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ROYAL GOVERNMENT OF BHUTAN

MINISTRY OF INFRASTRUCTURE AND TRANSPORT

DEPARTMENT OF INFRASTRUCTURE DEVELOPMENT

“Towards quality, cost effective, green and sustainable infrastructure”

**SPECIFICATIONS
FOR
ELECTRICAL WORKS
2025**

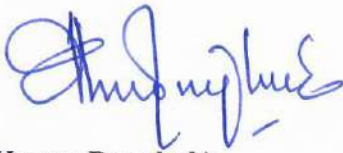
FOREWARD

The Department of Infrastructure Development under the Ministry of Infrastructure and Transport is pleased to publish the Specifications for Electrical works- 2025. This document is published as a guide to the engineers and contractors to oversee the works. We hope that this will be of great use to engineers, architects, and people undertaking electrical related constructions.

The specifications outline standards of materials, technical procedure to conduct works including test and quality checks, mode of measurement and applicability of rates for the items of works in Bhutan Schedule of Rates (Electrical) - (BSR -2025) and Labor and Materials Coefficient (Electrical) - (LMC-2025). This document should therefore be read in conjunction with the BSR-2025 (Electrical) and LMC-2025 (Electrical). Reference to relevant codes is made wherever is necessary.

While publishing this document, the department has made great effort to update the document with current construction practices.

Any comments and suggestions related to this publication may be brought to the notice of the Department. This will enable the Department to bring in positive changes.



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1- ABBREVIATIONS

The following abbreviations wherever they appear in the specifications shall have the meaning or implication hereby assigned to them.

Sl. No	Acronyms	Abbreviations
1	A	Amperes
2	A.C	Alternating Current
3	C.I	Cast Iron
4	CFLs	Compact Fluorescent Lamps
5	DB	Distribution Board
6	D.C	Direct Current
7	ELCB	Earth Leakage Circuit Breaker
8	G.I	Galvanized Iron
9	GLS	General Lighting Services
10	HF	High Frequency
11	HID	High Intensity Discharge
12	HRC	High Rupturing Capacity
13	HT	High Tension
14	I	Current
15	ICDB	Iron Clad Distribution Board
16	KV	Kilo Volt
17	KW	Kilo watt
18	LT	Low Tension
19	LED	Light Emitting Diode
20	MCB	Miniature Circuit Breaker
21	MS	Mild Steel
22	PVC	Polyvinyl Chloride
23	R	Resistance
24	RCCB	Residual Current Circuit Breaker
25	SDB	Sub Distribution Board
26	SPMCB	Single Pole miniature Circuit Breaker
27	SPN	Single Pole & Neutral
28	TPN	Triple Pole & Neutral
29	V	Volt
30	W	Watt

2- DEFINITIONS

The definitions given below shall be applicable to all sections unless otherwise indicated.

- 2.1 Accent lighting:** Directional lighting to emphasize a particular object or draw attention to a part of the field of view.
- 2.2 Aluminium conductor steel reinforced:** In Aluminium conductor steel reinforced conductor, aluminium wires surround a core consisting of one or more steel wires.
- 2.3 Arrester:** A non-linear device to limit the amplitude of voltage on a power line. The term implies that the device stops over voltage problems (i.e. lightning).
- 2.4 Armouring:** It consists of one or two layers of galvanized steel wire or steel tape, to protect the cable from mechanical injury while laying it and during the course of handling
- 2.5 Alternating current:** The term alternating current refers to a current that reverses at regular recurring intervals of time and that has alternately positive and negative values.
- 2.6 Arcing contacts (arcing horns):** Arcing contacts are the contacts on which the arc is drawn after the main contacts of a switch have parted.
- 2.7 Bonding jumper:** A bare or insulated conductor used to ensure the required electrical conductivity between metal parts required to be electrically connected. Frequently used from a bonding bushing to the service equipment enclosure to provide a path around concentric knockouts in an enclosure wall: also used to bond one raceway to another.
- 2.8 Bus-Bar:** A heavy, rigid conductor used for high voltage feeders.
- 2.9 Binding wire:** Annealed aluminium wire is used for fastening conductor to pin and shackle insulator.
- 2.10 Base:** A base of a switch is the main member to which the conducting parts or insulator unit are attached. It may also have parts of the operating or control mechanism attached.
- 2.11 Cables:** A length of one or more than one insulated conductor, which are laid up together and surrounded by a protecting cover.
- 2.12 Clear lamps:** Clear lamps absorb least amount of light but due to high brightness need shielding from direct view.
- 2.13 Conductor:** A substance, which offers low resistance to the passage of electric current.
- 2.14 Cross arms:** It provides support to the insulators.
- 2.15 Conduit:** A tubular raceway for data or power cables. Metallic conduit is common, although non-metallic forms may also be used.

- 2.16 Conduit joints:** Since the conduits are available in smaller lengths, so to obtain a continuous length of the conduit the two are coupled together by means of coupling.
- 2.17 Decorative lighting:** Decorative lighting is determined by the aesthetic and architectural considerations; utility lighting is primarily on economic considerations.
- 2.18 Earthling:** Earthling or grounding is the term used for electrical connection to general mass of earth.
- 2.19 Earth Ground:** A low impedance path to earth for the purpose of discharging lightning, static, and radiated energy, and to maintain the main service entrance at earth potential.
- 2.20 Earth wire:** A conductor connected to earth and usually situated in proximity to the associated live conductors.
- 2.21 Earth electrode:** A metal plate or pipe, which is electrically connected to the general mass of earth.
- 2.22 Flexible cable:** A cable containing one or more cores, each formed of a group of wires, the diameter of the wires being sufficiently small to afford flexibility.
- 2.23 Flood lighting:** It is the term used for lighting of construction projects, parking areas, recreation and sports ground, etc.
- 2.24 Fixture:** The assembly that houses a lamp or lamps, and which may include a housing, a mounting brackets or pole socket, a lamp holder, a ballast, a reflector or mirror, and or a refractor, lens, or diffuser lens.
- 2.25 Fuse:** A strip or wire or metal inserted in series with a circuit which, when it carries an excess of current over its rated capacity, will burn out.
- 2.26 Fluorescent lamp:** The lamp is filled with low-pressure argon gas and a drop of mercury.
- 2.27 Girder clips:** It is used to fix the conduit to the wooden plugs in the wall.
- 2.28 Guard wires:** Wires which are used at all points where a line crosses a street or road and have to be earthed at all points where their continuity is broken.
- 2.29 Grounded:** Conducted to earth or to some conducting body that serves in place of the earth.
- 2.30 Ground:** A conducting connection, whether intentional or accidental, between an electrical circuit or equipment and the earth, or to some conducting body that serves in place of earth.
- 2.31 High Intensity Discharge Lamps (HID):** A general group of lamps consisting of mercury, metal halide, high-pressure sodium, and low-pressure sodium lamps.
- 2.32 Incandescent lamp:** The light spectrum of an incandescent lamp is continuous, it contains all the colours, but contains relatively excess of red and yellow radiations and less of blue and violet radiations.

