

SECTION 7

TECHNICAL SPECIFICATION FOR SWITCHYARD ERECTION

1.0 GENERAL

This Section cover the technical requirements of various ancillary items and general switchyard erection practices. All ancillary items under the contractor's scope of supply shall conform to the type tests and routine tests as per the relevant Standards

1.1 STRING INSULATORS & HARDWARE

1.1.1 GENERAL

The insulators for suspension and tension strings shall conform to IS:731 and long rod insulator shall conform to IEC-433 (1980). Insulator hardware shall conform to IS 2485.

1.2 CONSTRUCTIONAL FEATURES

- 1.2.1 Suspension and tension insulator shall be wet process porcelain with ball and socket connections. Insulator shall be interchangeable and shall be suitable for forming either suspension or strings. Each insulator shall have rated strength marking on porcelain printed and applied before firing.
- 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 vitrified, tough and impervious to moisture.
- 1.2.3 Glazing of the porcelain shall be uniform brown color, free from blisters, burrs 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 to conductor or insulator by the formation of substances due to chemical action. No radio interference shall be cause when operating at normal rated voltage.
- 1.2.5 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. All ferrous 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-99.5 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.



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- 1.2.6 Bidder shall make available data on all the essential features of design including 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 of corona and thermal shock tests, recommended working strength and any special design or arrangement employed to increase life under service conditions
- 1.2.7 Insulator hardware shall conform to the requirements stipulated for clamps and connectors. All hardware shall be designed for tensile load with a factor of safety 2.
- 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 The tension Insulator string shall be designed for the required tensile load. Earth wire tension clamp shall be designed for the required tensile load with a factor of safety two (2).
- 1.2.10 The tension string assembly shall be supplied along with suitable turn buckle at the rate of one turn buckle per string.
- 1.2.11 All hardware shall be bolted type.

1.3 TESTS

In accordance with the requirements stipulated in section 1 and section 2, The suspension and tension strings, insulator discs and hardware shall conform to type tests as per relevant IS/IEC and shall be subjected to the following acceptance tests and routine tests:

1.3.1 ACCEPTANCE TESTS FOR DISC INSULATOR :

- a) Visual examination (IS 2486-1971) Part 1
- b) Verification of Dimensions :CI no. 10.5 IS:731-1971
- c) Temperature cycle test: CI no. 10.6 IS:731-1971
- d) Puncture Test: CI no 10.10 IS:731-1971
- e) Galvanizing Test: CI no. 10.12 IS:731-1971
- f) Mechanical performance test: IEC:575-1977 CI.4
- g) Test on locking device for ball and socket coupling IEC:372(2)-1976

- h) porosity test Cl no. 10.11 IS:731-1971

1.3.2 ACCEPTANCE TEST ON HARDWARE FITTING

- a) Visual Examination : Cl. 5. 10 IS:2486 (Part-1).
- b) Verification of Dimensions :Cl. 5.8 IS:2486 (part-I)-1971.
- c) Galvanizing/Electroplating tests : Cl. 5.9 IS:2486 (Part-I)-1971.
- d) Slip strength test :Cl 5.4 of IS:2486 (Part-I).
- e) Shore hardness test for the Elasto-meters (if applicable as per the value guaranteed by the Bidder).
- f) Mechanical strength test for each component.
- g) The load shall be so supplied that the component is stressed in the same way as it would be in actual service and the procedure as given in 13.1 (g) above should be followed.
- h) Test on locking devices for ball and socket coupling : IEC:372(2) – 1976.

1.3.3 ROUTINE TEST ON DISC INSULATOR/ LONG ROAD INSULATOR

- a) Visual inspection :Cl. No. 10.13 IS:731-1971.
- b) Mechanical Routine Test : Cl. No. 10.14 IS:731-1971.
- c) Electrical Routine Test: Cl. No. 10.15 IS:731-1971.

1.3.4 ROUTINE TEST OF HARWARE FITTINGS

- a) Visual examination :Cl. 5.10 of IS-2486(I).
- b) Mechanical strength test: Cl. 5.10 of IS-2486 (I).

Samples taken from the zinc ingot shall be chemically analyzed as per IS:209 - 1966. The purity of zinc shall not be less than 99.5%.

