

KARNATAKA POWER TRANSMISSION CORPORATION LIMITED

TECHNICAL SPECIFICATION

SECTION –

SWITCHYARD ERECTION

TECHNICAL SPECIFICATION

SECTION -

SWITCHYARD ERECTION

Clause No.	Particulars
1.0	General
1.1	Stringing insulator & hardware
1.2	Construction features
2.0	ACSR conductor
3.0	Galvanized steel wire
4.0	Tubular Bus conductor
5.0	Earthing Conductor
6.0	VOID
7.0	Bus post insulator
8.0	Earthing
9.0	Main Bus Bar
10.0	Bay equipments
11.0	Lightning protection.
12.0	Terminal Bay
13.0	Equipment Erection notes
14.0	Earthing
15.0	Directly Buried cables
16.0	Insulation of cables
17.0	Junction Box
18.0	Testing & commissioning

Annexure – A Testing procedure for ACSR DRAKE conductor.

Annexure – B Testing procedure for Galvanized steel earthwire.

VOLUME – IIA
TECHNICAL SPECIFICATION
SECTION 6.0

TECHNICAL SPECIFICATION FOR SWITCH YARD
ERECTION

1.0 GENERAL:

110kV and 66kV station single bus arrangement with Drake conductor is proposed. Also rigid bus bar arrangement is proposed in some of the substations in and around Bangalore City.

The detailed scope of work includes design, engineering, manufacture, testing at work, supply on F.O.R. destination site basis, insurance, handling, storage, erection, testing and commissioning of various items, (along with its spares) as detailed herein.

This section covers the description of the following items:

- i) Stringing insulators and hardware
- ii) ACSR conductor
- iii) Galvanized steel earthwire
- iv) Aluminum tubular bus bar
- v) Bus post insulators
- vi) Earthing & Earthing materials.
- vii) Lightning protection
- viii) Cabling material, etc.,
- ix) Bay marshalling box.

1.1 Stringing insulators & Hardware power connectors:

The insulators for suspension and tension strings shall conform to IS: 731, insulator hardware shall conform to IS: 2486

1.2 CONSTRUCTION FEATURES:

- 1.2.1 Suspension and tension insulators shall be wet process porcelain with ball and socket connection. Insulators shall be interchangeable and shall be suitable for forming either suspension or strain strings. Each insulator shall have rated strength markings on porcelain printed and applied before firings.
- 1.2.2 Porcelain used in insulator manufacture shall be homogeneous, free from laminations, cavities and other flaws or imperfections

that might affect the mechanical or dielectric quality and shall be thoroughly verified tough and impervious to moisture.

- 1.2.3 Glazing of the porcelain shall be uniform brown colour, free from blisters, burns and other similar defects.
- 1.2.4 When operating at normal rated voltage there shall be no electric discharge between conductor and insulator, which would cause corrosion or injury conductors or insulators by the formation of substance due to chemical action. No radio interference shall be caused when operating at normal rated voltage.
- 1.2.5 The design of the insulator shall be such that stress due to expansion and contraction in any part of the insulator shall not lead to deterioration. Ferrotis parts shall be hot dip galvanized in accordance with the latest edition of IS: 2629. The zinc used for galvanizing shall be of grade Zn – 99.95 as per IS – 209. The zinc coating shall be uniform, adherent, smooth, reasonably bright, continuous and free from imperfections such as flux, ash, rust stains bulky white deposits and blisters.
- 1.2.6 Bidder shall make available data on all essential features of design including the method of assembly of discs and metal parts, number of discs per insulators, the manner in which mechanical stresses are transmitted through discs to adjacent parts, provision for meeting expansion stresses, results in corona and thermal shock tests, recommended working strength and at special design or arrangement employed to increase life under service conditions.
- 1.2.7 VOID
- 1.2.8 Insulator hardware shall be of forged steel. Malleable cast iron shall not be accepted except for insulator disc cap. The surface of hardware must be clean, smooth, without cuts, abrasion or projections. No part shall be subjected to excessive localized pressure. The metal parts shall not produce any noise generating corona under operating conditions.
- 1.2.9 VOID
- 1.2.10 The tension string assemblies shall be supplied along with suitable turnbuckle sag compensation springs if required may also be provided.
- 1.2.11 All hardware shall be bolted type.
 - 1. The following types of clamps are required

- 2 Tension type both for single and twin conductor.
- 3 Suspension type both for single and twin conductor.
- 4 Post insulator clamps – both for single and twin conductor.
- 5 Spacer clamp for twin conductor.

1.2.12 VOID

1.2.13 Tests:

In accordance with the stipulations under section – 2, the suspensions and tension strings, insulator discs and hardware shall be subjected to the following type tests, acceptance tests and routine tests.

1.2.13.1 Type tests on insulator strings:

1. Dry and wet power frequency voltages withstand test with corona control rings as per Is – 731.
2. Lightning impulse voltage withstand test (dry) with corona control rings as per IS – 731.
3. Voltage distribution test (D)

The string shall be energized with 100KV power frequency voltage. The voltage across each insulator unit shall be measured by using a high impedance voltmeter. The voltmeter shall be calibrated before and after the measurement.

4. Corona Test (Dry)

As per Annexure-A of Section-2.

5. RIV Test (Dry)

As per Annexure-A of Section-2.

6. Mechanical strength test

The complete insulator string along with its hardware strings shall be subjected to a load equal to 50% of the specified minimum ultimate tensile strength (UTS), which shall be increased at a steady rate to 67% of the minimum UTS specified. The load shall be held for 5 minutes & then removed. After removal of the load, the string components shall not show any visual deformation and it shall be possible to dismantle them by hand. Hand tools may be used to remove cotter pins and loosen the nuts initially. The string shall then be reassembled and loaded to 50% of UTS and the load shall be further increased at a steady rate till the specified minimum UTS and held for one minute. No fracture should occur during

this period. The applied load shall then be increased until the failing load is reached and the value recorded.

1.2.13.2 Type tests on disc insulator

1. Thermal mechanical performance tests as per IEC 575 clause 3

1.2.13.3 Acceptance tests for disc insulators:

1. Visual examination
2. Verification of dimensions as per Cl. No. 10.5 of IS: 731
3. Temperature cycle test as per Cl. No. 10.6 of IS: 731
4. Puncture test as per Cl. No. 10.10 of IS: 731
5. Galvanizing test as per Cl. No. 10.12 of IS 731
6. Mechanical performance test as per IEC – 575 Cl. 4
7. Test on locking device for ball and socket coupling as per IEC 372 (2)
8. Porosity test as per Cl. No. 10.11 of IS: 731.

1.2.13.4 Acceptance test on hardware fitting

1. Visual examination as per Cl. 5.10 of IS: 2486 (part-1)
2. Verification of dimensions as per Cl. 5.8 of IS: 2486 (part- I)
3. Galvanizing /electroplating tests as per Cl. 5:9 of IS: 2486 (part – I)
4. Slip strength test as per Cl. 5.4 of IS: 2486 (Part – I)
5. Shore hardness test for the Elastometer (if applicable as per the value guaranteed by the bidder).
6. Mechanical strength test for each components (including corona control rings and arcing horns)
7. The load shall be so applied that the component is stressed in the same way as it would be in actual service and the procedure as given in 1.2.13.1 (1) above should be followed.
8. Test on locking devices for ball and socket coupling as per IEC 372 (2)

1.2.13.5 Routine test disc insulator

- 1) Visual inspection as per Cl. no. 10.13 of IS : 731
- 2) Mechanical routine test as per Cl. no. 10.44 of IS : 731
- 3) Electrical routine test as per Cl. no. 10.15 of IS : 731

1.2.13.6 Routine test on hardware fittings

1. Visual examination as per Cl. no. 10 of IS : 2486 (Part – I)
2. Mechanical strength test as per Cl. no. 5.11 of IS : 2486 (Part – I)

1.2.13.7 Test during manufacture on all components as applicable on disc insulator

- a. Chemical analysis of zinc used for galvanizing.

Samples taken from the zinc ingot shall be chemically analysed as per IS : 209. The purity of zinc shall not be less than 99.95%

- b. Chemical analysis, mechanical hardness tests and magnetic particle inspection for malleable casting.

The chemical analysis, hardness tests and magnetic particle inspection for malleable casting will be as per the internationally recognized procedures for these tests. The sampling will be based on heat number and heat treatment batch. The details regarding tests will be discussed and manually agreed to by the contractor and owner in quality assurance programme.

1.2.13.8 Tests during manufacture on all components as applicable on hardware fittings

- i. Chemical analysis of zinc used for galvanizing:

Sample taken from the zinc ingot shall be chemically analysed as per IS : 209. The purity of zinc shall not be less than 99.95%

- ii. Chemical analysis, hardness tests and magnetic particle for forgings :

The chemical analysis, hardness tests and magnetic particle inspection for forgings will be as per the internationally recognized procedures for the tests. The sampling will be based on head number and heat treatment batch

The details regarding tests will be as discussed and manually agreed to by the contractor and owner in quality assurance programme.

- iii. Chemical analysis and mechanical hardness tests and magnetic particle inspection for fabricator hardware:

The chemical analysis, hardness tests and magnetic particle inspection for fabricated hardware will be as per internationally recognized procedure for these tests. The sampling will be based on heat number and heat treatment batch. The details regarding test will be discussed and mutual and agreed to by contractor and owner in quality assurance programme.

1.2.14 PARAMETERS

1.2.14.1 DISC INSULATORS

	110 KV	66 KV	33 KV
a) Type of insulators	Fog type	Fog type	Fog type
b) Size of insulator units (mm)	255 x 145	255 x 145	255 x 145
c) Electromechanical strength	90 KN	90 KN	90 KN
d) Creepage distance of individual insulator units (minimum and as required to meet total creepage distance)	292 mm	292 mm	292 mm
e) Markings	Marking on porcelain shall be printed and applied before fitting.		
f) Power frequency puncture withstand Voltage.	1.3 times the actual wet flashover voltage.		

1.2.14.2 INSULATOR STRING

	110 KV	66 KV	33 KV
a) Power frequency withstand voltage of the complete string with corona control ring (wet) KV rms	230	140	70
b) Lightning impulse withstand voltage of string with corona control rings (dry) KVP	550	325	170
c) Total no. of discs per strings.	9	5	3

Note : For tension purpose, double insulator strings and for suspension purpose single suspension insulator string shall be used.

2.0 ACSR CONDUCTOR:

2.1 Details of conductor:

2.1.1 The contractor shall conform to IS: 398 (part – V) – 1982 except where other wise specified herein.

2.1.2 The details of the conductor are tabulated below :

	Drake	Lynx	Coyote	Rabbit
a) Stranding & wire diameter	26/4.442 mm Al + 7.3.454 mm steel	30/2.79 mm + 7/2.79 mm steel	26/2.54 mm Al + 7/1.91 mm steel	6/3.35 mm Al + 1/3.35 mm steel
b) Sectional area of Aluminum	402.9 mm sq.	183.4 mm sq.	131.7 mm sq.	52.9 mm sq.
c) Total sectional area	468.4 mm sq.	226.2 mm sq.	151.6 mm sq.	61.024 mm sq.
d) Overall diameter	28.13 mm	19.53 mm	15.89 mm	10.05 mm
e) Approximate weight	1624 kg/km	844 kg/km	521 kg/km	214 kg/km
f) Calculated DC resistance at 20 deg. C	0.0715 ohm/km	0.1589 ohm/km	0.2214 ohm/km	0.5449 ohm/km
g) Minimum UTS	14175 Kgs.	7950 Kgs.	4625 Kgs.	1860 Kgs.
h) Modulus of Elasticity (Kgs/Sq.cm x 10 ⁶)	0.773	0.787	0.773	0.809
i) Co-efficient of linear Expansion / °C	18.99 x 10 ⁻⁶	17.73 x 10 ⁻⁶	18.99 x 10 ⁻⁶	18.99 10 ⁻⁶

2.1.3 WORKMANSHIP

2.1.4 The finished conductor shall be smooth, compact from uniform and free from all imperfections including spills, die marks, scratches, abrasions, scuff marks, kinks (protrusion of wires), dents, press marks, cut marks, wire cross over, over riding, looseness (wire being dislocated by finger/hand pressure and/or unusual bangle noise on tapping), material inclusions, while rust powder formation or black spots (on account of erection with trapped rain water etc.,) dirt, grit etc.,

2.1.5 All the aluminum and steel strands shall be smooth, uniform and free from all innerfections such as spills and splits, die marks, scratches abrasions and kinks after drawing.