- 2.33 Insulator:** A device for fastening and supporting a conductor. Glass and porcelain are employed almost universally for supporting overhead wires.
- 2.34 Lamp:** The component of luminaries that produces the actual light.
- 2.35 Lighting arrester or a surge diverter:** It is a protective device, which conducts the high voltage surges on the power system to the ground.
- 2.36 Luminaries/Luminaries:** A complete lighting system, including a lamp or lamps and a fixture.
- 2.37 Mercury vapour lamps:** In this lamp, the discharge tube is filled in a bulb of hard glass provided with an internal mirror reflector.
- 2.38 Megger:** A test instrument for measuring the insulation resistance of conductors and other electrical equipment; specifically, a mega-ohm (million ohms) meter.
- 2.39 Mercury lamps:** An electric discharge lamp in which the major portion of the radiation is produced by the excitation of mercury atoms.
- 2.40 Metal halide lamps:** A discharge lamp in which the light is produced by the radiation from the mixture of metallic vapour and the products of disassociation.
- 2.41 Pole:** A pole of a switch consists of the parts necessary to control one conductor of a circuit. A switch may be single pole or multiple, depending upon the number of single poles that are operated simultaneously.
- 2.42 Reflector lamps:** A reflector lamp is provided with high quality internal mirror, which follows exactly the parabolic shape of the lamp.
- 2.43 Stay wires:** Stay wires are required to be earthed with an earth wire unless there are insulated by a strain insulator placed at a height not less than 3m from the ground.
- 2.44 Serving:** The protective material over the metal sheathing or the wire armour of a cable is known as serving.
- 2.45 Struts:** Struts may be used, where it is not possible to use stay wires due to limitation of space.
- 2.46 Socket outlet:** A device carrying three metallic contacts designed for engagement with corresponding plug pins and arranged for connections to fixed wiring.
- 2.47 Sodium lamps:** It is a low-pressure gas discharge lamp, consisting of a U-shaped glass tube, filled with an inert gas and some sodium, which can be seen in the form of solidified drops on the inner wall when the lamp is cold.
- 2.48 Switch:** A device of making, breaking, or changing the connections in an electric current.
- 2.49 Surge:** A short duration high voltage condition. A surge lasts for several cycles where a transient lasts less than one half cycle.

- 2.50 Switchboard:** A large single panel, frame or assembly of panels having switches, over-current, and other protective devices, buses, and usually instruments mounted on the face are not intended to be installed in cabinets.
- 2.51 Thyrite type arrester:** Thyrite type arresters incorporate non-linear resistors and are extensively used on systems operating at high voltages.

3- GENERAL

These Specifications are drawn to indicate the essential requirements and precautions to be taken regarding electrical installation for ensuring efficient, safe, economical and practical use of electrical materials and equipment including prevention of fire hazards.

The electrical installation and general safety precautions shall be carried out in accordance with the Specifications specified hereunder and shall be in conformity with:

Building Code of Bhutan- 2003 (Part 2: Building Services);

Any documents related to electrical installation, testing and commissioning published by the Bhutan Electricity Authority, Department of Energy and;

Relevant Indian Standards wherever not covered in this specification.

3.1.1 Drawings

The works shall be carried out in accordance with the drawings enclosed with the tender documents and also with modifications thereto from time to time as approved by the Engineer-in-charge.

All wiring diagrams shall indicate clearly in plan, the main switchboard, the distribution boards, the runs of various mains and their classification and controls. All circuits shall be indicated and numbered in the wiring diagram and all points shall be given the same number as the circuit to which they are electrically connected. Distribution boards shall also be marked to indicate the circuit numbers controlled by them.

3.1.2 Materials

All materials supplied shall be new and conforming to relevant Standard Specifications wherever they exist. Materials approved/standardized by the Royal Government from time to time only shall be used in any electrical work unless otherwise stated or directed by the Engineer-in-charge.

3.1.3 Workmanship

Good workmanship is an essential requirement to be complied with. The entire work shall be carried out under the direct supervision of a licensed electrician and/or qualified supervisor employed by the contractor who shall rectify then and there, the defects pointed out by the Engineer-in-charge and/or senior officials of the Department during the progress of work.

3.1.4 Ratings of electrical components

All components in a wiring installation shall be of appropriate ratings of voltage, current and frequency as required at the respective sections of the electrical installations in which they are used.

All conductors, switches and accessories shall be of such size as to be capable of carrying, without their respective ratings being exceeded, the maximum current that will normally flow through them.

3.1.5 Structural alteration to buildings

No alteration that shall affect the structure of building shall be done unless sanction of the Engineer-in-charge has first been obtained. All chases, ducts, holes etc. required in connection with the electrical works shall be provided and filled by the contractor at his own cost to the original architectural finish of the buildings. For new buildings, these chases, ducts, holes etc. shall be provided when the building is in progress.

3.1.6 Work in occupied buildings

When the building is occupied and major portion of the work is required to be done under that condition the work shall be carried out in such a way that there is minimum inconvenience to the occupants. In such cases, it may be necessary to work before and after office hours as required.

3.1.7 Testing and commissioning on completion

After completion of the works, and before handing it over to the client, it shall be ensured that the installation is tested and commissioned.

3.1.8 Additional load to an existing Installation

An addition, temporary or permanent, shall not be made to the authorized load of an existing installation until it has been definitely ascertained that the current carrying capacity and the condition of the existing accessories, conductors, switches etc. affected are adequate for the increased load.

3.1.9 Connection to ancillary buildings

Unless otherwise specified, electrical connections to ancillary buildings such as out-house, garages etc., adjacent to the main building at a distance not greater than 3 m and where no road intervenes shall be taken in an earthed G.I. pipe of suitable size in the exposed portion at a height of not less than 2.5 m. This applies to both runs of mains or sub mains or circuit wiring between the buildings. When the distance between the buildings exceeds 3 m or a road way intervenes, separate mains shall be run from the main building to ancillary building and the portion of the same exposed to weather proof cable on G.I. bearer wire at a height not less than 4 m above the ground. Alternatively, PVC insulated wire in G.I. pipe or underground cable may be used below ground level.

4- WIRING SYSTEM

The wiring shall be carried out on such a system as may be specified in the Tender Schedule. **Power** and **Heating** wiring shall be kept separately and distinct from **Lighting** and **Fan** wiring. Recessed conduit wiring system may generally be adopted for this purpose. The wiring shall be done on distribution system with main and branch distribution boards at convenient physical and electrical centres. All conductors shall run, as far as possible, along the walls and ceiling so as to be easily accessible and capable of being thoroughly inspected. In no case, the open wiring shall run above the false ceiling without the approval of Engineer. In all types of wiring, due consideration shall be given for neatness, good appearance and safety.

4.1 PVC Casing and Capping

4.1.1 Fixing casing-capping

PVC casing and capping shall be of standard material free from defects of any kind. It should be properly finished and conform to relevant standards. This system of wiring is suitable for low voltage installation where polyvinyl chloride (PVC), rubber, plastic or other approved insulated cables shall be used in the wiring work carried within PVC casing enclosure. PVC casing and capping wiring shall not be used in damp or poorly ventilated places without taking suitable precaution.

PVC casing and capping should be strong and properly fitted so as to hold wires laid in it to its full capacity even under the ceiling. For this reason, the thickness of the PVC casing and capping shall be 1.6mm for sizes up to 25mm and 1.5mm or more for sizes up to 50mm. It should be rigidly screwed at 150mm interval crosswise with suitable wood screws of 25mm length turned in PVC sleeve inserted in neatly drilled holes of proper size and depth with cup washer to give proper grip over more surface area. Providing and fixing of PVC casing and capping include bends, elbows, tees, inside and outside corners, round blocks and painting. It can be run whether in horizontal or vertical position as required. As much as possible, the colour of the casing and capping shall match the colour of the surface on which it is laid.

When wiring is to be carried out in places where aesthetic views is of great concern and to harmonize the look with the site condition, special casing capping shall be submitted to the Engineer for approval prior to laying out for the work. The inspection shall be done from time to time as the work progresses. Capping shall not be put on until the work has been inspected after the wires are laid in position and approved by the Engineer-in-charge.

