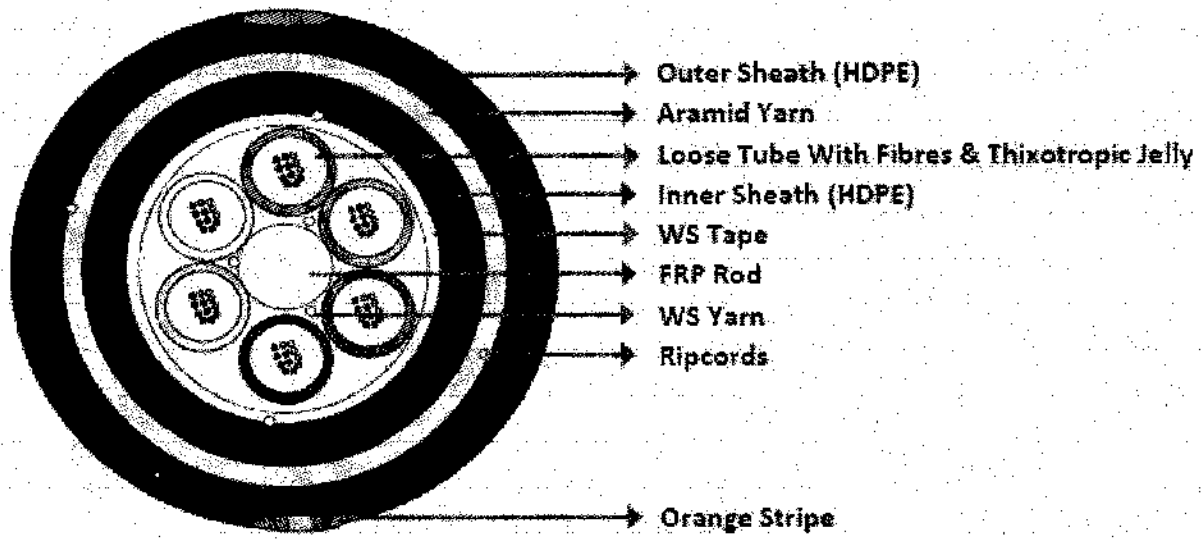
## Technical particulars of 72F DWDM ADSS Optical Fiber Cable

<b>1. Fiber properties</b>			
Sl.No	Characteristics	Unit	Value
1	Attenuation @ 1310 nm @1550 nm	dB/km	≤ 0.36 ≤ 0.23
2	Chromatic dispersion between 1270 - 1340 nm 1285 - 1330 nm 1550 nm 1625 nm	ps/(nm <sup>2</sup> km)	≤ 5.3 ≤ 3.5 ≤ 18 ≤ 22
3	Zero dispersion wavelength	Nm	1300 to 1324
4	Zero dispersion slope	ps/(nm <sup>2</sup> km)	≤ 0.092
5	Cut off wavelength	nm	≤ 1320
6	Mode field diameter at 1310 nm	μm	9.3 ± 0.5
7	Core-clad concentricity error	μm	≤ 0.6
8	Cladding non circularity	μm	≤ 1.0%
9	Cladding diameter	μm	125 ± 1.0
10	Coating diameter	μm	245 ± 10
11	Polarization mode dispersion	ps/√km	≤ 0.20
<b>2. Mechanical &amp; Environmental properties</b>			
A	Tensile Strength	KN	13.0
B	Crush resistance	Newton/100mm	2000 (200Kg load on 100x100mm plate for one minute), change in loss ≤ 0.05dB (IEC-60794-1-21-E3 standard)
C	Bending radius	mm	280 (IEC-60794-1-21-E11 standard)
B	Strain Margin	%	≤ 0.25
C	Impact Resistance	N	50, Change in loss ≤ 0.05dB (IEC-60794-1-21-E4 standard)
D	Torsion resistance	N	75, (10 cycles, ±180degree Change in loss ≤ 0.05dB (IEC-60794-1-21-E7 standard))
E	Max. operating /installation temperature	°C	-30 to +70
<b>3. Physical &amp; dimensions properties</b>			
I	Number of fibers		72F
II	Numbers of loose tubes Number of filler/Dummy Number of fiber per tube		6 0 12
III	Type of fiber		SM G652D
IV	Central strength member		FRP rod
V	Peripheral strength elements		Aramid Yarn – 12.6 kg/km
VI	Sequence of loose tubes (as per EIA/TIA 598)		Blue, Orange, Green, Brown, Slate & F White
VII	Color of fiber		Blue, Orange, Green, Brown, Grey, White, Red, Black, Yellow, Violet, Pink & Aqua
VIII	Inner & Outer sheath material		UV resistant (Black) polyethylene (H.D.P.E)
IX	Inner sheath thickness	mm	≥ 1.2