2.1.6 The steel strands shall be hot dip galvanized and shall have a minimum zinc coating of 260 gm/sq. mm after stranding of the uncoated wire surface. The zinc coating shall be smooth, continuous and of uniform thickness, free from imperfection and shall with stand minimum three dips after stranding in standard prerce test. The finished stands and the individual wire shall be of uniform quality and have the same property and the characteristics as prescribed in ASTM designation: B498-74 and relevant IS.

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

2.2 Joints in wires

2.2.5 Aluminum wires

No joints shall be permitted in the individual wire in the outermost layer of a finished conductor. However joints in the 12 wire and 18 wire inner layers of the conductor shall be allowed but these joints shall be made by cold pressure but twelding shall and be such that no such joints are within 15 Mtr. of each other in the complete stranded conductor.

2.2.6 Steel wire

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

2.3 Tolerance

The manufacturing tolerance to the extent of the following limits only shall be permitted in the diameter of individual aluminum and steel strands and lay-ratio of the conductor:

i. Diameter of Aluminum and steel strands :

	Standard	Maximum	Minimum
Aluminum	3.53 mm	3.55 mm	3,51 mm
Steel	3.53 mm	3.60 mm	3.46 mm

ii. Lay ratio of conductor:

		Maximum	Minimum
Steel	7 wire layer	18	16
Aluminum	12 wire layer	14	12

18 wire layer	13	11
26 wire layer	12	10

2.4 Materials

2.4.1 Aluminum

The aluminum strands shall be hard drawn from electrolytic aluminum rods having purity not less than 99.5% and a copper content not exceeding 0.04%

2.4.2 Steel

The steel wire strands shall be drawn from high carbon steel wire rods and shall conform to the following chemical composition:

Element	:	% composition
Carbon	:	0.50 to 0.85
Manganese	:	0.50 to 1.10
Phosphorous	:	not more than 0.035
Sulphur	:	not more than 0.045
Silicon	:	0.10 to 0.35

2.4.3 Zinc:

The zinc used for galvanizing shall be electrolytic high grades zinc of 99.95% purity. It shall conform to and satisfy all the requirements of IS 209 -1979.

2.5 Standard length:

2.5.1 The conductor shall be supplied in standard length of 1500- 1800 meters as required. No joint shall be allowed within a single span of stringing.

2.6 Tests:

2.6.1 The following type acceptance & routine tests and tests during manufacturing shall be carried out on the conductor.

2.6.2 Type tests

Type tested ACSR Conductor shall be offered. The type test reports shall not be older than Ten (10) years as on the last date of submission of bid.

a) For ACSR Conductor manufactured in India:

- i. Type tests on indigenous equipment for which testing facility is available in India, should have been conducted in any independent laboratories approved by Government or accredited by National accreditation body of the country like Central Power

Research Institute (CPRI), Electrical Research and Development Association (ERDA), etc.

- ii. Type tests on indigenous equipment, for which testing facility is not available in India, should have been conducted in a laboratory of foreign country accredited by National accreditation body of that country.
- iii. The type tests conducted in-house by manufacturers shall also be acceptable provided the lab (manufacturer's) is accredited by National accreditation body of the country and the tests have been witnessed by a representative of NABL accredited Independent laboratory/Power utility.

b) For ACSR Conductor manufactured Abroad:

- i. Type tests on imported equipment should have been conducted in an Indian Laboratory or foreign laboratory accredited by National accreditation body of respective country.
- ii. Type tests conducted in-house by manufacturers shall also be acceptable provided the laboratory is accredited by National accreditation body of the country and the tests have been witnessed by a representative of accreditation body/Power utility.

The following type tests shall be conducted on samples of conductor.

a. UTS test on stranded

Conductor	The no. of sample shall be mutually agreed between contractor and owner
-----------	---

b. DC resistance test on

standard conductor	As per Annexure – A.
--------------------	----------------------

2.6.3 Acceptance Tests

- a) Visual check, for joints)
scratches etc., and length of) As per Annexure - A
conductor)
- b) Dimension checks on steel)
and Aluminum strands)
- c) Check for lay ratios of)
various layers) - do -
- d) Galvanizing test on steel)
strands)

- | | | |
|--|---|--|
| e) Torsion and Elongation test on steel strands |) | |
| f) Breaking load test on steel and aluminum |) | |
| g) Wrap test on steel aluminum strands |) | IS : 398 (part V) 1982
clause 12.5.2, 12.7 & 12.8 |
| h) DC resistance test aluminum strands |) | |
| i) UTS test on welded joints of aluminum strands |) | As per Annexure – A. |

NOTE :

All the above tests except test mentioned at (i) shall be carried out on Aluminum and steel strands after stranding only.

2.6.4 Routine Tests :

- a) Check to ensure that the joints are as per specification.
- b) Check that there are no cuts, fins etc., on the strands.
- c) All acceptance test as mentioned in clause 2.7.3 above to be carried on each coil.

2.6.5 Tests during manufacture

- | | | |
|--|---|----------------------|
| a) Chemical analysis of zinc used for galvanizing |) | |
| b) Chemical analysis of aluminum used for making Aluminum strands. |) | As per Annexure – A. |
| c) Chemical analysis of steel & used for making steel strands) |) | |

2.6.6 Sample batch for type testing

The contractor shall offer material for selection of sample for type testing. Only after getting quality assurance plans from owners quality assurance department.

The samples shall be manufactured strictly in accordance with the quality assurance plan approved by owner.

3.0 GALVANIZED STEEL EARTH WIRE

3.1 Details of Earthwire.

3.1.1 The galvanized steel earthwire shall generally conform to the specification of ACSR core wire as mentioned in IS: 398 (part – II) 1976 except where otherwise specified herein.

3.1.2 The details of the earthwire are tabulated below :

a) Stranding and wire & Wire Dia	7/3.15 mm steel
b) Number of strands	
Steel core	1
Outer steel layer	6
c) Total sectional area	54.55 mm sq.
d) Overall diameter	9.45 mm
e) Approximate weight	426 kg/km
f) Calculated DC resistance at 20 deg. C.	2.95 ohms/km
g) Minimum ultimate tensile	56.98 KN
h) Direction of lay of outer layer	Right hand

3.2 WORKMANSHIP

3.2.1 All steel strands shall be smooth, uniform and free from all imperfections such as spills and splits, die marks, scratches, corrossions and kinks after drawing and also after stranding.

3.2.2 The finished material shall have minimum brittleness, as it will be subjected to appreciable vibration while in use.

3.2.3 The steel strands shall be hot dip galvanized (and shall have a minimum zinc coating of 275 gms/sq. m). The zinc coating shall be smooth, continuous of uniform thickness, free from imperfections and shall withstand three and a half dips after stranding in strand preece test. The steel wire rod shall be of such quality and purity that, when drawn to the size of the strands specified and coated with zinc the finished strands

shall be of uniform quality and have the same properties and characteristic in ASTM designation B498-74.

3.2.4 The steel strands shall be preformed and postformed in order to the prevent spreading of strands while cutting of composite earth wire. Care shall be taken to avoid damage to galvanization during performing and postforming operation.

3.2.5 To avoid susceptibility towards wet storage stains (while rust) the finished material shall be provided with a protective coating of boiled linseed oil.

3.3 JOINTS IN WIRES

There shall be no joint of any kink in the finished steel wire strand entering into the manufacture of the earth wire. There shall be no stand joints or stands splices in any length of the completed stranded earthwire.

3.4 TOLERANCES

The manufacturing tolerances to the extent of the following limits only shall be permitted in the diameter of the individual steel strands and any lay length of the earthwire.

	Standard	Maximum	Minimum
Diameter	3.66 mm	3.75 mm	3.57 mm
Lay length	181 mm	198 mm	165 mm

3.5 MATERIALS

3.5.1 STEEL

The steel wire strands shall be drawn from high carbon steel rods shall conform to the following requirements as to the chemical composition:

Elements	:	% composition.
Carbon	:	Not more than 0.55
Manganese	:	0.4 to 0.9
Phosphorous	:	Not more than 0.04
Sulphur	:	Not more than 0.04
Silicon	:	0.15 to 0.35

3.5.2 Zinc

The zinc used for galvanizing shall be electrolytic high grade zinc of 99.95% purify. It shall confirm to and satisfy all the requirement of IS: 209 – 1979

3.6 STANDARD LENGTH

3.6.1 The earth wire shall supplied in standard drum length of 1500 meters

3.7 TESTS

Type tested Earth wire shall be offered. The type test reports shall not be older than Ten (10) years as on the last date of submission of bid.

a) For Earth wire manufactured in India:

- i. Type tests on indigenous equipment for which testing facility is available in India, should have been conducted in any independent laboratories approved by Government or accredited by National accreditation body of the country like Central Power Research Institute (CPRI), Electrical Research and Development Association (ERDA), etc.
- ii. Type tests on indigenous equipment, for which testing facility is not available in India, should have been conducted in a laboratory of foreign country accredited by National accreditation body of that country.
- iii. The type tests conducted in-house by manufacturers shall also be acceptable provided the lab (manufacturer's) is accredited by National accreditation body of the country and the tests have been witnessed by a representative of NABL accredited Independent laboratory/Power utility.

b) For Earth wire manufactured Abroad:

- i. Type tests on imported equipment should have been conducted in an Indian Laboratory or foreign laboratory accredited by National accreditation body of respective country.
- ii. Type tests conducted in-house by manufacturers shall also be acceptable provided the laboratory is accredited by National accreditation body of the country and the tests have been witnessed by a representative of accreditation body/Power utility.

3.7.1 The following type, routine and acceptance tests and tests during manufacturing shall be carried out on the earthwire.

3.7.2 TYPE TESTS

The following type tests shall be conducted on samples of earthwire. The number of samples shall be mutually agreed between contractor and owner.

- | | | |
|-----------------------|---|----------------------|
| a) UTS test |) | As per Annexure – B. |
| b) DC resistance test |) | |

3.7.3 ACCEPTANCE TESTS :

- | | | |
|---|---|----------------------------|
| a) Visual check, for joints
scratches etc., and length of
Earthwire |) | As per Annexure - B |
| b) Dimensional check |) | |
| c) Check for lay ratios of
various layers |) | -do- |
| d) Galvanizing test |) | |
| e) Torsion test |) | |
| f) Elongation test |) | |
| g) Wrap test |) | |
| h) DC resistance test |) | IS : 398 (Part – III) 1976 |
| i) Breaking load test |) | |
| j) Chemical analysis of steel |) | |

3.7.4 ROUTINE TESTS :

1. Check that there are no cuts, fins etc., on the strands
2. Check for correctness of stranding.

3.7.5 TESTS DURING MANUFACTURE

- | | | |
|--|---|---------------------|
| a) Chemical analysis of zinc
used for galvanizing |) | As per Annexure – B |
| b) Chemical analysis of steel |) | |

3.7.6 SAMPLE BATCH FOR TYPE TESTING:

The contractor shall offer material for sample selection for type testing. Only after getting quality assurance programme approved by the owner. The samples for type testing shall be manufactured strictly in accordance with the quality assurance programme approved by the owner.