4.1.2 Providing earth continuity wires

The earth continuity wire shall be provided in the casing throughout the length of wiring. The size of earth continuity wire shall be not less than 1.5 sq.mm (16SWG) and 2.5sq.mm (14SWG) bare copper wire for light and power circuit respectively. All metallic parts, switchboards, light fittings and power sockets shall be connected to the earth wires and the connection shall be electrically and mechanically sound

4.1.3 Size and Measurement

The length of the PVC casing capping is available from 1.8 to 3 meters. The unit of measurement shall be in metres, measured to the nearest cm. The width, depth and thickness of PVC casing and capping shall be as given below:

- | | | | |
|----|---------------------------|----|---------------------------|
| a. | 12mm x 12mm x 1.2mm thick | d. | 32mm x 12mm x 1.5mm thick |
| b. | 20mm x 12mm x 1.2mm thick | e. | 40mm x 12mm x 1.5mm thick |
| c. | 25mm x 12mm x 1.2mm thick | f. | 50mm x 12mm x 1.5mm thick |

Table 1 gives the dimensions of PVC casing and capping and Table 2 shows the maximum number of PVC insulated 650/1100 V grade copper/aluminium conductors that can be drawn in a given size of casing.

Table 1: Dimension of PVC casing and capping

Width of casing or capping	No. of grooves	Width of grooves	Width of dividing fillet	Thickness of outer wall	Thickness of casing	Thickness of capping	Thickness at back under groove	Length
mm	mm	mm	mm	mm	mm	mm	mm	meter
44	2	6	12	10	16	6	6	2.5 to 3
51	2	9	13	10	19	10	6	
64	2	13	18	10	19	10	10	
76	2	16	24	10	25	10	10	
89	2	16	35	10	32	13	10	
102	2	19	38	10	32	13	13	

Table 2: No. of P.V.C insulated 650/1100 V grade (Copper or Aluminium) conductor cable that can be drawn in one groove of the casing

Nominal cross sectional area of conductor sq.mm	44 mm X 16 mm	51 mm X 19 mm	64 mm X 19 mm	76 mm X 25 mm	89 mm X 32 mm	102 mm X 32 mm
1.5	2	2	2	9	12	12
2.5	1	2	2	4	8	9
4	1	2	2	4	6	9
6	..	1	1	4	6	6
10	..	1	1	4	4	4
16	..	..	1	1	2	2
25	..	..	..	1	2	2
35	..	..	..	..	1	1
50	..	..	..	..	..	1
70	..	..	..	..	..	1

4.2 Conduit Wiring

a) Type and size of conduit

All conduit pipes shall be of approved gauge (Not less than 16 SWG for conduits of sizes upto 32 mm diameter and not less than 14 SWG for conduits of size above 32 mm diameter) solid drawn or reamed by welding finished with galvanized or stove enameled surface. All conduit accessories shall be of threaded type. The maximum number of PVC insulated 650/1100 V grade (copper or aluminium) conductor cable that can be drawn in one conduit of various sizes shall be as given in the Table 3 below, and the number of cables per conduit shall not be exceeded. No steel conduit less than 19 mm in diameter shall be used.

Table 3: Maximum number of PVC Insulated 650/1100 V Grade aluminium/copper conductor cable that can be drawn in one conduit.

Nominal Cross sectional area of conductor in sq.mm	20mm		25mm		32mm		38m		51mm		64mm	
	S	B	S	B	S	B	S	B	S	B	S	B
1	2	3	4	5	6	7	8	9	10	11	12	13
1.5	5	4	10	8	18	12	-	-	-	-	-	-
2.5	5	3	8	6	12	10	-	-	-	-	-	-
4	3	2	6	5	10	8	-	-	-	-	-	-
6	2	-	5	4	8	7	-	-	-	-	-	-
10	2	-	4	3	6	5	8	6	-	-	-	-
16	-	-	2	2	3	3	6	5	10	7	12	8
25	-	-	-	-	3	2	5	3	8	6	9	7
35	-	-	-	-	-	-	3	2	6	5	8	6
50	-	-	-	-	-	-	-	-	5	3	6	5
70	-	-	-	-	-	-	-	-	4	3	5	4

Note:

1. The above table shows the maximum capacity of conduits for a simultaneous drawing in of cables.
2. The columns headed “S” apply to runs of conduit which have distance not exceeding 4.25 m between draw in boxes and which do not deflect from the straight by an angle of more than 15 degrees. The columns headed “B” apply to runs of conduit, which deflect from the straight by an angle of more than 15 degree.
3. Conduit sizes are nominal external diameters

b) *Fixing of conduit*

Conduit pipes shall be fixed by heavy gauge saddles, secured to suitable PVC sleeves or other equivalent type with screws in an acceptable manner at an interval of not more than one meter but on either side of the couplers or bends or similar fittings. Saddles shall be fixed at a distance of 30 cm from the centre of such fittings. The saddle should not be less than 24 gauge for conduits up to 25 mm dia. and not less than 20 gauge for larger diameter.

When conduits pipes are to be laid along the trusses, steel joints etc. the same shall be secured by means of ordinary clips or glider clips as required by the Engineer-in-charge. Where it is not possible to drill holes in the truss members, suitable clamps with bolts and nuts shall be used. The width and the thickness of the ordinary clips or glider clips and clamps shall not be less than as indicated in Table 4 below:

Table 4: Width and thickness of saddle clips

For clamps or ordinary clips		
Size of conduit	Width of saddle clips	Thickness of clip
20 mm	20 mm	20 SWG
25 mm	20mm	20 SWG
32mm & above	25mm	18 SWG

c) *Conduit joints*

Conduit pipes shall be joined by means of screwed couplers and screwed accessories only. In long distance straight run of conduit, inspection type couplers at reasonable intervals shall be provided or running threads with couplers and jam nuts shall be provided. In the later case the bare threaded portion shall be treated with anticorrosive preservative. Threads on conduit pipes in all cases shall be between 13 mm and 19 mm long sufficient to accommodate pipes full threads portion of couplers or accessories. Cut ends of conduit pipes shall have no sharp edges or any burrs left to avoid damage to the insulation of conductors while pulling them through such pipes.

d) *Making of chase*

The chase in the wall shall be neatly made and ample dimensions to permit the conduit to be fixed in the manner desired. In the case of buildings under construction, conduits shall be finished neatly after erection of conduit. In case of exposed brick/rubble masonry work, special care shall be taken to fix the conduit and accessories in position along with the building work.

e) *Fixing of conduit in chase*

The conduit pipe shall be fixed by means of staples or by means of saddles not more than 60 cm apart or by any other approved means of fixing. Fixing of standard bends shall be avoided as far as practicable and all curves/bend shall be maintained by bending the conduit

pipe itself with a long radius that will permit easy drawing of conductors. All threaded joints of conduit pipes shall be treated with preservative compound to prevent from rusting.

f) Erection and earthing of conduit

Fixing of conduit shall have to be completed in all respect before the wires are drawn. After completing the fixing of conduit, it shall be tested for mechanical rigid and electrically sound continuity throughout its running length. Gas or water pipe shall not be used as earthing electrode. If conduit pipes are liable to mechanical damage they shall be adequately protected. In a conduit system pipe must be continuous when passing through walls and floors. Earthing wire shall run throughout its length and properly bonded to conduit pipe where possible to get uniform grounding effect.

g) Inspection boxes

Suitable size of inspection boxes to the minimum requirements shall be provided to permit periodical inspection and to facilitate drawing/replacement of wires conveniently. These shall be mounted flushed with the wall. Suitable ventilation holes shall be provided in the inspection box covers condensation and heat radiation.