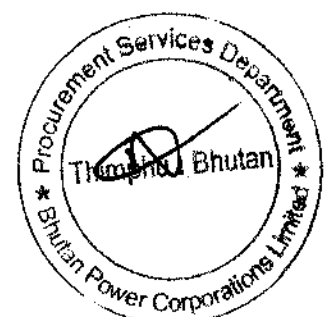
X	Outer sheath thickness	mm	$\geq 2.0$
XI	Outer cable diameter	mm	$14.8 \pm 0.5$ mm
XII	Cable weight	Kg/km	$165 \pm 20$
XIII	Printing on cable	<ol style="list-style-type: none"> <li>1. Manufacturer name</li> <li>2. Labelled "72F G652D ADSS OFC"</li> <li>3. Year of manufacture</li> <li>4. Labelled "BPC"</li> <li>5. Sequential length marking in meter</li> <li>6. Two orange colour (UV stabilized) lines of minimum 3 mm width diametrically opposite to each other, continuous over the length of the cable shall be applied (marked) for easy identification of this cable from other cables.</li> </ol>	
XIV	Standard length	2 km + 5%	

**Cross Section diagram of ADSS cable**



## Technical particulars of OPGW (Optical Ground Wire)

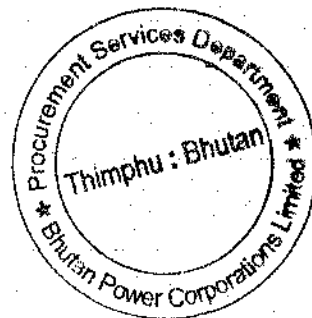
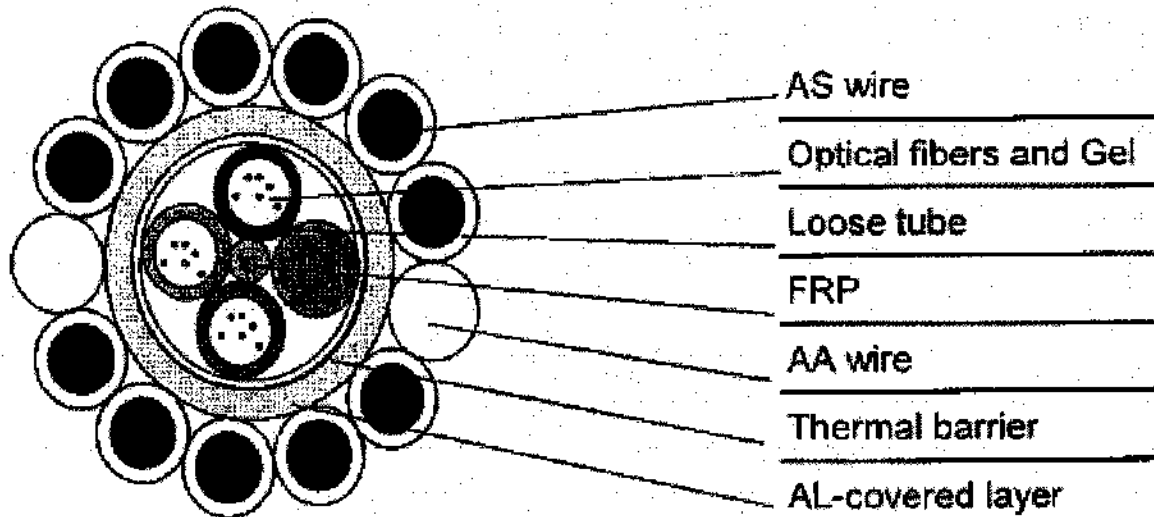
1. Fiber properties			
Category	Description	Specifications	
		Before cabling	After cabling
Optical Specifications	Attenuation @1310 nm	≤ 0.34 dB/km	≤ 0.35 dB/km
	Attenuation @1383 nm	≤ 0.34 dB/km	≤ 0.34 dB/km
	Attenuation @1550 nm	≤ 0.20 dB/km	≤ 0.21 dB/km
	Attenuation @1625 nm	≤ 0.23 dB/km	≤ 0.25 dB/km
	Zero dispersion wavelength	1300 ~ 1324 nm	
	Zero dispersion slope	≤ 0.092 ps/nm <sup>2</sup> km	
	PMD Link value (M=20 cables Q=0.01%) Maximum PMD <sub>Q</sub>	≤ 0.2 ps/nm <sup>2</sup> km	
	Cable cutoff wavelength (λ <sub>CC</sub> )	≤ 1260 nm	
	Macro bending loss (100 turns ; φ50 mm) @ 1550 nm (100 turns: φ50 mm) @ 1625 nm	≤ 0.05 dB ≤ 0.10 dB	
	Mode field diameter @1310 nm	9.2 ± 0.4 μm	
	Dimensional specifications	Cladding diameter	125 ± 1.0 μm
Core/clad concentricity error		≤ 0.6 μm	
Cladding Non-circularity		≤ 1.0 %	
Mechanical specifications	Proof stress	≥ 0.69 Gpa	
2. Physical properties			
Structure	Number of fibers	24 F	
	Number of loose tubes	3	
	Number of filler/dummy	1	
	Number of fiber per tube	8	
	Type of fiber	SM G.652D	
	AL tube @number of tube @Inner -diameter @Outer - diameter	1 5.6mm 7.30 mm	
	Layer 1 @ Number of 20% AS wire @ Number of AA wire @ Diameter (20% AS wire And AA wire)	11 2 2.25 mm	
Stranding directions of outer layer	Right hand (Z-stranding)		
Cable diameter	11.8 mm		
Cable weight	388 kg/km		
Supporting cross section	68.9 mm <sup>2</sup>		
Section of AS wire	43.74 mm <sup>2</sup>		
Section of AL tube	25.18 mm <sup>2</sup>		
Rated tensile strength (RTS)	58.0 KN		
Modulus Elasticity (E-Modulus)	124.3 KN/mm		
Thermal Elongation Coefficient	14.7 x 10 <sup>-6</sup> /°C		