4.0 TUBULAR BUS CONDUCTOR

4.1 GENERAL: (Supply and erection)

- 4.02 This specification is in two parts, part-II and part - III in addition to part-I (general condition)
- 4.03 Part - II relates to technical specification in regard of manufacture, testing and supply of Aluminium pipes and accessories like post insulator clamps, corona bells, expansion joints etc.
- 4.04 Part - III relates to erection of aluminium bus bars with accessories supplied as per specification in part - II and includes bending, and welding of aluminium pipes, fixing corona, bells, making expansion joints etc.
- 4.05 The scope of this specification covers the erection of tubular aluminium bus bars as detailed below:
- i) Erection of 110 KV or 66 KV main bus of 75 mm/ 63 mm, 33KV single main bus of 50 mm aluminium pipe with rigid cross bus connection to disconnects.

The scope of work covered by this specification is indicated in the layout plan drawings annexed . The main rigid bus is to be connected to the expansion type connectors of the disconnects through rigid cross bus aluminium pipes. Supply of terminal connectors of the disconnects, is not in the scope of supply.

4.06 VOID

- 4.07 The schedule of requirements is indicated in schedule of quantities, Volume II section - I General.

4.08 STANDARDS:

- 4.09 The materials offered shall conform to the relevant IS standards

- 4.10 Qualifying requirement : Refer Section IFB Volume I

- 4.11 The quantities and arrangement based on the drawing furnished by the purchaser may be altered by the successful bidder for ensuring better working arrangements with the written consent of the purchaser. The tenderer shall furnish reasons in detail for suggesting such alterations. The purchaser reserves the right to accept or to reject any or all of the alterations or suggestions made by the bidder without assigning any reason whatsoever.

The following points shall be kept in view while submitting the offer:

- a) The vertical connections from main bus bar to disconnects shall be as follows
 - i. The Y and 'V' tap shall be connected by bolted type clamp at top and bottom. Through a straight tap of height 1750mm and 1250 mm with 63 and 50 mm aluminium pipe in case of 110 KV and 66KV side bus connectors. The straight tap shall be connected by bolted type clamps both at top and bottom.
 - ii. Through a straight tap of height 1200 mm with 38 mm aluminium pipe in case of 33KV side bus connectors. The straight taps shall be connected by bolted type clamps both at top and bottom.
- b) The horizontal connector from vertical tap to disconnects shall be of aluminium pipe of the same size as that of vertical connectors and be rounded off at the end.
- c) Length of the horizontal connector from tap to disconnects is assessed, based upon the width of isolators of standard make. Hence there may be slight difference in the total length of horizontal connectors required, depending upon the make of disconnects which are being procured

4.12 OPERATING CONDITIONS

The materials supplied and the workmanship involved shall be suitable for operating conditions, which are detailed below

Particulars	110 KV	66KV	33KV
Normal current to base handled	As per normal rating Al. pipes indicated in annexure	As per normal rating Al. pipes indicated in annexure	As per normal rating Al. pipes indicated in annexure
Impulse withstand voltage(KV)	550	325	170
Power frequency withstand voltage(KV)	230	140	75

4.13 DRAWING FOR APPROVAL:

Detailed layout drawings indicating the various components as detailed below shall be got approved by the successful tenderer before execution of work.

- a) Aluminum pipes of various size.
- b) Position of post insulator clamps indicating various types i.e., rigid expansion / sliding type.
- c) Position of welds
- d) Cross - section at vital points like welding points, connection of vertical taps of 110KV and 33 KV main bus bars, post insulators, clamps points rigid, expansion and sliding types.
- e) Detailed drawings of various components namely length and cross section of pipes, straight taps, post insulators clamps, rigid, sliding, expansion clamps, aluminium pipe connectors 75 mm to 63 mm, 63 mm to 50mm, 50mm to 38mm used for connecting main bus bars to disconnects.

4.14 ALUMINIUM PIPE: (Supply of aluminium pipes and accessories)

- a. The purchaser proposes to use the under mentioned nominal size of aluminium pipes

	110KV	66KV	33KV
Main busbars	75mm	63mm	50mm
Cross bus connecting main busbars and disconnects	63mm	50mm	38mm

- 4.15 Aluminium pipe to be supplied shall conform to BS-1600 schedule 40(EPS) standard pipe sizes or equivalent standard having mechanical and electrical characteristics as detailed in annexure-I.
- 4.16 The aluminium pipe to be supplied should be of aluminium alloy of type 6340 WP as per IS-5082 of 1981 and shall have the chemical composition and electrical characteristics as detailed in annexure-I and II respectively.
- 4.17 The requirement for total lengths of various sizes of aluminium pipe is indicated in section I of volume II. The tubes shall be supplied in convenient lengths so as to keep wastages to a minimum without diminishing any of the mechanical and electrical properties. The length of the pipes indicated is based on the drawings furnished. Any increase

in lengths of pipes owing to any practical reasons, miscalculation will be to the account of the bidder.

4.19 The material shall be suitable for operating conditions detailed elsewhere of this specifications.

4.20 The aluminium pipes to- be supplied should withstand high temperature encountered during welding and no stress should develop in the pipe adjacent to the welding portion.

4.21 CORONA BELLS

a. These are required to be fixed at both ends of main buses to reduce corona effect.

b. The requirement of corona bells is indicated in the schedule of requirement.

c. SOLID CYLINDRICAL POST INSULATOR CLAMPS:

d. These are envisaged for holding the 220KV, 110KV, 66KV, and 33KV main bus supported on cylindrical type solid core post insulators. The clamps to be supplied shall be suitable for mounting holes on the insulator and size of the pipe which is detailed below :

Nominal diameter of Aluminium pipe (inches)	Cylindrical solid core post insulator	Pitch circle diameter of mounting holes on top (mm)	Number of holes (numbers)
i. 75 mm a 110KV main bus	As per IS 5350 Part II	127	4
ii. 63 mm a) 66KV main bus	As per IS 5350 Part II	127	4
iii. 50 mm a) 33 KV main bus	As per IS 5350 Part II	76	4

e. The clamps shall conform to latest edition of IS : 5561

4.22 The clamps required are of three types viz. Rigid, sliding and expansion types

i) RIGID TYPE CLAMPS : Are required to hold the aluminium pipe rigidly allowing for no lateral movement of pipe. These are required at points marked 'R' in the layout drawings and shall be suitable for insulator and

aluminium pipe details indicated in clause 4.24. At all rigid clamp locations, there shall be vertical straight tap connections in case of 110KV, 66KV and 33KV main buses for connecting disconnects respectively.

- ii) SLIDING TYPE CLAMPS : Are the ones located in between a rigid clamp and expansion type clamp, which shall allow for movement of pipes. These are marked as 'S' in layout drawing. These clamps may be bolted type or plain type i.e, without bolts. As in case of rigid type clamps, vertical straight line tap connections are located on sliding clamps also.
- iii) EXPANSION TYPE CLAMPS : Are the ones located between two rigid clamps and marked 'E' in the layout drawing. These clamps are meant for allowing for expansion of aluminium pipes used for main bus. The expansion joints so used in the clamps shall be complete in all respects with required aluminium straps, filler inserts, etc., and should allow for proper expansion of the portion of aluminium pipes between two rigid clamps.

4.23 'V' OR 'Y' TAPS OR STRAIGHT LINE TAPS:

- 4.24 As detailed in clause 4.23 and clause 4.12 in part-I, the main bus is to be connected to equipment of various terminal bays by means of straight taps in case of 110KV, 66KV, and 33KV main buses.
- 4.25 The vertical taps are to be connected to disconnects by means of horizontal taps
- 4.26 The tap connections shall be with 63 mm aluminium pipe for 110KV system and with 50mm aluminium pipe for 66KV (38mm) aluminium pipe for 33KV system.
- 4.27 The height of vertical taps shall be 1750 mm for 110KV system, 1250 mm for 66KV system and 1200mm for 33KV system.
- 4.28 The joints between the main bus and vertical tap and vertical tap to horizontal tap shall be made up of suitable clamps, which should conform to the latest edition of IS-5561.

4.3 WELDED JOINTS, INSERTS, ETC:

- 4.31 The main bus shall consists of standard lengths of aluminium pipe joined at various points by welded joints or expansion joints as the case may be.

- 4.37 Welded joints to an extent of 10% of the total quantity for each KV class shall be tested by radio-graphic test to prove the soundness of the weld joints. Further if desired by the owner, the tenderer shall arrange for the radio-graphic test of more number of joints for which the unit rates are to be indicated in price schedule.
- 4.32 The welded joint or the expansion joint shall be complete in all respects with required number of pipe filler inserts, proper welding etc.
- 4.33 The successful tenderer shall submit the quality assurance plan for the work and welder qualification for approval. The weld should be cut open to see the quality of the welds at no extra cost to the purchaser .
- 4.40 DRAWING
- 4.41 The tenderer should submit drawing in respect of all the components detailed in clause 1.00 to 5.00 and other essential and necessary components required for without which the tender will be rejected.
- 4.42 As stated in clause 6.00 of part-1 the tenderer shall submit drawings of various components for purchaser's approval. The material shall be offered for inspection only after purchaser's approval is accorded to the drawing.
- 4.43 The drawings of clamps and connectors **should be exhaustive** i.e, various views shall be depicted and current rating (Ampacity) mentioned.
- 4.44 MATERIALS:
- 4.45 The material used for the various pipe joints, connectors shall be of proven tested quality and workmanship. The composition of alloys used shall be made available to the purchaser for verification. The bolts and nuts shall conform to IS-1363- 1967 with latest revisions.
- 4.46 The clamps offered shall be complete in all respect and shall perfectly suit the required size of aluminium pipes specified in clause 1.00 of part-II.
- 4.47 All ferrous metal parts like bolts, nuts of size 12mm and above shall be hot dip galvanised and bolt sizes below 12mm may be electro galvanised. The threads in nuts shall be cut after galvanising and shall be lubricated and greased. All other threads shall be cut to take care of increase in diameter due to galvanising.
- 4.48 All bolts shall be provided with a lock nut along with fastening nut.

4.49 All casting shall be free from blow holes and other casting defects such as cracks etc.

4.50 The connectors shall have the same electrical characteristics as the associated aluminium bus bars and, shall be capable of carrying the normal and short time current rating detailed in clause 5.00 of part-I.

a. Special care should be taken in clamp design to account for

- (i) Galvanic corrosion,
- (ii) cold flow or creep of aluminium,
- (iii) thermal cycling.

The clamp body shall be of high conductivity aluminium alloy of high strength and non-corrosive. The aluminium alloy shall be copper free. The bolts and nuts used shall be of high tensile, non-corrosive galvanic resistant material. Aluminium alloy, phosphorous bronze or galvanised iron may be used as required by the clamp design.

4.52 Bolting pressure shall be well distributed. The outer surface of the clamp shall be smooth and free from sharp edges.

4.53 TESTS

4.54 Aluminium pipe, associated clamps and corona bell shall be designed for trouble free operation in the climatic and atmospheric conditions enumerated in the project data. Hence, the tests and especially the Corona discharge test, Special features of design to meet the requirement shall be brought out in the tender.

4-55 TYPE TESTS:

Type tested aluminium pipe and accessories shall be offered. The type test reports shall not be older than Ten (10) years as on the last date of submission of bid.

a) For aluminium pipe and accessories manufactured in India:

- i. Type tests on indigenous equipment for which testing facility is available in India, should have been conducted in any independent laboratories approved by Government or accredited by National accreditation body of the country like Central Power Research Institute (CPRI), Electrical Research and Development Association (ERDA), etc.
- ii. Type tests on indigenous equipment, for which testing facility is not available in India, should have been conducted in a laboratory of foreign country accredited by National accreditation body of that country.

iii. The type tests conducted in-house by manufacturers shall also be acceptable provided the lab (manufacturer's) is accredited by National accreditation body of the country and the tests have been witnessed by a representative of NABL accredited Independent laboratory/Power utility.

b) For aluminium pipe and accessories manufactured Abroad:

i. Type tests on imported equipment should have been conducted in an Indian Laboratory or foreign laboratory accredited by National accreditation body of respective country.

ii. Type tests conducted in-house by manufacturers shall also be acceptable provided the laboratory is accredited by National accreditation body of the country and the tests have been witnessed by a representative of accreditation body/Power utility.

Tenderer shall furnish the following type test certificates in respect of the aluminium pipe and accessories.