h) Protection of conduits against rust

If the materials are of the GI or Steel, the outer surface of the conduit including all bends, unions, tees, junction boxes etc. forming part of the conduit system shall be adequately protected against rust when such system is exposed to weather by being painted with two coats of oxide paint applied before they are fixed. In all cases, no bare threaded portion of conduit pipe shall be allowed unless such bare threaded portion is treated with anticorrosive preservation or covered with approved plastic compound.

i) Painting of conduits and accessories

After installation, all accessible surfaces of conduit pipes, fittings, switch and regulator boxes etc. shall be painted in compliance with clauses under Painting. No painting is required for PVC conduit/HDPE pipe and casing capping unless otherwise specified.

j) Glider Clips

For all sizes of conduit, the size of clamping rod shall be 7 SWG diameter.

k) Bends in conduits

All necessary bends in the system including diversion shall be formed either by bending the pipes by an approved method of heating, or by inserting suitable accessories such as bends, elbows or similar fittings, or by fixing cast iron inspection boxes whichever is most suitable. Radius of bends in conduit pipes shall not be less than 7.5 cm. No length of conduit shall have more than the equivalent of four quarter bends from outlet to outlet.

l) Outlets

The switch box shall be made of either rigid PVC moulding, or mild steel or cast iron on all sides except at the front. In the case of boxes, wall thickness shall be at least 3 mm and in case of welded mild steel sheet boxes the wall thickness shall not be less than 18 gauge for boxes, upto a size of 20 mm X 30 cm and above this size 16-gauge M.S, boxes shall be used. Except when otherwise stated 3 mm thick phenolic laminated sheets shall be fixed on the front with brass screws. Clear depth of the box shall not be less than 60 mm and this shall be increased suitably to accommodate mounting of fan regulators in flush pattern.

4.2.1 PVC Conduits/HDPE Pipes

4.2.1.1 Surface

Providing and fixing of surface PVC conduit pipes include bends and circular boxes and painting if required. PVC conduits shall be of standard material free from defects of any kind. It should be properly finished and conforming to relevant standards.

Providing and fixing of PVC conduit 1.8 mm thick for sizes up to 25mm and 2mm thick from 32mm to 50mm, run whether in horizontal or vertical position as required. It should be rigidly fixed on the wall surface with conduit saddles of thickness 1.8mm for sizes up to 25mm and 2mm thick for pipe sizes from 32mm to 50mm at the spacing of not more than 50cm. However, saddles have to be provided at the ends of the pipes if bend and circular boxes are used. The saddles are to be rigidly fixed on the wall with wooden screws of sizes 50mm long for stone masonry wall surface and 35mm for brick wall surface, screwed in PVC sleeves of appropriate size. The holes for PVC sleeves have to be drilled by motor drills using appropriate size bits to required depth. In case of conduits laid on the wooden surface, the screws of 25mm length shall be directly screwed and no sleeve is required.

4.2.1.2 Concealed

Wherever MS conduits are not feasible, HDPE pipes OR PVC conduits of appropriate size and standard shall be used. However, PVC accessories like boxes, sleeves, corners may be used. The HDPE pipes can be run whether in horizontal or vertical position as required. It should be embedded in the wall up to depth from 16mm to 25mm from the finished plaster level. Where applicable, the pipe has to be secured by binding wire tied on the nail to hold it till the plastering sets to its strength. In case of the pipes laid in RCC works, it has to be tied securely by binding wire to the external reinforcement bars and should be flushed in the ceiling surface. Lay of pipe diagonally can be permitted in the brick/stone masonry wall, provided there is no crossing with other pipes or change in direction.

4.2.1.3 Providing Earth Continuity Wires

The earth continuity wire shall be provided throughout the length of wiring. The size of earth continuity wire shall be not less than 1.5 sq.mm (16SWG) and 2.5sq.mm (14SWG) bare copper wire for light and power circuit respectively. All metallic parts, switchboards,

light fittings and power sockets shall be connected to the earth wires and the connection shall be electrically and mechanically sound.

4.2.1.4 PVC conduit size

The length of PVC conduit shall be available from 2.5 to 3metres. The unit of measurement shall be in metres and measured to the nearest cm. The diameters of the PVC conduit shall be:

- | | |
|----------------------|-------------------|
| a. 19mm diameter, b. | d. 40mm diameter, |
| b. 25mm diameter, | e. 50mm diameter, |
| c. 32mm diameter, | |

4.2.2 MS Conduits

4.2.2.1 Surface

Providing and fixing of MS conduit pipes includes bends and circular boxes including painting. The MS conduit pipe shall run whether in horizontal or vertical position as required. It should be rigidly fixed on the wall surface with conduit saddles of thickness 24 SWG for sizes up to 25mm and 20 SWG for pipe sizes from 32mm to 50mm at the spacing of not more than 100cm. However, saddles have to be provided at the end of the pipes if bends and circular boxes are used. The saddles are to be rigidly fixed on the wall with wooden screws of sizes 50mm long for stone masonry wall surface and 35mm for brick wall surface, screwed in PVC sleeves of appropriate size. The holes for PVC sleeves have to be drilled by motor drills using appropriate size bits. In case of conduits laid on the wooden surface, the screws of 25mm length shall be directly screwed and no sleeve is required.

All conduit works shall be finished by filing the sharp edges and providing bushings and jam nuts from inside and outside the junction boxes, switchboards and DBs/SDBs where the wiring terminal ends from the pipe. Threading has to be provided at the pipe edge up to 20mm.

4.2.2.2 Concealed

Providing and fixing of MS conduit pipe of specified gauge as indicated against the sizes mentioned hereunder, run whether in horizontal or vertical position as required. It should be embedded in the wall up to depth from 16mm to 25mm from the finished plaster level. Where applicable, the pipe has to be secured by binding wire tied on the nail to hold it till the plastering sets to its strength. In case of the pipes laid in RCC works, it has to be tied securely by binding wire to the external reinforcement bars and should be flushed in the ceiling surface. Laying pipe diagonally can be permitted in the brick/stone masonry wall, provided there is no crossing with other pipes or change in direction.

4.2.2.3 Providing Earth Continuity Wires

The earth continuity wire shall be provided throughout the length of wiring. The size of earth continuity wire shall be not less than 1.5 sq.mm (16SWG) and 2.5sq.mm (14SWG) bare copper wire for light and power circuit respectively. All metallic parts, switchboards, light fittings and power sockets shall be connected to the earth wires and the connection shall be electrically and mechanically sound.

4.2.2.4 Conduit size and Measurement

The length of MS conduit pipe shall be available from 2.5 to 3metres. The unit of measurement shall be in metres and measured to the nearest cm. The diameter and thickness in SWG of the MS conduit pipe are given here below:

- | | |
|--------------------------------|---------------------------------|
| a. 20mm diameter x 18SWG thick | d. 40mm diameter x 14 SWG thick |
| b. 25mm diameter x 16SWG thick | e. 50mm diameter x 14 SWG thick |
| c. 32mm diameter x 14SWG thick | |

Providing & fixing MS conduit pipes include bends and circular boxes including painting. The unit of measurement shall be in metres and measured to the nearest cm.