- c) **Chemical Analysis, mechanical hardness tests and magnetic – particle inspection for malleable casting:**
The chemical analysis, hardness tests and magnetic particle inspection for malleable castings will be as per the internationally recognised procedures for these tests. The sampling will be based on heat number and heat treatment batch. The details regarding

tests will be as discussed and mutually agreed to by the Contractor and Owner in Quality Assurance Program.

d) 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 these tests. The sampling will be based on heat number and heat treatment batch.

e) CHEMICAL ANALYSIS, HARDNESS TESTS AND MAGNETIC PARTICLE INSPECTION FOR FABRICATED HARDWARE:

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

1.4 PARAMETERS

1.4.1 DISC INSULATORS

- | | | |
|---|---|---|
| a) Type of insulators | : | Fog type |
| b) Size of insulator units (mm) | : | 280 x 145 for 12000 kg.
255 x 145 for 9000/4500 kg. |
| c) Electro mechanical strength | : | 12000/ 9000/ 4500 kg for
Twin/ single conductor. |
| d) Creepage distance of individual insulator units (minimum and as required to meet total creepage distance).e) Markings. | : | Markings on porcelain shall be printed and applied before firing. |

1.4.2 INSULATOR STRING

	220 kV	132 kV	66 kV	33 kV	11 kV
f) Power frequency withstand voltage of the complete string with arcing horns (dry & wet)	460 kV (rms)	275 kV (rms)	140 kV (rms)	75 kV (rms)	28 kV (rms)

g)	Lightning impulse withstand voltage of the complete string with corona control rings (+ and – peaks)	1050 kV	650 kV	325 kV	170 kV	75 kV
i)	Power frequency puncture withstand voltage for a string insulator unit.	1.3 times actual wet flashover voltage of the unit.				
j)	RIV level of the complete string with CC rings at 1.1 U/-3 (max)	1000 micro volts				
k)	Total creepage distance of the complete insulator string (mm)	----- 25 mm/kV -----				
l)	Total no. of discs per strings.	15 S/T 10 S/T 6 S/T 3 S/T 2 S/T 14 S/S 9 S/S 5 S/S 3 S/T 2 S/T				

2) ACSR MOOSE/ ZEBRA CONDUCTOR

2.1 DETAILS OF CONDUCTOR

2.1.1 The conductor shall conform to IS:398(Part V)-1982 except where otherwise specified herein.

2.1.2 The details of the conductor are tabulated below:

	<u>Moose</u>	<u>Zebra</u>
a) Stranding and wire diameter	54/3.53mm AL+7/3.53mm steel	54/3.18mm AL+7/3.18mm steel
b) Number of strands		
core	1	1
1 st Layer	6	6
2 nd Layer	12	12

	3 rd Layer	18	18
	4 th Layer	24	24
c)	Sectional area of aluminium	528.5 mm ²	428.9 mm ²
d)	Total sectional area	597 mm ²	484.50 mm ²
e)	Overall diameter	31.77mm	28.62 mm
f)	Approximate weight	1998 kg/km	1621 kg/km
g)	Calculated DC resistance at 20 degree C	0.05595 ohm/km	0.06868 ohm/km
h)	Minimum UTS	159.60 KN	130.32 KN

2.1.3 The details of aluminium strand are as follow:

i)	Minimum breaking load of strand before stranding	1.57 kN	1.29 kN
ii)	Minimum breaking load of strand after stranding	1.49 kN	1.23 kN
iii)	Maximum D.C resistance of strand at 20 ⁰ C	2.954 ohms/KM	3.651 ohms/KM

2.1.4 The details of steel strand are as follows:

i)	Minimum breaking load of strand before stranding	12.86 kN	10.43 kN
ii)	Minimum breaking load of strand after stranding	12.22 kN	9.95 kN
iii)	Minimum no. of twist to be with stood in torsion test when tested on a gauge length of 100 times diameter of wire	18-before stranding 16-after stranding	18-before stranding 16-after stranding

2.2) WORKMANSHIP

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

2.2.2 All the aluminium and steel strands shall be smooth, uniform and free from imperfections, such as spill, diemarks, scratches, abrasions and kinks after drawing.

2.2.3 The steel strands shall be hot dip galvanised and shall have a minimum zinc coating of 250 gm/sq.m after stranding of the uncoated wire surface. The zinc coating shall be smooth, continuous and of uniform thickness, free from imperfections and shall withstand minimum two and half dips after stranding in standard preece test. The steel wire rods shall be of such quality and purity that when drawn to the size of the strands specified and coated with zinc, the finished strands and the individual wires shall be of uniform quality and have the same properties and characteristics as prescribed in IEC 888-1987.

2.2.4 The steel strands shall be preformed and postformed in order to prevent spreading of strands in the event of cutting of composite core wire. Care shall be taken to avoid damage to galvanisation during preforming and post-forming operation.

2.3) JOINTS IN WIRES

2.3.1 ALUMINIUM WIRES

No joints shall, be permitted in the individual wires in the outermost layer of the 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 butt welding and shall be such that no such joints are within 15 metres of each other in the complete stranded conductor.

2.3.2 STEEL WIRES

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.