	Aluminium Pipe	Clamps	Corona bells
1. Tensile test	-----	Applicable	-----
2. Resistance test	Applicable	Applicable	Applicable
3. Temp.rise test	Applicable	Applicable	Applicable
4. Short time current test	Applicable	Applicable	Applicable
5. Visual discharge test.	Applicable	Applicable	Applicable

4.56 Acceptance tests: The following acceptance tests are to be conducted in presence of owner's representative.

- a) Tensile test.
- b) Resistance test.
- c) Temperature rise test.
- d) Visual and dimensional verification

4.57 The visual discharge is specified to know the corona effect. Special care shall be taken to design and manufacture to minimise corona discharge. Corona discharge shall not be visible from the clamps when the system consisting of pipe with clamps is energised to phase ground system.

4.58 For the purpose of temperature rise and other tests, the current carrying capacity of various clamps may be reckoned as follows clamps or part thereof in contact with IPS aluminium pipe of nominal diameter.

- | | |
|----------|------------|
| a) 75 mm | 2000 Amps. |
| b) 63 mm | 1250 Amps. |

- | | |
|----------|------------|
| c) 50 mm | 1250 Amps. |
| d) 38 mm | 800 Amps, |

4.59 The purchaser reserves the right to conduct temperature rise tests at rated current on any erected portions of the bus works. Total temperature of clamps more than 85 deg C (temperature rise plus ambient) will not be acceptable. Clamps which are found to show the usual corona discharge at the rated voltage will not be acceptable

4.60 SAMPLES

4.61 The tenderer shall furnish typical samples of tubular bus bar materials of 500 mm. Minimum length and one unit of each of components like clamps, corona bell, power connectors, etc., used in the above works, to enable the purchaser to assess the quality of workmanship of the products.

4.62 ERECTION AT SITE

4.63 WORKS AND WORKMANSHIP :

To elaborate the work involved at site

- i) It consists of cutting of tubular bus bars to required sizes.
- ii) Making of straight tap.
- iii) Welding of aluminium tubes after installation and mounting of tubular bus bars.
- iv) Welding of heater plates
- v) Bending and assembly of aluminium tubes with other accessories and equipments as shown in the tender drawings.
- vi) Radiographic test of all welded Joints.

4.64 The workmanship shall be of highest order. The cutting shall be smooth, even without any burrs on the cut edges. The welding shall be perfect and the successful tenderer shall take radiographs and furnish the same to the purchaser to depict the perfect ness of welding,

4.65 WELDING OF JOINTS:

4.66 Surface to be welded shall be cleaned thoroughly so that the same are free from grease, dust and loose particles. Sleeves shall be used for welded joints under short circuit conditions.

4.67 Pure argon gas shall be used for welding. In view of argon gas shield around the arc, the welding operation shall be shielded from wind that could displace the gas envelope.

4.68 The welding process shall be carried out at the rate of 15-30 cms per minute. After completion of welding, the surface shall be cleaned.

4.69 The ' weld ' shall have an average strength ranging from 120 to 155 KG/cm².

4.70 TESTING AND COMMISSIONING

4.71 After satisfactory completion of works as detailed in clause 1.05 and 2.01 above, the tubular bus bars will be energised in the presence of the tenderer or his authorised representative.

4.72 TESTS

Radio - graphic tests:

- a) The test is intended for the presence of the cracks, discontinuity in the welds.
- b) A minimum of 10 % of the welded joints are to be subjected to radiographic tests. These welded Joints shall be selected at random by the purchaser.
- c) Further if the purchaser desires for the radiographic test for more number of welded joints, the contractor shall arrange for the same.

7.73 Test to prove the mechanical strength ie, to withstand 155 KG/ cm² shall be conducted on 5% of the welded joints.

SL No.	Particulars	Unit	75 mm	63 mm	50 mm	38 mm
1	Nominal size	mm	75	63	50	38
2	Outer diameter	mm	88.9	73.03	60.33	48.26
3	Inner diameter	mm	77.92	62.71	52.51	40.89
4	Wall thickness	mm	5.449	5.16	3.91	3.68
5	Area of cross-section	Sq. mm	1439	1100	693.55	516.13
6	Weight per unit length	Kg/mtr	3.884	2.97	1.878	1.4
7	Section modules	Cubic cm	28.258	17.451	9.186	5.345
8	Movement of inertia	Cm ⁴	125.606	63.683	27.709	12.9
9	Radius of gyration	Cm	2.957	2.406	1.999	1.581
10	DC Resistance (max) at 20 deg C	Micro ohm/mtr	21.8	28.4	45.149	60.73
11	Reactance at 304.8 mm (1 foot)	Micro ohm/mtr	123.7	136.2	148.3	162.73

	spacing at 50 Hz					
12	Current rating at 50 Hz for outdoor conditions	Amps	2350	1950	1440	1160

ANNEXURE -II

CHEMICAL PROPERTIES OF ALUMINIUM ALLOY

(Clause 10.03)

- | | | |
|----|---|--|
| 1. | I.S specification 5082-1981 | 6340-wp type or equivalent of any international standards. |
| 2. | Chemical composition percentage | Cu - 0.04 Max
Mg - 0.4 to 0.9.
Si - 0.3 to 0-7.
Fe- 0.5 Max.
- 0.03 Min
Al - remaining part |
| 3. | Minimum 0.2% proof stress | 16.5 Kg. Per Sq.rrm |
| 4. | Minimum ultimate tensile strength | 20.5 Kgs/Sq.mm |
| 5. | Minimum elongation on 50 mm. | 10% |
| 6. | Electrical resistivity (max) at 20* C | 1133 Micro ohms cm |
| 7. | Minimum electrical conductivity | 55% I.A.C.S |
| 8. | Temperature co-efficient of resistance per centigade degree | 0.00364 |

9.	Linear temperature co-efficient of expansion (20 deg C - 200 Q per centigrade degree	0.000023
10.	Thermal conductivity (Calories/sec/sq. mm/cm/deg. Q at 100 deg C	0.43
11.	Modulus of elasticity	6700 Kgs./sq.mm.

5.0 EARTHING CONDUCTORS

5.1 General

All conductors buried in earth shall be of mild steel. All conductors above ground level and earthing leads shall be galvanized steel, except for cable trench earthing. The minimum sizes of earthing conductors to be used are as indicated in clause 8.4 this section.

5.2 Constructional features

5.2.1 Galvanised steel

1. Steel conductors above ground level shall be galvanized according to IS: 2629
2. The minimum weight of the zinc coating shall be 618 gm/sq.m and minimum thickness shall be 85 microns.
3. The galvanized surface shall consist of a continuous and uniformly thick coating of the firmly adhering to the surfaces of steel. The furnished surface shall be clean and smooth and shall be free from defects like discolored patches. Bare spots unevenness of coating, speller which is loosely attached to the steel globules, Spiky deposits, blistered surface, flaking or peeling off etc. The presence of any of these defects noticed on visual or microscopic inspection shall render the material liable to rejection.

5.3 Tests:

In accordance with stipulations under section – 2 galvanized steel shall be subjected to four one-minute fips in copper sulphate station as IS: 2633

6.0 VOID

7.0 Bus POST INSULATORS

The post insulators shall conform in general to latest IS: 2544, IEC 168 and IEC – 815, IS – 5350

7.1 Constructional Features.

7.1.1 Post type insulator shall consist of a porcelain part permanently seamed in a metal base to be mounted on the supporting structures. They shall be capable of being mounted upright. They shall be designed to withstand any shocks to which they may be subjected to the operation of the associated equipment only solid core insulators will be acceptable.

7.1.2 Porcelain used shall be homogeneous, free from lamination, cavities and other flaw or imperfections that might affect the mechanical or dielectric quality and shall be thoroughly verified, tough and impervious to moisture.

i. Glazing of the porcelain shall be of uniform brown in colour, free from blisters, burns and other similar defects.

7.1.4 The insulator shall have alternate long and short sheds with aerodynamic profile. The shed profile shall also meet the requirements of IEC – 815 for the specified pollution level.

7.1.5 When operating at normal rated voltage there shall be no electric discharge between conductor and insulators which would cause corrosion or injury to conductors or insulator by the formation of substance produced by chemical reaction.

7.1.6 The design of the insulator shall be such that stresses due to expansion and contraction in any part of the insulator shall not lead to deterioration.

7.1.7 All ferrous parts shall be hot dip galvanized in accordance with latest edition of IS: 2633 & IS: 4579. The zinc used for galvanizing shall be grade Zn 99.95 as per IS: 209. The zinc coating shall be uniform, adherent smooth, reasonably bright continuous and free from imperfections such as flux, ash, rust, stains, bulky white deposits and blisters. The metal parts shall not produce any noise generating coronation under the operating conditions.

7.1.8 a) Every bolt shall be provided with a steel washer under the nut so that part of the threaded portion of the bolts is within the thickness of the parts bolted together.

b) Flat washer shall be circular of a diameter 2.5 times that of bolt and of suitable thickness. Where bolts heads/nuts bear upon

the beveled surfaces they shall be provided with square tapered washers of suitable thickness to afford a seating square with the axis of the bolt.

- c) All bolts and nuts shall be steel with well formed hexagonal heads forged from the solid and shall be hot dip galvanized. The nuts shall be good fit on the bolts and two clear threads shall show through the nut when it has been finally tightened up.

- i. Bidder shall make available data on all the essential features of design including the method of assembly of shells and metal parts number of shells per insulator, the manner in which mechanical stress are transmitted through shells to adjacent parts, provision for meeting expansion stresses results of corona and thermal shock, tests recommended working strength and any special design or arrangement employed to increase life under service condition

7.2 Tests

In accordance with the stipulations under section – 2 the post insulator shall be subject to type, acceptance, sample and routine tests as per IS: 2544 and IEC: 60168

Type tested post insulator shall be offered. The type test reports shall not be older than Ten (10) years as on the last date of submission of bid.

a) For post insulator manufactured in India:

- i. Type tests on indigenous equipment for which testing facility is available in India, should have been conducted in any independent laboratories approved by Government or accredited by National accreditation body of the country like Central Power Research Institute (CPRI), Electrical Research and Development Association (ERDA), etc.
- ii. Type tests on indigenous equipment, for which testing facility is not available in India, should have been conducted in a laboratory of foreign country accredited by National accreditation body of that country.
- iii. The type tests conducted in-house by manufacturers shall also be acceptable provided the lab (manufacturer's) is accredited by National accreditation body of the country and the tests have been witnessed by a representative of NABL accredited Independent laboratory/Power utility.

b) For post insulators manufactured Abroad:

- i. Type tests on imported equipment should have been conducted in an Indian Laboratory or foreign laboratory accredited by National accreditation body of respective country.
- ii. Type tests conducted in-house by manufacturers shall also be acceptable provided the laboratory is accredited by National accreditation body of the country and the tests have been witnessed by a representative of accreditation body/Power utility.

7.2.1 In addition to acceptance/sample/routine tests as per IS: 2544 and IEC – 60168, the following tests shall also be carried out.

1. Ultrasonic test as an acceptance test.
2. Soundness test, metallurgical tests and magnetic test on MCI caps and pedestal tests as acceptance test.
3. All hot dip galvanized components shall be subject to check for uniformity of thickness and weight of zinc coating on sample basis.
4. The bending test shall be carried out at 50% minimum failing loads in four directions as a routine test and at 100% minimum failing load in four directions as an acceptance test.
5. Acceptance norms for visual defects allowed at site and also at works shall be agreed in the quality plan.

7.2.3 The following type tests are proposed to be conducted on the post insulators. The test charge for conducting these tests shall be indicated in the offer.

- a) Power frequency withstand test (dry & wet)
- b) Lightning impulse test (dry)
- c) Measurement of RIV (dry) – As per Annexure A, Section - 2
- d) Corona extinction Voltage test (dry) – As per Annexure A, Section - 2
- e) Test for deflection under load.
- f) Test for mechanical strength.