4.2.3 Steel Conduits

4.2.3.1 Surface

Providing and fixing of surface steel conduit pipes includes bends and circular boxes. In the areas of aesthetic concern, stainless steel conduit pipe shall be provided. When surface steel conduit is provided, steel saddle of thickness 24SWG or base holder with coupler as applicable shall be used to match the looks. The steel saddles or base holders shall be provided at the spacing of not more than 30cm. The saddles have to be provided at the end of the bends, circular boxes and tees. The saddles are to be rigidly fixed on the wall with wooden screws of sizes 50mm long for stone masonry wall surface and 35mm for brick wall surface, screwed in PVC sleeves of appropriate size. The holes for PVC sleeves have to be drilled by motor drills using appropriate size bits. In case of conduits laid on the wooden surface, the screws of 25mm length shall be directly screwed and no sleeve is required.

4.2.3.2 Providing Earth Continuity Wires

The earth continuity wire shall be provided throughout the length of wiring. The size of earth continuity wire shall be not less than 1.5 sq.mm (16SWG) and 2.5sq.mm (14SWG) bare copper wire for light and power circuit respectively. All metallic parts including the pipes, switchboards, light fittings and power sockets shall be connected to the earth wires and the connection shall be electrically and mechanically sound

4.2.3.3 Conduit size and measurement

The length of PVC conduit shall be available from 2.5 to 3metres. The unit of measurement shall be in metres and measured to the nearest cm. The standard lengths available are from 1.8 to 3m. The diameters shall be:

- | | |
|-------------------|-------------------|
| a. 20mm diameter, | d. 40mm diameter, |
| b. 25mm diameter, | e. 50mm diameter, |
| c. 32mm diameter, | |

Providing & fixing Steel conduit pipes include bends and boxes, etc. The unit of measurement shall be in metres and measured to the nearest cm.

5- INTERNAL WIRING PRACTICES

5.1 Circuit wiring

Circuit wiring shall mean portion of wiring from the distribution board to the switchboard. Where the circuit wiring is looped to more than one switchboard, such wiring shall be considered as circuit wiring and the wire size should remain the same. The measurement of the circuit wiring shall be on linear basis and the unit shall be in metres.

5.2 Sub-main wiring

Submain wiring is the wiring from outgoing terminal of the main/power distribution main bus-bars to the distribution switchgears. The measurement of such circuit wiring shall be on linear basis and the unit shall be in metres.

5.3 Power distribution mains wiring

In the large building/premises where the provision of main and submain switchgears alone is not feasible, the power distribution main needs to be provided. The wiring of such main shall be from the out-going terminal of the main control panel busbar to the incoming terminal of the power distribution main switch. The measurement of such circuit wiring shall be on linear basis and the unit shall be in metres.

5.4 System of wiring and loads

When the connected load of the building or premises exceeds more than 12KW, three-phase wiring shall be carried out. Lighting circuit (6 ampere) and power circuit (16 ampere rating) shall be separated from the distribution board in all types of wiring. Connected load of the circuit shall be equally distributed. In case of three phase wiring, balancing of load among the phases shall be carried out as equally as possible. Due consideration shall be given for neatness, good appearance, safety and electrically and mechanically sound connections.

There shall not be more than 8 points and the load shall not exceed more than 800Watts on one particular lighting circuit controlled by a 6A MCB. Individual 16A MCBs shall be provided for every power socket.

5.5 Joints & looping back

The wiring shall be done in the “Looping system”. Phase or live conductors shall be looped at the switch box and neutral conductor can be looped from the light, fan and socket outlet points. Where joint box is required due to unavoidable situation, mechanically and electrically sound connector shall make all joints in suitable and proper junction box. In

both systems of wiring no bare or twist joints shall be made. In through run of cables, if the length of final circuit, sub-main is more than the length of the standard coil, joints shall be made by means of approved connectors in suitable junction boxes. The brass connectors are suitable for the mechanical and electrically connections.

5.6 Passing through wall

When wiring cables are to pass through walls, care shall be taken to see that the wires pass very freely through protective (PVC/steel) pipe or porcelain tube of suitable size, and that the wires pass through in a straight line without any twist or cross in them on either end of such holes. The ends of metallic pipes shall be neatly bushed with porcelain, PVC or other approved material.

5.7 Passing through floor

While passing through the floor or ceiling, care shall be taken to protect the conductor from mechanical damages. In order to protect from such damages, a solid pipe without any joint and bend shall be provided with bushes at both ends. Providing inspection box at both ends can enable easy drawing of wire.

All floor openings for carrying any wiring must be suitable sealed after installation.

5.8 Bunching of Cables

Cables carrying direct current may, if desired be bunched whatever their polarity, but cables carrying alternating current, if installed in metal conduit shall always be bunched so that the outgoing and return cables are drawn into same conduit. Should the bunching of return wire not be possible, the pipe shall be properly bonded with the earth wire.

6- POINT WIRING

Point wiring shall include all works necessary for complete wiring of length up to 10m, including switch and circuit up to termination point as described below:

- a) Lamp holder (includes the holders also in case of angle and batten points).
- b) Pendant/fans/call bell points (up to and including ceiling rose)
- c) Socket outlet (in case of light socket outlet point and includes a socket outlet).

The above applies to surface or recessed/concealed wiring of all types as required.

6.1 Measurement of point wiring

Based on the lengths of wiring, points are classified as under:

Short point	:	Length of point not exceeding 3m.
Medium point	:	Length of point exceeding 3m but not exceeding 6m.
Long point	:	Length of point exceeding 6m but not exceeding 10m

The length of point exceeding 10 shall be measured on linear basis

7- BOXES (SURFACE/RECESSED)

7.1 Wooden, PVC and Steel boxes

Wooden boxes (hard wood), PVC boxes and steel boxes are normally available readymade in the following sizes. While wooden and PVC boxes are normally used for surface wiring, steel boxes can be used for surface as well as recessed wiring.

Table 5: Size of boxes

Hard wooden boxes	PVC boxes		Steel boxes
	without shutter	with shutter	
4" x 4" x 2 ¹ / ₂ "	31 x 86 x 20 mm	31 x 86 x 20 mm	31 x 86 x 20 mm
6" x 4" x 2 ¹ / ₂ "	86 x 86 x 20 mm	86 x 86 x 20 mm	86 x 86 x 20 mm
8" x 6" x 2 ¹ / ₂ "	86 x 86 40 mm	86 x 86 40 mm	86 x 86 40 mm
10" x 8" x 2 ¹ / ₂ "	146 x 86 x 40 mm	146 x 86 x 40 mm	146 x 86 x 40 mm

7.2 MS Boxes

MS boxes are normally available in market in the sizes given below. 4 mm thick fibre sheet cover (Backlite) shall have to be provided. Such boxes are used for surface as well as recessed wiring.

- a. 60 x 60 60 mm
- b. 75 x 75 x 60 mm
- c. 150 x 150 x 60 mm
- b. 180 x 100 x 60 mm
- c. 200 x 125 x 60 mm
- d. 200 x 150 x 60 mm
- e. 200 x 150 x 100 mm
- f. 200 x 250 x 100 mm
- g. 200 x 300 x 100 mm
- h. 250 x 300 x 100 mm
- i. 300 x 380 x 100 mm
- j. 300 x 450 x 100 mm

8- FITTINGS, ACCESSORIES AND APPLIANCES

8.1 Fittings

The fittings can be classified as consumer's luminaries, rails, industrial fluorescent luminaries, integral high way luminaries, non integral highway luminaries, wall fixtures, well glass fittings, luminaries for hazardous areas, bulkhead, indoor decorative fittings (surface/pendent) , mirror optics (surface, pendent and recessed mounted) Modulus fittings HF ballast fittings, street light fittings, environmental light fittings, flood light fittings Accent lighting fittings, low and normal voltage lighting tracks with spot light fittings. These fittings are available in the range of PL lamp, florescent lamp, GLS lamp, argent lamp, reflector lamp, mercury vapour lamp, sodium vapour lamp and metal halide lamp of various voltage/wattage ratings.