2.4) TOLERANCES

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

a) Diameter of Aluminium and steel strands:

	Nominal	Maximum	Minimum
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Aluminium

Moose	3.53 mm	3.57mm	3.49mm
Zebra	3.18 mm	3.21 mm	3.15 mm

Steel

Moose	3.53mm	3.60mm	3.46mm
Zebra	3.18 mm	3.24 mm	3.12 mm

b) Lay ratio of Conductor:

		MOOSE		ZEBRA	
		Maximum	Minimum	Maximum	Minimum
Steel	6 wire layer	28	13	28	13
Aluminium	12 wire layer	17	10	17	10
	18 wire layer	16	10	16	10
	24 wire layer	14	10	14	10

2.5) MATERIALS

2.5.1 ALUMINIUM

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

2.5.2 STEEL

The steel wire strands shall be drawn from high carbon steel wire rod 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

2.5.3 ZINC

The Zinc used for galvanising shall be electrolytic High Grade Zinc of 99.95% purity. It shall conform to and satisfy all the requirements of IS:209-1992.

2.6) STANDARD LENGTH

2.6.1 The Conductor shall be supplied in standard length of 1500/1800 meters as required. No joining shall be allowed withing a single span of stringing.

2.7 TESTS:

In accordance with the requirements stipulated in Section 1 and Section 2, the conductor shall conform to type tests as per relevant IS/IEC and shall be subjected to the following acceptance tests and routine tests:

2.7.1 ACCEPTANCE TESTS

- a) Visual check for joints, scratches etc. and lengths of conductor.) IS:398 (Part – V) 1982
- b) Dimensional check on steel and alumnium strands.)
- c) Check for lay ratios of various layers.)
- d) Galvanising test on steel strands.)
- e) Torsion and Elongation test on steel strands

- | | | |
|---|---|--|
| f) Breaking load test on steel and aluminium strands. |) | IS:398 (Part – V) 1982
Clause 12.5.2, 12.7 & 12.8 |
| |) | |
| |) | |
| |) | |
| g) Wrap test on steel and aluminium strands |) | |
| |) | |
| h) DC resistance test on aluminium strands. |) | |
| |) | |
| i) UTS test on welded joint of aluminium strands. |) | |
| |) | |
| |) | |

NOTE:

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

2.7.2 ROUTINE TESTS

- Check to ensure that the joints are as per specification.
- Check that there are no cuts, fins etc. on the strands.
- All acceptance test as mentioned above to be carried out on each coil.

2.7.3 TESTS DURING MANUFACTURING

- Chemical analysis of zinc used for galvanishing.)
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- Chemical analysis of aluminium used for making aluminium strands.)
)
)
- Chemical analysis of steel used for making steel strands.)
)
)

strands

GALVANISED STEEL EARTHWIRE

3.

3.1 DETAILS OF EARTHWIRE

3.1.1 The galvanised 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 earthing are tabulated below:

a)	Stranding and wire diameter	7/3.66 mm steel
b)	Number of strands	
	Steel core	1
	Outer Steel Layer	6
c)	Total sectional area	73.65 mm ²
d)	Overall diameter	10.98 mm
e)	Approximate weight	583 kg/Km
f)	Calculated d.c resistance at 20°C	2.5 ohms/Km
g)	Minimum ultimate tensile strength	68.4 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 all imperfections, such as spills and splits, die marks, scratches, abrasions 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 galvanised (and shall have a minimum zinc coating

275 gms/sq.m.) after stranding of the uncoated wire surface. The zinc coating shall be smooth, continuous, of uniform thickness, free from imperfections and shall withstand three and a half dips after stranding in standard 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 characteristics in ASTM designation B498-74.

3.2.4 The steel strands shall be performed and postformed in order to prevent spreading of strands while cutting of composite earthwire. Care shall be taken to avoid damage to galvanisation during preforming and postforming operation.

3.2.5 To avoid susceptibility towards wet storage stains (white 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 kind in the finished steel wire strand entering into the manufacture of the earthwire. There shall be no strand joints or strand 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 lay length of the earthwire:

	<u>Standard</u>	<u>Maximum</u>	<u>Minimum</u>
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 rod and shall conform to the following requirements as to the chemical composition:

<u>Element</u>	<u>% Composition</u>
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 galvanising shall be electrolytic High Grade Zinc of 99.95% purity. It shall conform to and satisfy all the requirements of IS:209-1979.

36 STANDARD LENGTH

3.6.1 The earthwire shall be supplied in standard durm length of manufacturer as per actual requirement.

3.7 TESTS

In accordance with the requirements stipulated in Section 1 and Section 2, earth wire shall conform to **type tests** as per relevant IS/IEC and shall be subjected to the following acceptance tests and routine tests :

3.7.1 ACCEPTANCE TESTS

- a) Visual check for joints scratches etc. and length of Earthwire
- b) Dimensional check
- c) Galvanising test
- d) Lay length check
- e) Torsion test
- f) Elongation test
- g) Wrap test
- h) DC resistance test

IS:398 (Part-III) 1976

- i) Breaking load test)
- ii) Chemical Analysis of steel)

3.7.2 ROUTINE TESTS

- a) Check that there are no cuts, fins etc. on the strands.
- b) Check for correctness of stranding.