7.2.4 Technical parameter of Bus post insulators:

a) Type	Solid Core		
b) Voltage class (KV)	123	72.5	36
c) Dry and wet One minute			
Power frequency withstand			
voltage (KV rms)	230	140	70
d) Dry lightning impulse	550	325	170
with stand voltage (KVP)			

e)	Wet switching surge withstand voltage (KVP)			
f)	Max. radio interference voltage (in micro volts) at voltage 156 (rms) for 220 KV between phase to ground.			
g)	Corona extinction voltage (KV rms)	123KV	72.5KV	36KV
h)	Total minimum cantilever strength (KN)	6	6	6
i)	Minimum torsional moment	---- As per IEC – 273 ----		
j)	Total height of insulator (mm)	1220	770	445
k)	P.C.D.			
	Top (mm)	127	127	76
	Bottom	225	127	76
l)	No. of bolts			
	Top	4	4	4
	Bottom	4	4	4
m)	Diameter of bolt holes (mm)			
	Top	M16	M16	M12
	Bottom dia	18	16	12
n)	Pollution level as per IEC – 815			
o)	Minimum total creepage distance for Heavy pollution (mm)	3075	1815	900

8.5 Earthing Conductor Layout

8.5.1 Earthing conductors in outdoor areas shall be buried at least 600 mm below finished ground level unless stated otherwise

- i. Whenever earthing conductor crosses cable trenches, underground service ducts, pipes, tunnels, railways tracks etc., it shall be laid minimum 300mm. below them and shall be re-routed in case it fouls with equipment/ structure foundations.

8.5.3 Tap connections from the earthing grid to the equipment/structure to be earthed shall be terminated on the earthing terminals of the equipment/structure as per "Earthing Details-

8.5.4 Earthing conductors or leads along their run on cable trench ladder columns, beams, walls etc., shall be supported by suitable welding/cleating at intervals of 750 mm. Wherever it passes through walls, floors etc., galvanised iron sleeves shall be provided for the passage of the conductor and both ends of the sleeve shall be sealed to prevent the passage of water through the sleeves.

8.5.5 Earthing conductor around the building shall be buried in earth at a minimum distance of 1500 mm from the outer boundary of the building. In case high temperature is encountered at some location, the earthing conductor shall be laid minimum 1500 mm away from such location.

8.5.6 Earthing conductors crossing the road shall be laid 300mm below road or at greater depth to suit the site conditions.

8.5.7 Earthing conductors embedded in the concrete shall have approximately 50 mm concrete cover

8.6 Equipment and Structure Earthing

- 8.6.1 Earthing pads shall be provided for the apparatus/equipment at accessible position. The connection between earthing pads and the earthing grid shall be made by two short earthing leads (one direct and another through the support structure) free from kinks and splices. In case earthing-pads are not provided on the item to be earthed, same shall be provided in consultation with owner.
- 8.6.2 Whether specifically shown in drawings or not, steel/RCC columns, metallic stairs etc., shall be connected to the nearby earthing grid conductor by two earthing leads. Electrically continuity shall be ensured by bonding different sections of hand-rails and metallic stairs.
- 8.6.3 Metallic pipes, conduits and cable tray sections for cable installation shall be bonded to ensure electrical continuity and connected to earthing conductors at regular interval. Apart from intermediate connections, beginning points shall also be connected to earthing system.
- 8.6.4 Metallic conduits shall not be used as earth continuity conductor.
- 8.6.5 A separate earthing conductor shall be provided for earthing lighting fixtures
receptacles, switches, junction boxes, lighting conduits etc.
- 8.6.6 Wherever earthing conductor crosses or runs along metallic structures such as gas, water, steam conduits, etc., and steel reinforcement in concrete it shall be bonded to the same.
- 8.6.7 Light poles, junction boxes on the poles, cable and cable boxes/glands, lockout switches etc., shall be connected to the earthing conductor running alongwith the supply cable which inturn shall be connected to

earthing grid conductor at a minimum two points whether specifically shown or not.

8.6.8 Railway tracks within switchyard area shall be earthed at a spacing of 30m and also at both ends.

8.6.9 Earthing conductor shall be buried 1500mm away from the switchyard fence. All the gates and every alternate post of the fence shall be connected to earthing grid as specified in earthmat design.

8.6.10 Flexible earthing connectors shall be provided for the moving parts.

8.6.11 All lighting panels, junction boxes, receptacles fixtures, conduits etc., shall be bonded in compliance with the provision of I.E. rules

8.6.12 A continuous round conductor of 16 SWG wire shall be run all along each conduit run and bonded at every 600mm. by not less than two turns of the same size of wires. The conductor shall be connected to each panel ground bus. All junction boxes, receptacles, lighting fixtures etc., shall be connected to this 16 SWG ground conductor.

8.6.13 50mm x 6mm MS flat shall run on the top tier and all along the cable trenches and the same shall be welded to each of the racks. Further this flat shall be earthed at both ends and at an interval of 30 Mtrs. The M.S. flat shall be finally painted with two coats of red oxide primer and two coats of post office red enamel paint

8.7 Jointing

- 8.7.1 Earthing connections with equipment earthing pads shall be bolted type. Contact surface shall be free from scales, paint, enamel, grease, rust or dirt. Two bolts shall be provided for making each connection. Equipment bolted connections, after being checked and tested, shall be painted with anti-corrosive paint/compound.
- 8.7.2 Connection between equipment earthing lead and main earthing conductors and between main earthing conductors shall be welded type. For rust protection, the welds should be treated with red lead and afterwards coated with two layers bitumen compound to prevent corrosion.
- 8.7.3 Steel to copper connections shall be brazed type and shall be treated to prevent moisture ingress.
- 8.7.4 Resistance of the joint shall be more than the resistance of the equivalent length of the conductor.
- 8.7.5 All ground connections shall be made by electric arc welding. All welded joints shall be allowed to cool down gradually to atmospheric temperature before putting any load on it. Artificial cooling shall not be allowed.
- 8.7.6 Bending of earthing rod shall be done preferably by gas heating.
- 8.7.7 All arc welding with large dia. Conductors shall be done with low hydrogen content electrodes.

8.7.8 The 50x 6 mm 41 flat shall be clamped with the equipment support structures at 1000mm interval.

8.8 Power Cable Earthing

Metallic sheaths and armour of all multicore power cables shall be earthed at both equipment and switchgear end. Sheath and armour of single core power cables shall be earthed at switchgear end only.

8.9 Specific Requirement for Earthing Systems

8.9.1 Each earthing lead from the neutral of the power transformer shall be directly connected to two pipe electrodes in treated earth pit (as per IS) which in turn, shall be buried in cement concrete pit with a cast iron cover hinged to a cast iron frame to have an access to the joints. All accessories associated with transformer like cooling banks, radiators etc., shall be connected to the earthing grid at minimum two points.

8.9.2 Earthing terminal of each lightning arrester & capacitor voltage transformer shall be directly connected to rod earth electrode which in turn shall be connected to station earthing grid,

8.9.3 Auxiliary earthing mat comprising of closely spaced (300mm x 300mm)

conductors shall be provided at depth of 300 mm from ground level below the operating handles of the M.O.M box of the isolators. M.O.M boxes shall be directly connected to the auxiliary earthing mat.

9.0 Main Bus Bars

The brief description of the bus switching scheme, bus bar layout and equipment connection to be adopted are indicated in section-1. The bus bar arrangements are shown in drawings enclosed with the bid documents.

- 9.1 The welds in the aluminium tubes shall be kept to the minimum and there shall not be more than one weld per span. The procedure and details of welding shall be subject to owner's approval. Material for welding sleeve shall be same as that of aluminium tube. Welding sleeve shall be of 600mm length.

VOID

- 9.1.1 Corona bells be provided where the bus extends beyond the clamps and on free ends, for sealing the ends of the tubular conductor against rain and moisture and to reduce the electromtic discharge loss at the end points. There shall be a small drain hole in the corona bell. The material of corona cell shall be aluminium alloy similar to that of clamps & connectors.

- 9.1.2 Details of past experience of the persons proposed to be employed for Aluminium tube welding and the test reports of the welded pieces to prove the electric and mechanical characteristics shall also be furnished along with the bid. Welding at site shall be done by adopting a qualify procedure and employing qualified welders as per ASME - section IX.

10.0 BAY EQUIPMENT

- 10.1 The disposition of various bay equipment is shown in single line diagram and layout drawings.

11.0 LIGHTNING PROTECTION:

- 11.1 Direct stroke lightning protection (DSLP) shall be provided in the EHV switchyard by lightning masts and shield wires. The layout drawings enclosed indicate the tentative arrangement.

- 11.2 The lightning protection system shall not be in direct contact with underground metallic service ducts and cables.
- 11.3 A 40 mm dia. 2750 mm long earth electrode with test links , CI frame and cover shall be provided to connect down conductor of lightning masts and towers with peak.
- 11.4 Conductors of lightning protection system shall not be connected with the conductors of safety earthing system above ground level.
- 11.5 Down conductors shall be cleated on the structures at 2000 mm interval.
- 11.6 Connection between each down conductor and rod electrode shall be made via test joint (pad type compression clamp) located approx. 1500 mm above ground level.
- 11.7 Lightning conductors shall not pass through or run inside G.I conduits.
- 11.8 All metallic structures within a vicinity of 2000 mm in air and 5000 mm below ground shall be bound to the conductors of lightning protection system.

12.0 TERMINAL POINTS

The terminal points for the scope of work of switchyard are given below:

- 12.1 Line feeders
 - 12.1.1 The transmission line shall terminate on line side gantry structure. The supply and erection of tension insulator string for line termination and tension clamps for earth wire termination are included in the scope.
 - i. Lightning protection down conductor at this end, tap offs and jumper connections from this dead end to all equipment in the switchyard are also in the Bidder's scope.

13.0 EQUIPMENT ERECTION NOTES

- 13.1 All support insulators, GIS modules and other fragile equipment shall preferably be handled with cranes having suitable booms and handling capacity.
- 13.1.1 The slings shall be of sufficient length to avoid any damage to insulator due to excessive swing, scratching by sling ropes etc.
- 13.1.2 Handling equipment, sling ropes etc., should be tested periodically before erection for strength.
- 13.1.3 Bending of compressed air piping if any should be done by a bending machine and through cold bending only. Bending shall be such that inner diameter of pipe is not reduced
- 13.1.4 Cutting of the pipes wherever required shall be such as to avoid flaring of the ends. Hence only a proper pipe cutting tool shall be used. Hack saw shall not be used.
- 13.1.5 Muslin or leather cloth shall be used for cleaning the inside and outside of hollow insulators.
- 13.1.6 All the equipment, instruments and auxiliaries required for testing and commissioning of equipment shall be arranged at site by the contractor.

13.2 STORAGE

- 13.2.1 The contractor shall provide and construct adequate storage shed for proper storage of equipments, where sensitive equipments shall be stored indoors. All equipments during storage shall be protected against damage due to acts of nature or accidents.
- 13.2.1 The storage instructions of the equipment manufacturer / owner shall be strictly adhered to.

14.0 EARTHING MATERIAL

Cable tags and Markers

Each cable and conduit run shall be tagged with numbers that appear in the cable and conduit schedule.

14.2 The tag shall be of aluminium with the number punched on it and securely attached to the cable conduit by not less than two turns of 20 SWG GI wire conforming to IS : 280. Cable tags shall be of rectangular, shape for power cables and of circular shape for control cables.

14.3 Location of cables laid directly underground shall be clearly indicated with cable marker made of galvanised iron plate.

14.4 Location of underground cable joints shall be indicated with cable marker with an additional inscription "cable Joints".

14.5 The marker shall project 150 mm above ground and shall be spaced at an interval of 30 meter and at every change in direction. They shall be located on both sides of road and drain crossings.

14.6 Cable tags shall be provided on all cables at each end (just before entering the equipment enclosure), on both sides of a wall or floor crossing, on each duct/conduit entry and at every twenty meters (20 m) in cable tray/trench runs. Cable tags shall be provided inside the switchgear, motor control centres, control and relay panels etc., wherever required for cable identification, where a number of cables enter together through a gland plate.