8.2 Lamps

a) *Incandescent Lamps*

Incandescent light bulb shall consist of a coiled tungsten filament that glows (incandesces) when electric current passes through it. The filament shall be encapsulated in a glass bulb with an inert gas to prevent the filament from burning quickly. The glass bulb shall be set into a metal cap (BC/ES) with one electrical contact being the threads and the other being a small protrusion on the bottom. They shall be of lifetime 750 to 1500 hours and shall be dimmable. They shall be of the following types:

GLS Clear/Pearl/Argenta: GLS Clear/Pearl/Argenta shall be of tungsten filament for general lighting services with advantages of instantaneous light, low installation costs and warm color tone for a wide variety of interior/exterior lighting applications. They shall be of good colour, appearances, instantaneous operation and suitable for dimming. The ratings of such lamps are: 25, 40, 60, 100, 150, 200, 300 and 500 watts (W).

Argenta Super lux Lamps: Argenta Superlux Lamps shall be of distinctive mushroom shape specially designed to provide around 30% more light on the working plane. These are used in intricate tasks like on lathes and work benches in workshops, for needle work, on reading table, etc. for high intensity local lighting, and in shops, show-windows and for indoor games on card tables, carom board, etc. The rating of such lamps is: 40 and 60 Wattage (W).

Special Incandescent Lamps (Pygmy, Candle, Night/Decoration and Clear): Special Incandescent Lamps (Pygmy, Candle, Night/Decoration and Clear) shall be clear, frosted or coloured version depending on type. These shall be of low-level illumination with minimum power consumption for applications in bedrooms, decorative lighting effects, signboards, Refrigerator lighting, and indicating lamp etc. The rating of such lamps are 15 Watts (W) Clear, Night, Coloured and pygmy and 25 Watts (W) Decoration Candle.

b) *Reflector Lamps*

The Reflector Lamps are intended to give directional light with substantially higher level of illumination against normal incandescent lamps of comparable wattage. These shall be with satin frosted front finish and high efficiency internal mirror reflector to achieve high intensity homogenous beam. The ratings of reflectors lamps 60W, 75W, 100W, 150W and 250W.

c) Spotlighting Colour Lamps

Spotlighting colour lamps shall have silicon lacquer coating in different colours and shall provide a wide beam for creating distinctive lighting effects. Such lighting effect is generally required for security, patrolling and inspection purposes. The ratings of such lamps are 40w, 50w and 60w.

d) Infrared Heat Lamps

The Infrared heat lamps shall provide controllable Infrared radiant energy for a convenient, simple, safe, clean and easy method of heating for industrial, agricultural and other professional and domestic applications. The wattage shall be of 250W.

e) Halogen Lamps

Halogen Lamps have halogen vapour inside the lamp to create a regenerative cycle intended for higher efficiency, better colour of light and longer life. These shall be provided with low voltage halogen burner, optically positioned in a glass reflector which has special heat transmitting and light reflecting diachronic coating, with an integral front glass cover. These shall be characterized by their crisp white light, a colour temperature of around 3000K and a colour-rendering index approaching 100. The wattage of such lamp is 20w and 50W. The Capsule Halogen Lamps shall be single ended or double ended, extra low voltage halogen lamp with a quartz glass clear envelope provided with a standardized base. The wattage of single ended shall be of 12w and double ended shall be of 100w, 150w, 200w, 300w, 500w, 750w and 1000w depending up on types like compact, small or large.

f) Compact Fluorescent Lamps (CFLs)

The compact fluorescent lamps are intended to be energy-efficient, long lasting with significant versatility and cost saving advantage over alternate light sources. They shall be of the same technology as linear fluorescent tubes but shall be smaller and shall often be integrated with ballast. Some other type shall have a screw base identical to conventional incandescent lamps. So, the compact fluorescent lamp shall be in two categories. i.e. Retrofit type: This type can directly can replace ordinary bulbs like GLS 25W, 40W, 60W, 100W, etc. Non-Retrofit type: This type requires special luminaries with built-in ballast.

The CFLs shall have the features like high efficiency, low wattage and Tri band Phosphors. It shall be compact, light in weight and consist of narrow fluorescent tubes. The Non-Retrofit shall have standardized base with two or four pins depending on the design. The geometric of CFLs available are: twin tubes, quad tubes, F-lamps, circular, and double-D lamps. They shall have lifetime up to about 10,000 hours.

g) Fluorescent Lamps

These are usually available in lengths of 0.61m and 1.22m. The tubes are usually coated inside with fluorescent materials and the colour of light given out by the tube depends on the fluorescent material used. The powder used as fluorescent material is activated by the ultraviolet rays generated in the tube. The popularity of these tubes in the daily lives is due to the reason that they have higher luminous efficiency as compared with the normal filament lamps, operate at low temperature, and have no glare.

It shall not have black ends over life due to Anode Ring. The current ratings of the lamp are 0.37, 0.44 and 0.68A and wattage ratings are 18, 20, 36, 40, 58 and 65W. Linear fluorescent lamps shall vary from 2 feet to 5 feet in length, and from 5/8 to 1-1/2 inches in diameter. They shall have a lifetime of 10,000 to 20,000 hours.

h) High Intensity Discharge Lamps (HID lamps)

The type of lamp for high intensity discharge (HID) light are Mercury vapour lamps, Metal Halide lamps and Sodium Lamps. They shall require ballast similar to fluorescent lighting. The rating of HID lamps ranges from 35 to 2000 watts. The lamp has a lifetime of about 10,000 to 24,000 hours and shall not normally be dimmable.

Mercury vapour lamps: Mercury vapour lamps shall have quartz discharge tube enclosed in an internally phosphor coated outer shell and have universal burning position. It shall have high luminous efficacy; short run-up time and light output shall not be affected by temperature variations.

Metal Halide Lamps: Metal Halide Lamps shall have excellent colour rendering, crisp white light, high lumen output and high efficacy. The nucleus of the Metal halide lamp shall be the discharge tube manufactured from quartz. The discharge tube shall contain metal compounds, which have the effect of increasing the intensity of radiation in the three spectral bands: blue, green and yellow-red. The discharge tube shall be enclosed in an outer bulb with a fluorescent coating.

Sodium Lamps: High-pressure sodium vapour lamps shall be with a polycrystalline translucent Aluminium Oxide discharge tube enclosed in an outer glass envelope. The outer shell shall be internally coated with a uniform layer of diffusing powder applied electrostatically. The discharge tube shall contain an amalgam of mercury and sodium along with Xenon gas as starting aid. They shall have very short run-up time and rapid re-strike time, excellent lumen-maintenance, and high efficacy.

Low-pressure sodium vapour lamps shall be with a discharge tube enclosed in a clear tubular bulb. They shall attain the highest luminous efficacy of any light source in the world. The discharge tube shall be made of special non-staining glass and the clear outer bulb shall be coated with an internal indium oxide layer. Low pressure sodium lamps shall have high visual acuity, sharp contrast, low luminosity, little glare and instant re-ignition at 190V and higher.

Blended light lamps shall not require any control gear. They shall have outer envelope coated with phosphor to give good colour radiation, shall have high luminous efficacy, and internal tungsten filament shall act as ballast.