3.7.3 TESTS DURING MANUFACTURE

- a) Chemical analysis of zinc used for galvanising)
- b) Chemical analysis of steel)

4. MARSHALING KIOSK

4.1 PRINCIPAL PARAMETERS

The marshalling Kiosk shall be suitably fixed so as provide no opening to inside and shall be sufficiently projected to prevent splash of rain water to the inside of the marshalling Kiosk.

The marshalling kiosk will be 1400 mm (height), 1200 mm (width), and 550 mm (depth) complete with double door in front provided with pad-locking facility in the door handle.

The marshalling kiosk shall be bolted on the 550 mm high angle-iron frame work made of 35 x 35 x 6mm MS angle braced length-wise by 35 x 6mm MS flat.

The marshalling kiosk shall be equipped with 3no. earth test links made of tinned copper for CT circuits.

4.1.2 TERMINAL BLOCK CONNECTORS

Terminal blocks shall conform to requirements given in Section 2 (GTR).

The terminal connector will conform to the following details :

- i) Current and voltage rating

30 Amps, 660 VAC/900 VDC

ii) Capacity

upto three ring-tongue crimped copper wires of 4 square mm, cross sectional area.

- iii) a) disconnecting type terminal blocks for CTs and PTs Terminal Connectors for CT/PTs shall have provision of disconnecting and shortening links for measurement of CT currents without opening the CTs and isolation of PT circuits.

4.1.3 DISTRIBUTION OF TERMINALS AND THEIR IDENTIFICATION NUMBERS

The No. of terminals required shall be as follows :

220 kV - 300, 132 kV - 250 & 66 kV - 200

The total number of terminal in the marshalling kiosk will be distributed in ten rows. Terminal block connector row's shall be adequately spaced and in on case less than 100 mm apart center of the terminal block so as to permit convenient access to terminations. Labels in the form of plastic/steel plates carrying numerals for terminal identification shall be so mounted as to cause no interference with regard to access to terminal nuts. The numerals marked from top to bottom in ascending order starting from left-hand side as viewed from the front of the marshalling kiosk and a progressively increasing from left hand side to right hand side. The numbering of Terminals and their aggangement in a 200, 250 and 300 terminals marshalling kiosks shall be as per sketch enclosed (Drg.No. C/ENG /HSEB/MB).

5. EARTHING CONDUCTORS

5.1 GENERAL

All conductors buried in earth and concrete shall be of mild steel. All conductors above ground level and earthing leads shall be of galvanized steel.

5.2 CONSTRUCTIONAL FEATURES

5.2.1 GALVANIZED STEEL

- Steel conductors above ground level shall be galvanized according to IS:2629.
- The minimum weight of the zinc coating shall be 610 gm/sq.m. and minimum thickness shall be 85 microns.
- The galvanized surfaces shall consist of a continuous and uniformly thick coating

of zinc, firmly adhering to the surfaces of steel. The finished surface shall be clean and smooth and shall be free from defects like discolored patches, bare spots, unevenness of coating, spelter which is loosely attached to the steel globules, spiky deposits, blistered surfaces, 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.

3 TESTS

Galvanized steel shall be subjected to four one minute dips in copper sulfate solution as per IS:2633.

SPACERS

GENERAL

Spacers shall conform to IS-10162

2 CONSTRUCTIONAL FEATURES

- 2.1 No magnetic material shall be used in the fabrication of spacers except for GI bolts and nuts.
- 2.2 Spacer design shall be made to take care of fixing and removing during installation and maintenance.
- 2.3 The design of the spacers shall be such that the conductor does not come in contact with any sharp edge.

3 TESTS

- 3.1 In accordance with requirements stipulated in Section 1 and Section 2, each type of spacers shall conform to type tests as per relevant IS/IEC and shall be subjected to the following, acceptance tests and routine tests in addition to those specified in IS/IEC :

3.2 ACCEPTANCE TEST

The acceptance tests shall be as per IS: 10162 (latest revision)

3.3 ROUTINE TEST

- a) Visual examination

- b) Dimensional verification

7. EARTHING

The Earthing shall be in accordance with requirements given hereunder. The earthmat design shall be done by the contractor as per IEEE 80. The earthmat shall be connected to the existing earthmat in case of substations where earthmat is already laid

7.1 GENERAL

- 7.1.1 Exact location of earthing connections shall be designed to suit the site conditions.
- 7.1.2 Neutral points of system of different voltages, metallic enclosures and frame works associated with all current carrying equipments and extraneous metal works associated with electric system shall be connected to a single earthing system unless stipulated otherwise.
- a) Code of practice for Earthing IS:3043
 - b) Code of practice for the protection of building and allied structures against lightning IS:2309
 - c) Indian Electricity Rules 1956 with latest amendments.
 - d) National Electricity Safety code IEEE-80.