14.7 Storage and handling of cable drums

14.7.1 Cable drums shall be unloaded, handled and stored in an approved manner and rolling of drums shall be avoided as far as possible. For short distances, the drums may be rolled provided they are rolled slowly and in proper direction as marked on the drum. In the absence of any indication the drums may be rolled in the same direction as it was rolled during taking up the cables.

14.8 Cable Supports and Cable Tray Mounting Arrangements

14.8.1 The contractor shall provide embedded steel inserts on concrete floors/walls to secure supports by welding to these inserts or available building steel structures, for the purpose of casting in the control room.

14.8.2 The supports shall be fabricated from standard structural steel members.

14.8.3 Insert Plates and the Cable support angles shall be provided as per the drawings enclosed.

14.9 Cable Termination and Connections

14.9.1 The termination and connection of cables shall be done strictly in accordance with cable and termination and kit manufacturer's instructions, drawing and / or as directed by the owner.

14.9.2 The work shall include all clamping fittings, fixing, plumbing, soldering, drilling, cutting taping heat shrinking (where applicable), connecting to cable terminal shorting and grounding as required to complete the job.

14.9.3 Supply of all consumable material shall be in the scope of contractor.

14.9.4 The equipment will be generally provided with undrilled gland plates for cables / conduit entry. The contractor shall be responsible for drilling of gland plates, painting and touching up. Holes shall not be made by gas cutting.

14.9.5 Control cable cores entering control panel, switchgear / MCCB / miscellaneous panels shall be neatly bunched, clamped and tied with nylon strap or PVC perforated strap to keep them in position.

14.9.6 The contractor shall tape / ferrule control cable cores at all termination's, as instructed by the owner. In panels where a large number of cables are to be terminated and cable identification may be difficult, each core ferrule may include the complete cable number as well.

14.9.7 Spare cores shall be similarly tagged with cable numbers and coiled up.

14.9.8 All cable entry points shall be sealed and made vermin and dust proof. Unused openings shall be effectively closed.

i. Double compression type nickel plated (coating thickness not less than 10 microns) brass cable glands shall be provided by the contractor for all power and control cables to provide dust and weather proof terminations.

- 14.9.10 The cable glands shall be tested as per BS : 6121. They shall comprise of heavy duty brass casting, machine finished and nickel plated, to avoid corrosion and oxidation. Rubber components used in cable glands shall be neoprene and of tested quality. Cable glands shall be of approved make.
- 14.9.11 The cable glands shall also be tested for dust proof and weather proof termination. The test procedure has to be discussed and agreed to between owner and cable gland manufacturer.
- 14.9.12 If the cable- end box or terminal enclosure provided on the equipment is found unsuitable and requires modification, the same shall be carried out by the contractor, as directed by the owner.
- 14.9.13 Crimping tool used shall be of approved design and make.
- 14.9.14 Cable lugs shall be of tinned copper solderless crimping type conforming to IS - 8309 & 8394 . Cable lugs shall be of approved make.
- 14.9.15 Solderless crimping of terminals shall be done by using corrosion inhibitory compound. The cable lugs shall suit the type of terminals provided.

15.0 DIRECTLY BURIED CABLES

- 15.1 The contractor shall construct the cable trenches required for directly buried cables. The scope of work shall include excavation, preparation of sand bedding, soil cover, supply and installation of brick or concrete protective covers, back filling and ramming, supply and installation of route markers and Joint markers. The bidder shall ascertain the soil conditions prevailing at site, before, submitting the bid.
- 15.2 The cable (power and control) between LT station, control room and DG set room and fire lighting pump house shall be laid in the buried cable trenches. In addition to the above, for lighting purpose also, buried cable trench can be used in outdoor area.
- 15.3 Cable route and joint markers and RCC warning covers shall be provided wherever required. The voltage grade of cables shall be engraved on the marker.

16.0 INSTALLATION OF CABLES

- 16.1 Cabling shall be on cable racks, in built-up trenches, vertical shafts, excavated trenches for direct burial, pulled through pipes and conduits laid in concrete ducts, run bare and clamped on wall/ceiling/steel structures etc., as shown in the drawings in detailed Engineering stage. Where specific cable layouts are not shown on drawings, Contractor shall route these as directed by the owner.
- 16.2 The contractor shall fabricate and install mounting arrangements for the support and installation of all the cables on angles in the trenches. These mounting structures/cable racks shall be fabricated from structural steel members (channels, angles and flats) of the required size. The fabrication, welding and erection of these structures shall conform to the relevant clauses of chapter - STRUCTURES in addition to the specification given herein.
- 16.3 Cable racks and supports shall be painted after installation with two coats of metal primer (comprising of red oxide and zinc chromate in a synthetic medium) followed by two finishing coats of aluminium paint. The red oxide and zinc chromate shall conform to IS : 2074. All welding works inclusive of the consumables required for fabrication and installation shall be in the scope of the contractor.
- 16.4 All interpole cables (both power and control) for all equipment, shall be laid in cable trenches conduit pipes of NTB 50/100 mm diameter, class medium as per IS: 1239/part-I and IS : 4736 which shall be buried in the ground at a depth of 250 mm. The interpole cabling piping of breakers shall be laid in cable trenches. The scope shall include all labour, material, equipment, for transporting, laying, burying etc., including required bends and end seals.
- 16.5 Cables shall be generally located adjoining the electrical equipment through the pipe insert embedded in the floor. In the case of equipments located away from cable trench either pipe inserts shall be embedded in the floor connecting the cable trench and the equipment or in case the distance is small notch / opening on the floor shall be provided. In all these cases necessary bending radius as recommended by the cable manufacturer shall be maintained. Cabling in the control room shall be done on ladder type cable trays.

- 16.6 Cables from the equipment to trench shall run in conduits. Necessary conduits of adequate sizes and length shall be supplied and installed by the contractor. Flexible conduit should be used between fixed conduit/cable trays (perforated type) and equipment terminal boxes, where vibrations are anticipated. The flexible conduit shall be as per the relevant IS
- 16.7 Power and control cables shall be laid in separate tiers. The order of laying of various cables shall be as follows, for cables other than directly buried.
- a) Power cables on top tiers,
 - b) Control, instrumentation and other service cables in bottom tiers.
- 16.8 Single core cables in trefoil formation shall be laid with a distance of three times the diameter of cable between trefoil centre lines. All power cables shall be laid with a minimum centre to centre distance equal to twice the diameter of the cable.
- 16.9 Trefoil clamps for single core cables shall be of pressure die cast aluminium (LM- 6), Nylon - 6 or fibre glass and shall include necessary fixing GI nuts, bolts, washer etc., These are required at every 2 meter of cable runs.
- 16.10 Power and control cables shall be securely fixed to the trays/supports with self locking type nylon ties with de-interlocking facility at every 5 meter interval for horizontal run. Vertical and inclined cable runs shall be secured with 25 mm wide and 2mm thick aluminium strip clamps at every 2m
- 16.11 Cables shall not be bent below the minimum permissible limit. The permissible limits are as follows:
- Power cable - $12D$
 - Control cable - $10D$
- where D is overall diameter of cable

- 16.12 Where cables cross roads, drains and rails tracks, these shall be laid in reinforced spun concrete or steel pipes buried at not less than one metre depth,
- 16.13 In each run some extra length shall be kept at a suitable point to enable one (for LT cables)/two (for H.T. cables) straight through joints to be made in case the cable develop fault at a later date.
- 16.14 Selection of cable drums for each run shall be so planned as to avoid using, straight through joints. Cable splices will not be permitted except where called for by the drawings, unavoidable or where permitted by the owner. If straight through joints are unavoidable, the contractor shall use the straight through joints kit of reputed make.
- 16.15 Control cable termination's inside equipment enclosure shall have sufficient lengths so that changing of termination in terminal blocks can be done without requiring any splicing
- 16.16 Metal screen and armour of the cable shall be bonded to the earthing system of the station, wherever required by the owner
- 16.17 Rollers shall be used at intervals of about two meters while pulling cables.
- 16.18 All due care shall be taken during unreeling, laying and termination of cable to avoid damage due to twist, kinks, sham bends, etc,
- 16.19 Cable ends shall be kept sealed to prevent damage.
- 16.20 Inspection on receipt, unloading and handling of cables shall generally be in accordance with IS : 7255 and other Indian Standard Codes of practices
- 16.21 Wherever cable pass through floor or through wall openings or other partitions, wall sleeves with bushes having a smooth curved internal surface so as not to damage the cable should be supplied, installed and properly sealed by the contractor.
- 16.22 Contractor shall remove the RCC / steel trench covers before taking up the work and shall replace all the trench covers after the erection work in that particular area is completed or when further work is not likely to be taken up for some time.

16.23 Contractor shall furnish three copies of the report on work carried out in a particular week, indicating cable numbers, date on which laid, actual length and route, testing carried out, terminations carried out, along with the marked up copy of the cable schedule and interconnection drawing wherever any modification are made.

16.24 Contractor shall paint the tray identification number on each run of trays at an interval on 10 m

16.25 In case the outer sheath of a cable is damaged during handling / installation, the contractor shall repair it at his own cost to the satisfaction of the owner. In case any other part of a cable is damaged, the same shall be replaced by a healthy cable at no extra cost of the owner, i.e. the contractor shall not be paid for installation and removal of the damaged cable.

16.26 All cable terminations shall be appropriately tightened to ensure secure and reliable connections. The contractor shall cover the exposed part of all cable lugs whether supplied by him or no, with insulating tape, sleeve or paint.

16.27 Tests on Cable Trays

The contractor shall perform all tests and inspection to ensure that material and workmanship are according to the relevant standards. Contractor shall have to demonstrate all, tests as per specification and equipment shall comply with all requirements of the specification.

a) Test for galvanising (Acceptance Test)

The test shall be done as per approved standards.

b) Deflection Test : (Type Test)

A 2.5 metre straight section of 300 mm, 600 mm wide cable tray shall be simply supported at two ends. A uniform distributed load of 76 Kg-m shall be applied along with the length of the tray. The maximum deflection at the mid-span shall not exceed 7mm.

16.28 Conduits, Pipes and Duct Installation

16.28.1 Contractor shall supply and install all rigid conduits, mild steel pipe & flexible conduits, fibre pipes etc including all necessary sundry materials such as tees, elbows, check nuts, bushing reducers, enlargers,

coupling cap, nipples, gland sealing fittings, pull boxes etc as specified and to be shown in detailed drawing. The size of the conduit/pipe shall be selected on the basis of 40% fill criterion.

- 16.28.2 Contractor shall have his own facility for bending cutting and threnching the conduits at site. Cold bending should be used. All cuts & threaded ends shall be made smooth without leaving any sharp edges. Anti-corrosive paint shall be applied at all field threaded portions.
- 16.28.3 All conduit/pipes shall be extended on both sides of wall/floor openings. The fabrication and installation of supports and the clamping shall be included in the scope of work by contractor.
- 16.28.4 When two lengths of conduits are joined together through a coupling. Running threads equal to twice the length of coupling shall be provided on each conduit to facilitate easy dismantling of two conduits.
- 16.28.5 Conduit installation shall be permanently connected to earth by means of special approved type of earthing clamps. GI pull of adequate size shall be laid in all conduits before installation.
- 16.28.6 Each conduit run shall be painted with its designation as indicated on the drawings such that it can be identified at each end.
- 16.28.7 Embedded conduit shall have a minimum concrete cover of 50 mm.
- 16.28.8 Conduit run sleeves shall be provided with the bushings at each end.
- 16.28.9 Metallic conduit runs at termination shall have two locknuts and a bushing for connection. Flexible conduits shall also be suitably clamped at each with the help of bushings. Bushings shall have rounded edges so as not to damage the cables.
- 16.28.1 Where embedded conduits turn upwards from a slab or fill, the termination dimensions shown on the drawings, if any, shall be taken to represent the position of the straight extension of the conduit external to and immediately following the bend. At least one half of the arc length of the bend shall be embedded.
- 16.28.11 All conduits/pipes shall have their ends closed by caps until cables are pulled. After cables are pulled, the ends of conduits/pipes shall be sealed in an approved manner to prevent damage to threaded portions and entrance of moisture and foreign material.