<b>Technical data</b>	Permissible maximum working stress (40 % RTS)	336.8 N/mm <sup>2</sup>	
	Everyday stress (16 % ~ 25% RTS)	134.7 ~ 210.5 N/mm <sup>2</sup>	
	Ultimate exceptional stress (70% RTS)	589.4 N/mm <sup>2</sup>	
	DC resistance	0.735 Ω/km	
	Short time current (1s)	6.32 kA	
	Short time current capacity (20°C~200°C)	39.9kA <sup>2</sup> S	
	Minimum bending Radius installation	472 mm	
	Operating	354 mm	
<b>Temperature range</b>	Ratio of RTS to weight	15.3km	
	Installation	-10°C ~ +50°C	
	Transportation and operation	-40°C ~ +80°C	

### 1. Cross section diagram of OPGW cable



## 2. Color Identification of fiber in OPGW

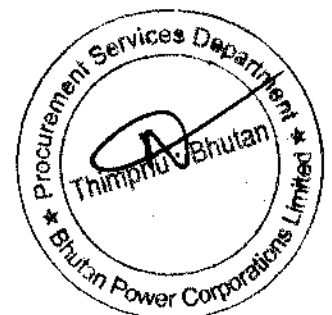
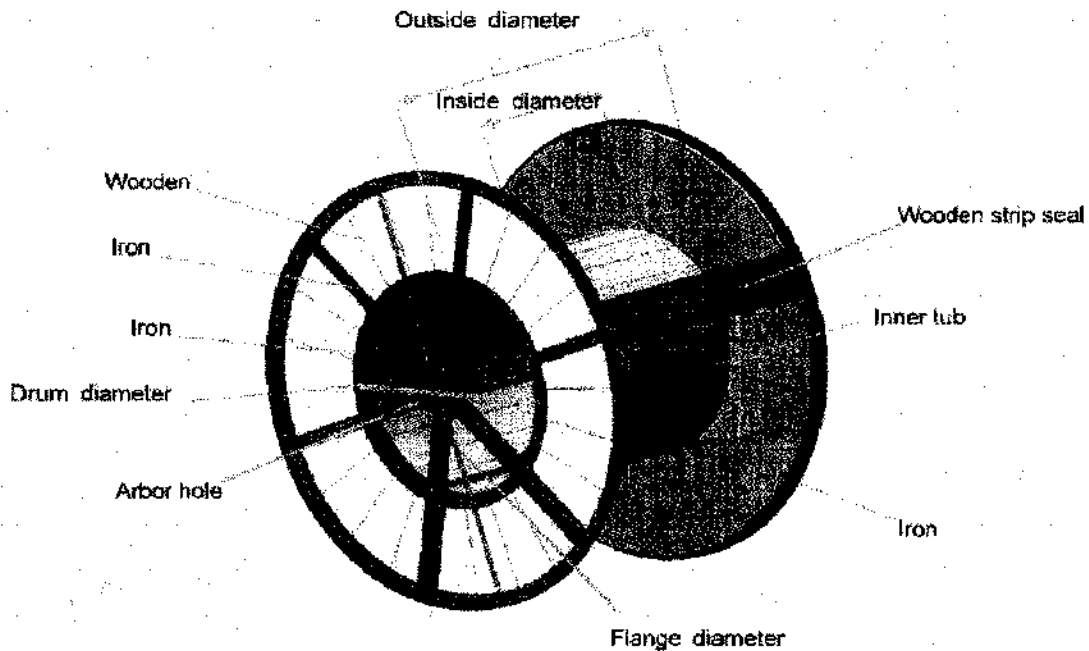
Color code of fiber in OPGW shall be identified referring to the following table