7.2 DETAILS OF EARTHING SYSTEM

Item	Size	Material
a) Main Earthing Conductor	40 mm dia MS Rod	Mild Steel
b) Conductor above ground & earthing leads (for equipment)	75x12mm GS flat	Galvanised steel
c) Conductor above ground & earthing leads (for columns & aux. structures)	75x12mm GS flat	Galvanised steel

d)	Earthing of indoor LT panels, Control panels marshalling boxes, MOM boxes, Junction boxes & lighting Panels etc	50x6 mm GS flat	Galvnised steel
e)	Rod Electrode (in treated earth pit)	40mm dia, 3000mm	Mild Steel
f)	Earthing for motors flat	25x3 mm steel	Galvanised
g)	Earthing conductor along outdoor cable trenches primer	50x6mm flat	Mild steel painted with Red oxide

3 EARTHING CONDUCTOR LAYOUT

- 3.1 Earthing conductors in outdoor areas shall be buried at least 600 mm below finished grade level unless stated otherwise.
- 3.2 Wherever earthing conductors cross cable trenches, underground service ducts, pipes, tunnels, railway tracks etc. It shall be laid minimum 300 mm below them and shall be re-routed in case it fouls with equipment/structure foundations.
- 7.3.3 Tap-connections from the earthing grid to the equipment/structure to be earthed, shall be terminated on the earthing terminals of equipment/structure.
- 7.3.4 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 passage through walls, floors etc., galvanised iron sleeves shall be provided for the passage of the conductor and both ends of the sleeves shall be sealed to prevent the passage of water through the sleeves.
- 7.3.5 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.

7.3.6 Earthing conductor crossing the road shall be laid 300 mm below road or at a greater depth to suit the site conditions.

7.3.7 Earthing conductor embeded in the concrete shall have approximately 50 mm concrete cover

7.4 EQUIPMENT AND STRUCTURE EARTHING

7.4.1 Earthing pads shall be provided by the Supplier of the apparatus/equipment at accessible position. The connection between earthing pads and the earthing grid shall be made by short and direct earthing leads 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 engineer

7.4.2 Whether specifically shown in drawings or not, steel/structure columns, metallic stairs etc. shall be connected to the nearby earthing grid conductor by two earthing leads. Electrical continuity shall be ensured by bonding different sections of hand-rails and metallic stairs

7.4.3 Metallic pipes, conduits and cable tray sections for cable installation shall be bonded to ensure electrical continuity and connected to earthing conductors at regular. Apart from intermediate connections, beginning points shall also be connected to earthing system.

7.4.4 Metallic conduits shall not be used as earth continuity conductor.

7.4.5 A separate earthing conductor shall be provided for earthing lighting fixtures, receptacles, switches, junction boxes, lighting conduits etc.

7.4.6 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

7.4.7 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.

7.4.8 Railway tracks within switchyard area shall be earthed at a spacing of 30 mm and also by both the ends.

7.4.9 Earthing conductor shall be buried 500 mm inside the switchyard fence. Every alternate post of the fence and gates shall be connected to earthing loop by one lead.

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

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

4.12 A continuous ground conductor of 16 SWG GI wire shall be run all along each conduit run and bonded at every 600 mm 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.

4.13 50 mm x 6mm MS flat shall run on the top tier and along the cable trenches and the same shall be welded to each of the racks. Further this flat shall be earthed at both the ends at an interval of 30 mtrs. The MS flat shall be finally painted with two coats of Red Oxide primer and coats of post Office red enamel paint.

5 JOINTING

5.1 Earthing connections with equipment earthing pads shall be bolted type. Contact surfaces shall be free from scale, 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.

7.5.2 Connection between equipment earthing lead and main earthing conductors and between main earthing conductors shall be welded/brazed type. For rust protections, the welds should be treated with red lead and afterwards thickly coated with bitumen compound to prevent corrosion.

7.5.3 Steel to copper connections shall be brazed type and shall be treated to prevent moisture ingress.

7.5.4 Resistance of the joint shall not be more than the resistance of the equivalent length of the conductor.

7.5.5 All ground connections shall be made by electric arc welding. All welded joints shall be allowed to cool down gradually to atmospheric before putting any load on it. Artificial cooling shall not be allowed.