16.29.12 For underground runs, contractor shall excavate and back fill as necessary.

16.28.13 Contractor shall supply, unload, store and install conduits required for the lighting installation as specified. All accessories/fittings required for making the installation complete, including but not limited to pull out boxes, ordinary and inspection tees and elbow, check-nuts, male and female bushings (brass or galvanised steel), caps, square headed male plugs, nipples, gland sealing fittings, pull boxes, conduits terminal boxes, gaskets and box covers, saddle terminal boxes, and all steel supporting work shall be supplied by the contractor. The conduit fittings shall be of the same material as conduits.

16.28.14 All unarmoured cables shall run within the conduits from lighting panels to lighting fixtures, receptacles etc.

16.28.15 Size of conduit for lighting (shall be selected as per the table given in the drawings enclosed with the bid documents).

16.28.16 Exposed conduits shall be run in straight lines parallel to building columns, beams and walls. Unnecessary bends and crussings shall be avoided to present a neat appearance.

16.28.17 Conduit supports shall be provided at an interval of 750 mm for horizontal runs and 1000mm for vertical runs.

16.28.18 Conduit supports shall be clamped on the approved type spacer plates or brackets by saddles or U-bolts. The spacer plates or brackets in turn, shall be securely fixed to the building steel by welding, and to concrete or brick-work by grouting, or by nylon rawl plugs. Wooden plug inserted in the masonry or concrete for conduit support is not acceptable.

16.28.19 Embedded conduits shall be securely fixed in position to preclude any movement. In fixing embedded conduit, If welding or brazing is used, extreme care should be taken to avoid any injury to the inner surface of the conduit.

16.28.20 Spacing of embedded conduits shall be such as to permit flow of concrete between them and in no case shall be less than 38 mm.

16.28.21 Where conduits are along with cable trays, they shall be clamped to supporting steel at an interval of 600 mm.

16.28.22 For directly embedding in soil, the conduits shall be coated with an asphalt-base compound. Concrete pier or anchor shall be provided wherever necessary to support the conduit rigidly and to hold it in place.

16.28.23 Conduit shall be installed in such a way as to ensure against trouble from trapped condensation

16.28.24 Conduits shall be kept, wherever possible, at least 300 mm away from hot pipes, heating devices etc., when it is evident that such proximity may reduce the service life of cables.

16.28.25 Slip joints shall be provided when conduits cross structural expansion joints or where long run of exposed conduits are installed, so that temperature change will cause no distortion due to expansion-or contraction of conduit run.

16.28.26 For long conduit run, pull boxes shall be provided at suitable intervals to facilitate wiring.

16.28.27 Conduit shall be securely fastened to Junction boxes or cabinets, each with a lock nut inside and outside the box.

16.28.28 Conduit joints and connections shall be made thoroughly water-tight and rust proof by application of a thread compound which insulates the joints. White lead is suitable for application on - embedded conduit and red lead for exposed conduit.

16.28.29 Field bends shall have a minimum radius of four (4) times the conduit diameter. All bends shall be free of kinks, indentations or flattened surfaces. Heat shall not be applied in making any conduit bend. Separate bends may be used for this purpose.

16.28.30 The entire metallic conduit system, whether embedded or exposed, shall be electrically continuous and thoroughly grounded. Where slip joints are used, suitable binding shall be provided around the joint to ensure a continuous ground circuit.

16.28.31 After installation, the conduits shall be thoroughly cleaned by compressed air before pulling in the wire.

- i. 16.28.32 Lighting fixtures shall not be suspended directly from the junction box in the main conduit run..

17 JUNCTION BOX

- i) The contractor shall supply and install junction boxes complete with terminals as required. The brackets, bolts, nuts, screws etc., required for erection are also included in the scope of the contractor.
- ii) Junction boxes having volume less than 1600 cubic centimeters may be installed without any support other than that resulting from connecting Conduits where two or more rigid metallic conduits enter and accurately position the box. Boxes shall be installed so that they level plumbed and properly aligned to present a pleasing appearance.
- iii) Boxes with volumes equal to or greater than 1600 cubic cm, and smaller boxes terminating on less than two rigid metallic conduits or for other reasons not rigidly held, shall be adequately supported by auxiliary steel of standard steel shapes or plates to be fabricated and installed. The contractor shall perform all drilling, cutting, welding, shimming and bolting required for attachment of supports.

18.0 C-TYPE WEDGE, BOLTLESS CONNECTORS

18.1 SCOPE:

- 18.1.1 This specification covers the design, manufacture, testing & supply of C-Type wedge boltless connectors (fired wedge type/ wedge type without bolted mechanism etc) which are to be used for overhead lines and jumpers making connection from the main bus/auxiliary bus conductor to the station equipments and for connection between the main bus and auxiliary bus conductor and also for connection to terminal pads of different station equipments such as circuit breakers, CTs, PTs, isolators, Lightning Arresters, wave traps etc of different makes. The equipment required shall be complete with all components which are necessary or usual for their efficient performance and satisfactory maintenance.
- 1) Bi-metallic connector used for copper to ACSR conductor connections shall be aluminium alloy clamps with necessary cast in copper liners. T-connectors used between bus bars shall be of aluminium alloy. The connectors should suit the respective equipment in respect of bolting/fixing arrangement. The requirements/details/drawings/samples should be approved by owners.
 - 2) The suitable size of Aluminium connectors/Bi-metallic connectors shall be used for making connection to the equipment terminals. These shall be wedge type. The surface of the clamp shall be smooth with all edges rounded off.

- 3) The T & PG connectors shall be “C” wedge type conforming to latest version of ANSI-C119.4 (AA) : extra heavy duty class tested. The connectors shall have maximum contact surface with the conductor, extremely low and stable contact resistance and minimum power loss. These shall maintain constant force within the connection for the life of connector/clamp while compensating for thermal expansion or grip and increased life span.

18.2 SERVICE CONDITIONS:

All parts of fittings shall be suitable for use in atmospheric condition indicated elsewhere in the specification inherently resistant to atmospheric corrosion or be suitably protected against corrosion both during storage and in service. The connector shall be capable of withstanding dynamic and thermal stresses without any damage or deterioration.

- a. Annual average ambient temperature - 30°C
- b. Maximum ambient temperature: 54°C
- c. Maximum relative humidity: 85-100%
- d. Wind Pressure – 150 Kgs/Sqmtrs. (Max).
- e. Environmental conditions: Tropical climate with polluted atmosphere.
- f. Operational altitude: Not exceeding 1000 meters.
- g. Average Rainfall 1000-3000/5000mm.

18.3 APPLICABLE STANDARDS:

IS Specification or any other equivalent authoritative standard. Except as modified by this specification, the conductor accessories to be supplied shall conform to the latest edition with amendments and revisions thereof the following Bureau of American National Standards, Inc, (ANSI).

The C-Type wedge boltless connectors - latest edition of ANSI C 119.4 - 2004 Standards.

18.4 MATERIAL REQUIREMENT & WORKMANSHIP:

18.4.1 Material:

The C-Type wedge boltless connectors shall be of high strength and high conductivity aluminium alloy. The same shall be suitable for use on all combinations of aluminium to aluminium, or aluminium to copper conductors.

The components shall be properly proportioned to minimize stress concentration, corrosion and deterioration by galvanic action.

18.4.2 Workmanship:

High quality workmanship shall be maintained in the process of manufacture of the C-Type wedge boltless connectors. They shall be free from sharp edges, burs and swarf. The contact surface of the C-Type wedge boltless connectors shall be uniform to provide effective contact with the conductors.

18.5 TECHNICAL REQUIREMENTS:

18.5.1 “C” TYPE FIRED WEDGE BOLTLESS CONNECTOR:

- a. The connector consists of tapered “C” shaped member and wedge that is made of aluminium alloy
- b. The connector should be bolt less and of wedge system.
- c. The “C” member should be provided with built-in spring tension to maintain constant pressure for a firm electrical contact.
- d. The connector shall be used for multiple combinations of solid/stranded AAC, AAAC, ACSR, Copper combination etc.
- e. Copper to copper connectors - the “C” member to be composed of aluminum bronze alloy and the wedge of copper alloy very close to pure copper.
- f. “C” member wedge shall be factory coated with an inhibitor containing abrasive particles to help clean the contact surfaces during installation.

1) UNIVERSAL DISTRIBUTION “C” TYPE BOLTLESS WEDGE CONNECTOR:

- a. The connectors are composed of a “C” member and a wedge.
- b. “C” & wedge are made of a Tin plated copper alloy in a configuration that creates a spring action.
- c. They are recommended to connect conductors of Aluminium, copper, steel and their alloys.

18.5.3 The wedge type boltless connectors shall consist of C-member and wedge. The wedge shall be inserted at a speed (at a speed of 40m./sec approximately in case of fired wedge type) so as to be effective in abrading all sliding surface and disrupting surface oxide film to generate

large number of contact spot in the electrical interfaces. The mechanical stresses during the wedge insertion shall cause plastic deformation of the C-Clamp and shall increase the geometrical conformation of the clamp to the conductor. An Oxidation inhibitor shall be applied to the surface thereby elimination of oxidation of metallic surface. The normal current carrying capacity of clamp shall not be less than the specified in the specification. If the connectors are to be installed by Powder actuated tool using cartridges with explosive, valid explosive license issued by the Government of India/State Government should be possessed.

Clamps shall be corona free and shall carry an overload of at least 20% over the rated current. The connectors should be easily removable and reusable type. Reusable means that the connector may be removed from service and installed again. Prior to reuse, any instructions to be followed for reconditioning the reusable connector shall be furnished.

- 18.5.4 The wedge type boltless connectors of station equipments should be of universal type facilitating to take horizontal or vertical jumps.

18.6 TECHNICAL PARAMETERS:

a). Insulation level

Sl. No.	Technical Particulars	Voltage Class			
		11KV	33KV	66KV	110KV
1	Nominal Voltage (KV).	11	33	66	110
2	Maximum System Voltage (KV).	12	36	72.5	123
3	BIL (Impulse) KV peak.	75	170	325	550
4	Power frequency withstand voltage (wet) KV rms.	28	70	140	230

b). Normal Current rating

Equipment terminal connectors:- The current rating of the connectors should be same

as that of the equipments for which the connector is used

Connectors used for conductors:- The 'C' connectors should be designed to carry the same current as the conductor when same conductors are used. And the 'C' connectors should be designed to carry the current of higher size conductors when conductors of different size are used. The rated current for which the clamps/connectors is designed with respect to the specified reference ambient temperature shall also be indelibly marked on each component of the connector.

c). Short time current rating

The short time current rating of the connectors shall be as per relevant standards.

18.7 ADDITIONAL REQUIREMENTS:

18.7.1 Identification:

The C-Type wedge boltless connectors shall be identified with the manufacturer's identification marks and catalogue numbers.

18.7.2 Markings:

For easy identification of the C-Type wedge boltless connectors shall have markings indicating that the connectors are suitable for station bus conductor/station equipments/transmission lines.

18.8 INSPECTION

The inspection may be carried out by the purchaser at any stage of manufacture. The successful bidder shall grant free access to the purchaser's representative at a reasonable time when the work is in progress. Inspection and acceptance of any equipment under this specification by the purchaser shall not relieve the supplier of his obligation of furnishing boltless connector in accordance with the specification and shall not prevent subsequent rejection if the equipment is found to be defective. The supplier shall keep the purchaser informed in advance, about the manufacturing programme so that arrangement can be made for inspection.

18.9 PACKING AND FORWARDING:

18.9.1 The "C" type wedge boltless connector shall be packed in wooden crates suitable for vertical / horizontal transport, as the case may be and suitable to withstand handling during transport and outdoor storage during transit. The supplier shall be responsible for damage to the equipment during the transit, due to improper and inadequate packing. The easily damageable materials shall be carefully packed and marked with the appropriate caution symbols. Any material found damaged inside the packing cases shall be supplied by the supplier without any extra cost to the purchaser.