8.3 Luminaries

8.3.1 Indoor Luminaries

8.3.1.1 Home lighting Luminaries

The luminaries for the fluorescent lamps shall comprise of:

- Channel made of CRCA sheet steel painted white, complete with electrical accessories like polyester filled copper wound ballast, especially designed lamp holder and starter holder with starter, all pre-wired upto a terminal block.
- Lamp holder brackets accommodating click-fix lamp holder shall be made of sheet steel finished in stove enamelled white. These shall be fixed at two ends.
- The copper wound ballast mounted on the channel of Copper star shall be provided with specifically designed connector, which has a provision for the main input.

The luminaries shall be suitable for fixing on the wall/ceiling or suspension mounting with a conduit. The surface mounted and recessed luminaries suitable for Compact fluorescent lamps used in halls, corridors, staircase landings, offices and similar areas shall consist of a housing suitably painted. The housing shall accommodate an aluminium reflector, ballast, lamp holder and earthing terminal. The luminaries shall also be fitted with a suitable screening device.

The table lamp shall consist of a base, an adjustable arm and an adjustable lamp unit. The base shall accommodate the ballast and also a balancing weight for enabling standing. The lamp unit shall house the lamp holder and a reflector. Each luminary shall be provided with an on-off switch. The lamp shall have glare free shade.

8.3.1.2 Luminaries for Commercial areas

The objective of lighting in commercial indoors is to create an optimum ambience combined with high efficacy; good glare protection and maximum comfort.

The commercial luminaries suitable for fluorescent lamps shall comprise of:

- mounting rail incorporating all accessories such as polyester filled copper wound ballast, click-fix lamp holder, power factor improvement capacitor duly wired upto a terminal block.
- a frame assembly comprising two side panels painted white, two end plates made of high impact polystyrene. The entire assembly shall be mounted on specially designed lamp holder brackets.
- a structured louver assembly shall provide for effective screening of the lamp in longitudinal and transverse directions.

The decorative recess mounted luminaries with flexibility in the choice of screening devices for various applications shall comprise of a sheet steel housing containing all accessories pre-wired upto the connector block and a louver/diffuser with a metal frame which shall be provided with mechanisms for fixing onto the housing. The luminaries shall be suitable for pendent or ceiling mounting. The pendant type shall be provided with two knockouts suitable for 19mm conduit.

8.3.1.3 Luminaries for decorative and accent lighting

The decorative recess mounted luminaries with flexibility in the choice of screening devices for various applications shall comprise of a sheet steel housing containing all accessories pre-wired up to connector and a louver/diffuser with a metal frame which shall be provided with mechanisms for fixing onto the housing. The fittings shall be suitable for surface/pendant mounting.

The decorative and accent lighting fixtures are basically same as commercial lightings. The difference is: the decorative and accent lighting fixtures are provided with reflector and it can be mounted surface, pendant, semi-recessed, recessed and down lighter suitable for use with fluorescent lamp, compact lamp, reflector lamps incandescent lamps. The fitting shall be provided with a pair of mounting clips for easy installation as per choice and the design of the fitting at site. The fitting shall consist of a ceiling ring made of suitable material, painted white in colour. A connector system made of glass-filled nylon shall be provided for cable termination. The fitting shall also be provided with an adjustable swivelling unit for adjusting lamp direction in the vertical plane.

Wall mounted decorative luminaries suitable for use with Compact fluorescent lamps shall consist of a housing made of mild steel, which is suitably painted. The housing shall accommodate ballast, connector, lamp-holder and an earthing terminal. An acrylic diffuser shall help to curb the direct glare from the lamp.

Surface mounted luminaries suitable for use with CFLs shall consist of a housing made of mild steel, and suitably painted. A mirror system shall be fixed into the housing for directing light onto the working plane. The optical plane shall have a set of transverse louvers for limiting glare.

8.3.1.4 Luminaries for Industries uses

Industrial reflector luminaries suitable for use with fluorescent lamps shall comprise of:

- mounting channel made of CRCA sheet steel stove enamelled grey which incorporates all accessories such as copper wound polyester filed ballast (s), click-fix lamp holder, starter holder(s) and starter (s) duly wired upto the connector block. The channel shall be provided with knockouts suitable for 19mm conduit.
- a cover for channel made of CRCA sheet steel stove enamelled white, fixed by means of two knurl head screws. Stove enamelled reflector shall be installed and removed with the aid of any tool.

The luminaries for the industrial uses shall be ceiling/suspension mounted.

The closed industrial luminaries suitable for fluorescent lamps shall consist of housing made of CRCA sheet steel painted grey with gasket, stainless steel toggles, cable entry gland and two brackets for mounting. The gear tray made of sheet steel shall house all the pre-wired accessories. The cover shall be made of Red acrylic. The fixture shall be mounted by use of clamps provided on the canopy.

8.3.1.5 Bulkhead luminaries

Bulkhead fixtures suitable for use with GLS lamp up to 100W and compact lamps from 9 to 18W shall have a cast-aluminium, stove-enamelled painted (white inside and grey outside) housing with fixing 19mm entry holes for wall mounting, a neoprene rubber gasket and a frosted thermal shockproof glass cover. It shall be provided with locking arrangement wire guard for mechanical protection.

8.3.1.6 Indoor industrial well glass luminaries

Indoor industrial well glass fixtures suitable for GLS lamp up to 500W, mercury vapour lamp up to 125W, MLN lamp up to 160 W and sodium vapour. The fixture comprises light weight corrosion-resistant, die-cast aluminium alloy housing, a porcelain lamp-holder, pre-wired up to connector terminal inside the housing, clear heat -resistance glass cover, wire guard, with an ethyl-propylene rubber gasket and a die-cast aluminium ring. A vitreous enamelled reflector and entry hole with inner threaded suitable for 19/20mm suspended MS pipe shall be provided.

Indoor Industrial low-bay luminaire suitable for HID lamps shall have housing made of sheet steel which shall enclose a specially designed mirror system for wide distribution of light as well as good vertical illumination. Acrylic covers and wires guard shall be available as options. The mounting shall be either by chain or through specially designed bracket arrangement.

Indoors industrial high-bay and medium-bay luminaries suitable for high-pressure sodium vapour lamp and high-pressure mercury vapour lamp shall comprise of:

- a) a housing made from die-cast aluminium with low copper content offering excellent corrosion resistance painted black
- b) an eyebolt of 30mm inside diameter for suspension
- c) an eyebolt of 30mm inside diameter for suspension
- d) anodized aluminium reflector

Closed industrial high-bay and medium-bay luminaries suitable for high-pressure metal halide lamps, high-pressure sodium vapour lamps and high-pressure mercury vapour lamps shall comprise of:

- a) a housing made from die-cast aluminium with low copper content offering excellent corrosion resistance painted black
- b) an eyebolt of 30mm inside diameter for suspension
- c) anodized aluminium reflector

d) toughened glass cover assembly with safety chain

8.3.1.7 Luminaries for hazardous areas

Luminaries for hazardous areas are available in GLS, MLN and HPLN type of fixtures. But such fixture shall have flame proof features or capable of withstanding very high heat of not less than about 100°C. Such fittings are normally used in ammunition go-down, chemical laboratories, painting workshop, POL de-pot, gas go-down etc.

8.3.2 Outdoor Luminaries

8.3.2.1 Public lighting luminaries

Public lighting luminaries shall be of a very efficient optical design resulting in uniformity of lighting levels along and across the road apart from spread of light on both sides of the luminaries. Such fixture shall have to ensure complete immunity of the housing from insects and rainwater. The fixtures are available in fluorescent lamps, GLS lamp, HPLN lamp and sodium vapour lamp. The florescent lamp fixture comprises of a sheet aluminium canopy finished in stove grey, detachable CRCA sheet stove enamel white reflector, tray with pre-wired ballast(s), capacitor, starter(s), and other accessories up to the connector terminal. High transparent clear, ribbed, activity cover shall be held in an aluminium frame and secured to the canopy against a rubber gasket with hinge arrangement on one side and four toggle latches on the other side. The fixture shall be suitable for side entry mounting and shall also be supplied with top suspension arrangement if required.