7.5.6 Bending of large rod/thick conductor shall be done preferably by gas heating.

7.5.7 All arc welding with large dia. conductors shall be done with low hydrogen content electrodes.

7.6 POWER CABLE EARTHING

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

7.7 SPECIFIC REQUIREMENT FOR EARTHING SYSTEMS

- 7.7.1** Each earthing lead from the neutral of the power transformer shall be directly connected to two pipe electrodes in treated earth pit upto water level 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 the Power Transformer shall be connected to the earthing grid at minimum two points.
- 7.7.2** Earthing terminal of each lightning arrester, capacitor voltage transformer and down conductors of Tower with peak etc. shall be directly connected to rod electrode which in turn, shall be connected to station earthing grid.
- 7.7.3** Auxiliary earthing mat comprising of closely spaced (300 mm x 300 mm) conductors shall be provided at depth of 300 mm from ground level below the operating handles of the MOM Boxes of Isolators. MOM boxes shall be directly connected to the auxiliary earthing mat.
- 7.7.4** Earthing of each Post Insulator base of Isolator and support Insulators of circuit breakers is required to be connected with earthing strip.
- 7.7.5** The earthing strips are required to be connected at the top of support structure on both sides and not at bottom.
- 7.7.6** Insulating strings in the gantry beam are required to be connected at the base with common strip.

7.8 SPECIFIC REQUIREMENTS FOR LIGHTNING PROTECTION SYSTEM

- 7.8.1** Conductors of the lightning protection system shall not be connected with the conductors of the safety earthing above ground level.
- 7.8.2** Down conductors shall be cleated on the structures at 2000 mm interval.
- 7.8.3** Connection between each down conductor and rod electrodes shall be made via test joint located approximately 1500 mm above ground level. The bidders shall include the cost of test links in the erection price component of respective equipment/structure and no extra payment shall be made for the same.
- 7.8.4** Lightning conductors shall not pass through or run inside G.I. conduits.
- 7.8.5** All metallic structures within a vicinity of 2000 mm in air and 5000 mm below ground shall be bounded to the conductors of lightning protection system.

8. MAIN BUS BARS

- 8.1** The brief description of the bus switching scheme, bus bar layout and equipment connection already adopted are indicated in the SLDs enclosed with Section 1.

2 The bidder shall furnish supporting calculations for the bus bars/conductors to show adequacy of design parameters for

- a) Cantilever strength of post insulators
- b) Short circuit forces and spacer location for each span of ACSR conductor stringing
- c) Earthing design calculation
- d) Direct stroke lightning protection
- e) Ampacity calculations

Bay EQUIPMENT#

The disposition of various bay equipment is shown in single line diagrams and standard section drawing/layout drawings enclosed with Section 1

10. LIGHTNING PROTECTION#

10.1 Direct stroke lightning protection (DSLPP) shall be provided in the switchyard by shield wires. The layout drawings enclosed indicate arrangement. The final arrangement shall be decided after approval of the DSLPP calculations. Rezviki method of lightning protection shall be followed. Any additional expenditure resulting from change of layout if required shall be to the firm's account.

10.2 The lightning protection system shall not be in direct contact with underground metallic service ducts and cables

11. TERMINAL POINTS

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

11.1.1 LINE FEEDERS

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 earthwire are included in the scope of the bidder

11.1.2 Lightning protection down conductor at this end, tap offs and jumper connections from this dead end to all equipment in the switchyard are in Contractor's scope

12. EQUIPMENT ERECTION NOTES

- 12.1.1** All support insulators, circuit breaker interrupters and other fragile equipment shall preferably be handled with cranes having suitable booms and handling capacity.
- 12.1.2** The slings shall be of sufficient length to avoid any damage to insulator due to excessive swing, scratching by sling ropes etc.
- 12.1.3** Handling equipment, sling ropes etc. should be tested periodically before erection for strength.
- 12.1.4** Bending of compressed air piping should be done by a bending machine and through cold bending only. Bending shall be such inner diameter of pipe is not reduced.
- 12.1.5** 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.
- 12.1.6** Muslin or leather cloth shall be used for cleaning the inside and outside of hollow insulators.
- 12.1.7** All the equipment, instruments and auxiliaries required for testing and commissioning of equipment shall be arranged at site by the Contractor.

12.2 STORAGE

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. The storage instructions of the Equipment manufacturer/HVPN shall be strictly adhered to.

13 CABLE TAGS AND MARKERS

- 13.1** Each cable and conduit run shall be tagged with numbers that appear in the cable and conduit schedule.
- 13.2** 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 circular shape for control cables.