18.9.2 Each consignment shall be accompanied by a detailed packing list containing the following information.

- a) Name of the consignee.
- b) Details of consignment.

- c) Destination
- d) Total weight of consignment
- e) Sign showing upper / lower side of the crate.
- f) Handling and unpacking instructions.
- g) Bill of materials indicating contents of each package.
- h) One set of approved drawings and manual.

18.9.3 The supplier shall ensure that the purchaser before dispatch approves the packing list and bill of material.

18.10 INSTRUCTION MANUALS

Fifteen copies of the Fixing and Maintenance manuals in English shall be supplied for “C” type wedge boltless connector one month prior to dispatch of the equipment. The manual shall be bound volume and shall contain all drawings and information required for Fixing and Maintenance of the connectors.

18.11 SUBMISSION OF DRAWINGS:

6 sets of drawings for each item have to be submitted for approval before commencement of supply. Supplies shall not be commenced before approval of drawings. Non submission of drawing /receipt of approval shall not be linked with delivery schedule. Delivery schedule should be adhered to. Final drawings equivalent to the number of consignees for each item have to be supplied.

The drawing shall be complete in all respects. Detailed dimensions shall be furnished in each of the drawings. Full specification of the equipment such as material, weight, tensile strength, tolerance, chemical composition etc., shall be incorporated in each drawing.

Any defects noticed in the manufacture of the equipment during inspection or after receipt at destination have to be promptly set right by the contractor free of all cost to the owner.

The following shall be furnished with the offer.

- a) The catalogues (in English) describing the items and indicating the Model/Reference number, Code Name/Across Flat dimension of the relevant die to be used for compression, conductor sizes and other relevant details.
- b) Constructional features and material used for components and relevant technical literature.
- c) Certification for Quality Assurance conforming to ISO 9001.
- d) Dimensional Drawings of all items.

- e) Type Test Reports which were conducted on C-Type wedge boltless connectors (Not older than 7 years)

18.12 SAMPLE STUDY:

Three samples of each item offered shall accompany the bid to facilitate analysis and evaluation.

18.13 TESTS:

All tests shall be conducted in accordance with latest edition of ANSI C 119.4 -2004. Type tested C type wedge boltless connectors shall be offered. The type test reports shall not be older than Seven (7) years as on the last date of submission of bid.

- a) For C type wedge boltless connectors manufactured in India:
 - i. Type tests on indigenous equipment for which testing facility is available in India, should have been conducted in any independent laboratories approved by Government or accredited by National accreditation body of the country like Central Power Research Institute (CPRI), Electrical Research and Development Association (ERDA), etc.
 - ii. Type tests on indigenous equipment, for which testing facility is not available in India, should have been conducted in a laboratory of foreign country accredited by National accreditation body of that country.
 - iii. The type tests conducted in-house by manufacturers shall also be acceptable provided the lab (manufacturer's) is accredited by National accreditation body of the country and the tests have been witnessed by a representative of NABL accredited Independent laboratory/Power utility.
- b) For C type wedge boltless connectors manufactured Abroad:
 - i. Type tests on imported equipment should have been conducted in an Indian Laboratory or foreign laboratory accredited by National accreditation body of respective country.
 - ii. Type tests conducted in-house by manufacturers shall also be acceptable provided the laboratory is accredited by National accreditation body of the country and the tests have been witnessed by a representative of accreditation body/Power utility.

The following shall constitute the tests.

18.13.1 Type Tests:

- a) Failing load test.
- b) Electrical resistance test.
- c) Heating cycle test.
- d) Tensile strength test.
- e) Torque strength test
- f) Conductor damage test.
- g) Short time current rating as per relevant standards.

i. Acceptance Tests:

- a. Tensile strength test.
- b. Electrical resistance test.
- c. Dimensional check.

ii. Routine Tests:

- a. Visual examination.
- b. Dimensional verification.

18.14 SPECIAL TOOLS AND TACKLES:

- 18.14.1 A set of special tools and tackles, which are necessary or convenient for fixing/connecting, removing and reusing of connectors shall be supplied.

18.15 DEVIATION FROM TECHNICAL SPECIFICATION:

Deviations, as compared to Technical specifications, if any, shall be brought out in the relevant sheet enclosed. Any deviations other than that mentioned in relevant sheet WILL NOT BE CONSIDERED.

18.16 PERFORMANCE GUARANTEE:

The “C” type Wedge Boltless connectors offered shall be guaranteed for satisfactory performance for a period of 24 months from the date of satisfactory commissioning. The “C” type Wedge Boltless connectors found defective within the above guarantee period shall be replaced and supplied by the supplier free of cost within one month from the date of receipt of intimation.

18.17 GUARANTEED TECHNICAL PARTICULARS:

The bidder should furnish the guaranteed technical particulars as required in Annexure.

GUARANTEED TECHNICAL PARTICULARS FOR WEDGE:

TYPE BOLTLESS CONNECTORS

1. Manufacturer's name.
2. Applicable standards.
3. Type.
4. Material of connector.
 - a. 'C' member
 - b. Wedge
 - c. Spring washers (if any)
5. Temperature rise above ambient Temperature
 - a. At rated current.
 - b. At 150% of rated current.
6. Rated current
7. Short time current rating.
8.
 - a). Rated terminal load (Kg)
 - b). Factor of safety.
9. Minimum thickness of any part.
10. weight of clamp complete (Kg)
11. Type test reports - enclosed.
12. OGA drawing - enclosed.

19.0 TESTING AND COMMISSIONING

- 19.1 An indicative list of tests is given below. Contractor shall perform any additional test based on specialties of the items as per the field Q.P/instruction of the equipment contractor or owner without any extra cost to the owner. The contractor shall arrange all instruments required for conducting these tests along with calibration certificate and shall furnish the list of instruments to the owner for approval.

19.2 GENERAL CHECKS

- i) Check for physical damage.
- ii) Visual examination of zinc coating/plating.
- iii) Check from name plate that all items are as per order/specification.
- iv) Check tightness of all bolts, clamps and connecting terminals using torque wrenches.
- v) For oil filled equipment check for oil leakage, if any. Also check oil level and top up wherever necessary.
- vi) Check ground connections for quality of weld and application zinc thick paint over weld and application of Zinc with paint over weld joint of Galvanised surface
- vii) Check cleanliness of insulators and bushings

- viii) All checks and tests specified by the manufacturers in their drawings and manuals as well as all tests specified in the relevant code or erection
- ix) Check for surface finish or grading rings (Corona control ring).

19.3 STATION EARTHING

- i) Check soil resistivity
 - ii) Check continuity of grid wires.
 - iii) Check earth resistance of the entire grid as well as various sections of the same.
 - iv) Check for welded joint and application of zinc rich paint as galvanized surfaces.
 - v) Dip test on earth conductor prior to use.
- a. TABULAR BUS WORK AND POWER CONNECTORS
- i. Physical check for finish.
 - ii. Electrical clearance check
 - iii. Testing of torque by torque wrenches on all bus bar power connectors and other accessories.
 - iv. Millivolt drop test on all power connectors.
 - v. Sag and tension check on conductors.
- b. ALUMINUM TUBE WELDING
- i. Physical check.
 - ii. Millivolt drop test on all joints.
 - iii. Dye penetration test & radiography test on 10% samples basis on weld joints.
 - iv. Test check on 5% sample joints after cutting the weld piece to observe any voids.

ANNEXURE “A”

(Testing procedure for ACSR DRAKE 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 suitably compressed with dead end clamps at either end. The load shall be

increased at a steady rate up to 80 KN and held for one minute. The circles drawn shall not be distorted due to relative movement of strands. Thereafter the load shall increased at a steady rate to 141.75 KN and held for one minute. The applied load shall then be increased until the failing load is reached and the value recorded. UTS tests on other types of ACSR conductor should be conducted to the parameters applicable as for IS.

2 VOID

3 VOID

4 DC Resistance Test on stranded conductor

On a conductor sample of minimum 5m length two contact clamps shall be fixed with a pre-determined bolt torque. The resistance shall be measured by a Kelvin double bridge 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 deg. C as per clause no. 12.8 of IS : 398 (part V) 1982. The resistance corrected at 20°C shall conform to the requirements of this specification.

5 Chemical Analysis of Zinc.

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

6 Chemical Analysis of Aluminum and Steel

Sample taken from the aluminum ingots / strands shall be chemically spectrographically analyzed. The same shall be in conformity to the requirements stated in this specification.

7.0 Visual checks for joints, scratches etc.,

Conductor drums shall be rewound in the presence of the inspector. The inspector shall visually check for scratches, joints etc., and that the conductor generally conform to the requirements of this specification. The length of conductor wound on the drum shall be measured with the help of counter meter during rewinding.

8.0 Dimensional checks for steel and aluminum strands.

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

9.0 Check for Lay – ratios of various layers.

The Lay – ratios of various layers shall be checked to ensure that they conform to the requirements of this specification and clause no. 9.4 and 9.5 of IS - 398 (part – V) 1982.

10.0 Galvanizing Test

The test procedure shall be as specified in IS : 4826 – 1968. The material shall conform to the requirements of this specification.

1.0 Torsion and Elongation Tests on steel strands

The test procedure shall be as per relevant clause of IS: 398 (Part – V) 1982. In torsion test, the number of complete twists before fracture shall be less than 18 on a length equal to 100 times the standard diameter of the strand before stranding & 16 after stranding. In case test sample length of less or more than 100 times the standard diameter of the strand, the minimum number of twist will be proportionate 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 200 mm.

2.0 Breaking load test on welded Aluminum strands

Two Aluminum wires shall be welded as per the approved quality plan and shall be subjected to tensile load. The welded point of the wire shall be able to withstand the minimum breaking load of the individual Strand guaranteed by the bidder.

ANNEXURE “B”

(Testing procedure for Galvanised steel Earthwire)

1. UTS TEST

Circle perpendicular to the axis of the earthwire shall be marked at two places on sample of earthwire of minimum 5m length suitably compressed with dead end clamps at either end. The load shall be increased at steady rate up to 34 KN and held for a minute. The circles drawn shall not be distorted due to relative movement strands. Thereafter, the load shall be increased at a steady rate of 56.98 KN and held for one minute. The earthwire sample shall not

fail during this period. The applied load shall then be increased until the failing load is reached and value recorded.

2. DC RESISTANCE TEST

On an earthwire sample of minimum 5m length, two contact clamps shall be fixed with a predetermined bolt torque. The resistance shall be measured by a Kelvin with a predetermined bolt torque. The resistance shall be measured by a Kelvin double – bridge 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 voltage obtained shall be corrected to the value at 20deg. C shall conform to the requirements of this specification.

3. Visual Check for Joints, scratches etc., and length of earthwire

Earthwire drums shall be rewound in the presence of the inspector. The inspector shall visually check for joints, scratches etc., and see that the earthwire generally conforms to the requirements of this specification. The length of earthwire wound on the drum shall be measured with the help of counter meter during rewinding.

4. TORSION AND ELONGATION TESTS

The test procedure shall be as per relevant clause of IS: 398 (Part – V). The minimum number of twists which a single steel strand shall withstand during torsion test shall be eighteen for a length equal to 100 times the standard diameter of the strand. In case the test sample length is less or more than 100 times the standard diameter of the strand, the minimum number of twists will be proportionate to the length and if number comes in fraction then it will be rounded off to the next higher whole number. In elongation test, the elongation of the strand shall not be less than 4% for a gauge length of 200 mm.

5. DIMENSIONAL CHECK

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

6. LAY LENGTH CHECK

The length shall be checked to ensure that they conform to the requirements of this specification.

7. GALVANISING TEST

The test procedure shall as specified in IS: 4826 – 1968. The material shall conform to the requirements of this specification.

8. CHEMICAL ANALYSIS OF ZINC USED FOR GALVANIZING

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

9. CHEMICAL ANALYSIS OF STEEL

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