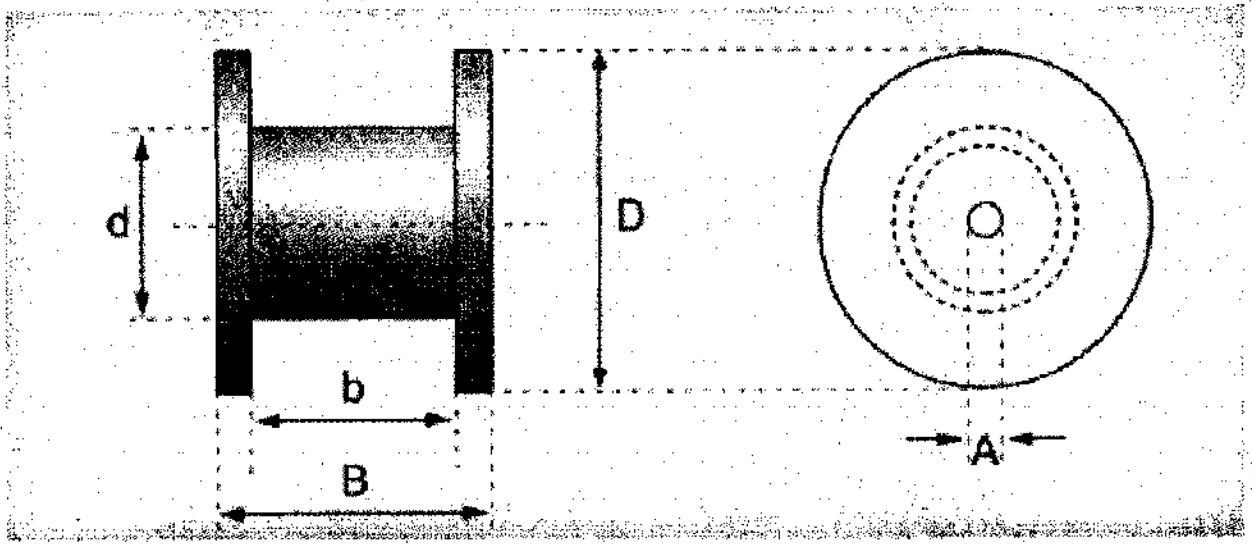
Typical number of fiber: 24

Fiber units	Fiber No. & color					
Blue tube	1	2	3	4	5	6
	Blue	Orange	Green	Brown	Gray	White
	7	8				
Orange tube	9	10	11	12	13	14
	Blue	Orange	Green	Brown	Gray	White
	15	16				
Green tube	17	18	19	20	21	22
	Blue	Orange	Green	Brown	Gray	White
	23	24				
	Red	Black				

## 3. Packing and drum

OPGW shall be wound round a non-returnable iron-wooden drum. Both ends of OPGW shall be securely fastened to drum and sealed with a shrinkable cap. The required marking shall be printed with a weatherproof material on the outsides of drum according to customer's requirement.





Cable diameter (mm)	Drum length (m)	Drum Dimensions & weight					Weight (kg)
		D (cm)	b (cm)	B (cm)	d (cm)	A cm	
11.80	3000	130	90	110	80	11	210
	2000	120	90	110	80	11	200