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

- 13.4 Location of underground cable joints shall be indicated with cable marker with an additional inscription "Cable joints".
- 13.5 The marker shall project 150 mm above ground and shall be spaced at an interval of 30 meters and at every change in direction. They shall be located on both sides of road and drain crossings.
- 13.6 Cable tags shall be provided on all cables at each end (just before entering the equipment enclosure), on both side 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 centers, control and relay panels etc., wherever required for cable identification, where a number of cables enter together through a gland plate.

13.7 CABLE SUPPORTS AND CABLE TRAY MOUNTING ARRANGEMENTS

- 13.7.1 The contractor shall provide embedded steel insert on concrete on concrete floors/walls to secure supports for by welding to these inserts or available building steel structures, for the purpose of casting in the control room.
- 13.7.2 The supports shall be fabricated from standard structural steel members.
- 13.7.3 Insert plates will be provided at an interval of 750 mm wherever cables are to be supported without the use of cable trays, such as in trenches, while at all other places these will be an interval of 1000 mm. (AS PER DRG ATTACHED)

13.8 CABLE TERMINATION AND CONNECTIONS

- 13.8.1 The termination and connection of cables shall be done strictly in accordance with cable and termination kit manufacturer's instructions, drawing and/or as directed by the Owner.
- 13.8.2 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.
- 13.8.3 Supply of all consumable material shall be included in the scope of the contractor.
- 13.8.4 The equipment will be generally provided with un-drilled 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.
- 13.8.5 Control cable cores entering control panel/switchgear/MCC/miscellaneous panels shall be neatly bunched, clamped and tied with nylon strap or PVC perforated strap to keep them in position.

- 13.8.6** The contractor shall tag/ferrule control cable cores at all terminations, 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.
- 13.8.7** Spare cores shall be similarly tagged with cable numbers and coiled up.
- 13.8.8** All cable entry points shall be sealed and made vermin and dust proof. Unused openings shall be effectively closed.
- 13.8.9** Double compression type tinned/nickel plated brass cable glands shall be provided by the contractor for all power and control cables to provide dust and weather proof terminations.
- 13.8.10** The cable glands shall be tested as per BS:6121. They shall comprise of heavy duty brass casting, machine finished and tinned to avoid corrosion and oxidation. Rubber components used in cable glands shall be neoprene and of tested quality. The cable glands shall be of approved make.
- 13.8.11** The cable gland shall also be tested for dust proof and weather proof termination. The test procedure has to be discussed and agreed to between the Owner and cable glands manufacturer.
- 13.8.12** If the cable and box or the 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 employer.
- 13.8.13** Crimping tool shall be of approved design and make.
- 13.8.14** Cable lugs shall be tinned copper solderless crimping type conforming to IS:8309 and 8394. The cable lugs shall be of approved make.
- 13.8.15** Solderless crimping of terminals shall be done by using corrosion inhibitory compound. The cable lugs shall suit the type of terminals provided.

DIRECTLY BURIED CABLES

14.1 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 quoting the unit rates.

14.2 The power and control cable between LT station, Control room, shall be laid in the buried cable trenches. Further, for lighting purposes also, buried cable trench can be used in the outdoor area.

14.3 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.

15. INSTALLATION OF CABLES

15.1 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.

15.2 The Contractor shall fabricate and install mounting arrangements for the support and installation of all the cables on angles at 1000 mm spacing in the trenches, as shown in the drawing enclosed with specification. 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 Section STR, in addition to the Specifications given herein.

15.3 Cable racks and supports shall be painted after installation with two coats of metal primer (comprising of red oxide 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 Specifications given herein.

15.4 All inter pole cables (power & Control) for all equipment shall be laid in cable trenches/GI conduit pipes of NB 50/100 mm diameter, class medium as per IS 4736 which shall be buried in the ground at a depth of 250mm. 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 seals.

15.5 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 supplier shall be maintained. Cabling in the control room shall be done on ladder type cable trays.

15.6 Cables from the equipment to trench shall run in GI 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 vibration is anticipated. The flexible conduit shall be

as per the relevant IS.

15.7 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 cable on top tiers

b) Control instrumentation and other service cables in bottom tiers.

15.8 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 cable shall be laid with a minimum center to center distance equal to twice the diameter of the cable

15.9 Trefoil clamps for single core cable shall be pressure die cast aluminium (LM-6), Nylon or fibre glass and shall include necessary fixing GI nuts, bolts, washer etc. These are required at every 2 metre of cable runs. The cost of supply and erecting these clamps shall be made on the unit rate basis.

15.10 Power and control cable shall be securely fixed to the trays/supports with self locking type nylon ties with deinterlocking facility at every 5 metre interval for horizontal run. Vertical and inclined cable runs shall be secured with 25 mm wide and 2 mm thick aluminium strip clamps at 2m.

15.11 Cables shall not be bent below the minimum permissible limit. The permissible limits are as follows

Table of cable and Minimum bending radius voltage grade

Power cable 12 D

Control cable 10 D

D is overall diameter of cable

15.12 The cables are to be laid in single layers on racks and are to be routed through culvert whenever there is road crossing.

15.13 In each cable 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.

15.14 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.

- 15.15 Control cable terminations inside equipment enclosures shall have sufficient lengths so that changing of termination blocks can be done without requiring any splicing.
- 15.16 Metal screen and armour of the cable shall be bonded to the earthing system of the station. Wherever required by the Owner.
- 15.17 Rollers shall be used at intervals of about two meters while pulling cables.
- 15.18 All due care shall be taken during unreeling, laying and termination of cable to avoid damage due to twist, kinks, sharp bends, etc.
- 15.19 Cable ends shall be kept sealed to prevent damage.
- 15.20 Inspection on receipt, unloading and handling of cables shall generally be in accordance with IS:1255 and other Indian Standard Codes of practices.
- 15.21 Wherever cable pass through wall openings or other partitions, wall sleeves with bushes having a smooth curved internal surface so as not to damage the cable, shall be supplied, installed and properly sealed by the Contractor at no extra charges.
- 15.22 Contractor shall remove the RCC/Steel trench covers 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.
- 5.23 Contractor shall furnish three 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 modifications are made.
- 5.24 Contractor shall paint the tray identification number on each run of trays at an interval of 10 m
- 5.25 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 to the Owner, i.e. the Contractor shall be paid for installation and removal of the damaged cable.
- 5.26 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 not with insulating tape, sleeve or paint.

- 15.26 a Separate racks/trays will be utilized for different voltage levels from switchyard to control room
- 15.26.b All the cable trenches will be constructed as per standard HVPN design as far as electrical portion is concerned
- 15.26 c The GI pipe duly plugged at both ends and by providing bends/elbows or trenches will be provided/constructed from equipment to trenches
- 15.26 d Provision for accommodation of cables of future bays (All bays position marked on the drawing whether shown dotted or not to be included for future provision in main the trench size) are to be made in the main trenches.

15.26 TESTS ON CABLE TRAYS

- 15.26.1 Test for galvanizing (Acceptance test) to be done as per relevant standard

15.26.1 DEFLECTION TEST (TYPE TEST)

A 2.5 meter straight section of all widths cable trays be simply supported at two ends a uniform distributed load of 76 Kg meter shall be applied along the length of the tray. A maximum deflection at the mid span shall not exceed 7 mm

15.27 CONDUITS, PIPES AND DUCT INSTALLATION

- 15.27.1 Contractor shall supply and install all rigid conduits, mild steel pipes, flexible conduits, hume 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 engineering drawing. The size of the conduit/pipe shall be selected on the basis of 40% fill criterion
- 15.27.2 Contractor shall have his own facility for bending, cutting and threading the conduits at site. Cold bending should be used. All cuts & threaded ends shall be made smooth without leaving any edges. Anticorrosive paint shall be applied at all field threaded portions
- 15.27.3 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
- 15.27.4 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
- 15.27.5 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
- 15.27.6 Each conduit run shall be painted with its designation as indicated on the drawing such that it can be identified at each end.
- 15.27.7 Embedded conduits shall have a minimum concrete cover of 50 mm

- 15.27.8 Conduit run sleeves shall be provided with the bushings at each end.
- 15.27.9 Metallic conduit runs at termination shall have two locknuts and a bushing for connection. Flexible conduits shall also be suitably clamped at each end with the help of bushings. Bushings shall have rounded edges so as not to damage the cables.
- 15.27.10 When 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.
- 15.27.11 All conduits/pipes shall have their ends closed by caps until cable 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.
- 15.27.12 For underground runs, contractor shall excavate and back fill as necessary.
- 15.27.13 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, checknuts, 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.
- 15.27.14 All unarmoured cable shall run within the conduits from lighting panels to lighting fixtures, receptacles etc.
- 15.27.15 Size of conduit for lighting shall be selected as per the table given in the attached drawings.
- 15.27.16 Exposed conduits shall be run in straight lines parallel to building columns, beams and walls. Unnecessary bends and crossings shall be avoided to present a neat appearance.
- 15.27.17 Conduit supports shall be provided at an interval of 750 mm for horizontal runs and 100 mm for vertical runs.
- 15.27.18 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.

15.27.19 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

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

15.27.21 Where conduits are alongwith cable trays, they shall be clamped to suporting steel at an interval of 600mm.

15.27.22 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

15.27.23 Conduit shall be installed in such a way as to insure against trouble from trapped condensation

15.27.24 Conduit 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

15.27.25 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.

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

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

15.27.28 Conduits 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 lead for exposed conduit.

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

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

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

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