Street lighting fixture suitable for sodium vapour and other HID lamps shall have a lamp compartment made of sheet aluminium and a separate ballast housing. An acrylic cover shall ensure satisfactory insect-free and ingress of water. High transparent clear, ribbed, activity cover shall be held in an aluminium frame and secured to the canopy against a rubber gasket with hinge arrangement on one side and four toggle latches on the other side.

Compact Post-Top lantern suitable for use with sodium vapour, GLS, MLN and HPL-N lamps. A cast aluminium spigot for satisfactory corrosion free performance and shall be provided with a double conical HDP/ellipsoidal/spherical or any other suitably shaped cover for satisfactory insect-free and ingress of water.

8.3.2.2 Luminaries for Environment lighting

Environmental fixture suitable for use with GLS and Compact fluorescent lamp fixtures, the housing shall be made of coloured FRP. A clear acrylic cover shall protect the housing from the immediate environment such as satisfactory performance insect-free, ingress of water and high resistant to extreme climatic condition.

8.3.2.3 Floodlighting Luminaries

Floodlighting fixture shall have a spun aluminium/cast aluminium housing for corrosion resistance, the inside of which is anodised. A glass cover shall be provided to ensure

satisfactory insect-free operation and the ingress of water. The fitting shall be suitable for GLS lamp, HPL-N lamp, SON lamp, Metal Halide lamp and Halogen lamp. The fixtures are provided with individual choke and condenser. The wattage rating of the fixture ranges from 150 to 500W. In case of halogen lamp fixture, the wattage rating is up to 2000 watts. So, each fixture shall have to be provided with individual control switches.

8.4 Accessories

All accessories such as switches, socket outlets, ceiling rose, lamp holders, call bell etc. shall be either flush mounted surface mounted as per the type of wiring. Similarly, the boxes shall be flush mounted or surface mounted. When metal box is used, it shall be efficiently earthed.

8.4.1 Switches

Switches are available in one way, two way and intermediate way. Only live wire shall be connected to the switch. 6-ampere rating switch shall be used for light, fan and 6-ampere socket outlets and 16 -ampere rating switch shall be used for 16 socket outlets. Switch shall be so connected that when the circuit is opened when button position shall be “UP” and when the circuit is closed, the button position shall be “DOWN”.

8.4.2 Lamp Holders

Lamp holders may be batten, angle, pendant or bracket holder type as required. The holder shall be made of brass and there should be sufficient threading for fixing the base to the lamp holder parts.

Lamp holders for use on brackets and the like shall have not less than 1.3 cm nipple and all those for use with flexible pendant shall be provided with cord grips. All lamp holders shall be provided with shade carriers. Where centre contact Edison Screw lamp holders are used, the outer or screw contact shall be connected to the live conductor and neutral to the earthed/neutral conductor of the circuit.

8.4.3 Ceiling Rose

A ceiling rose shall not be used on a circuit, the voltage of which normally exceeds 240 volts. Normally only one flexible cord shall be attached to ceiling rose. Specially designed ceiling roses shall be used for multiple pendants. A ceiling rose shall not embody fuse terminal as an integral part of it.

8.4.4 Socket Outlets

Plugs and socket outlets of rated voltage upto and including 250 volts and rated current upto and including 16 amperes shall conform to Indian Standards IS 1293 as revised from time to time.

A socket outlet shall not have fuse terminal as integral part of it. But the fuse may be provided which shall be non-reversible and so arranged that the fuse is connected to live conductor. Every socket outlet shall be controlled by a switch. 16 amperes socket outlet point shall normally be fixed at 25 cm above the floor level. In case of toilet and kitchen, it shall be placed at light point switch level. 6 amperes socket are normally placed at lighting point switch level. When 6 ampere rating is required at 25cm above floor level, 16 ampere socket outlets shall be replaced by 6/16 ampere socket outlet.

In a room containing a fixed bath or shower, there shall be no socket outlet and there shall be no provision for connecting a portable appliance. Any stationary appliance connected permanently in the bathroom shall be controlled by an isolator switch or circuit breaker.

The socket outlet and plug shall be of the three-pin type and the third pin shall be connected to earth. Conductors connecting electrical appliance with socket outlet shall be of flexible twin core with an earthing cord that shall be secured by connecting between the earth terminal of plug and the metallic body of the electrical appliance. The socket outlets used at 25cm above floor level shall be shutter type or interlocking type.

8.4.5 Socket outlet for call bell

Socket outlet for call bell shall be 2 pin type and not more than 6 ampere rating. When the socket is provided for the call bell, push type pendant switch is connected with a flexible wire through 2 pin plugs. Such socket is normally mounted at 25cm above floor level. When flush type switch is used for the call bell, it is normally mounted at the light point switch level.

8.4.6 Socket outlet for telephone

Socket outlet for telephone shall be 2pin, RG11 type and not more than 6 ampere rating. It is normally mounted at 25cm above floor level. The socket and line shall be minimum 0.5m away from any electrical point or wiring of 240 volts. The telephone shall be connected to the socket by telephone wires through 2pin plug.

Industrial socket outlet: Industrial socket outlets are normally used in workshop, factories and laboratories, where heavy-duty (single as well as three phase) equipment or appliances are used. It is available in 3pin for single-phase and 4pin for three-phase. The rating for single is up to 20 ampere and three -phase rating is higher than 63 amperes. In practice, using socket out rating shall not exceed more than 63 amperes. All industrial type socket outlet shall be connected through correct rating RCCB and miniature circuit breaker.

8.4.7 Attachment of fittings and accessories

In casing capping and wooden batten wiring, accessories like ceiling rose, brackets, batten holders and stiff pendants holders shall be mounted to ceiling or wall on substantial blocks of hard wood double board varnished both inside and outside including base. Blocks shall not be less than 5.5 cm deep. Fan regulators shall be mounted on well -seasoned hard wood of suitable size to accommodate the number of fittings. The board shall be well varnished on all sides, both inside and outside, irrespective of being painted to match the surroundings.

The board shall be divided into two sections, one for the switches, which shall be flush mounted, and the other for mounting regulators with suitable screws.

In case of conduit wiring, all accessories like switches, socket outlets, call bell pushes and regulators shall be fixed in flush pattern inside metal boxes conforming to relevant standards. Accessories like ceiling roses, brackets, battens, stiff pendants etc. shall be fixed on metal outlet boxes which shall be bonded to earth wires.

8.5 Appliances

8.5.1 Ceiling Fans

Ceiling fan including their suspension shall conform to IS: 374:1979. All ceiling fans shall be wired, ready for connection to ceiling roses and to suspend on hooks. There shall be no joints in the suspension rod. For wooden joists and beams, the suspension shall consist of M.S. flat of size not less than 40mm x 6mm. For secure suspension of ceiling fan, the flat shall be projected above the beam or joist by about 30mm and either bend to "L" inward or a through-bolt of size not less than 16mm diameter shall be placed above the beam. In either case, the flat shall be secured on the sides of the joists or beams by means of two coach screws of size not less than 5 cm for each flat to prevent from movements. A hook consisting of M.S. rod of size not less than 16mm diameter shall be inserted between the MS flat through oval holes on their sides for the suspension of ceiling fan.

In the case of 'I' beams, flats shall be shaped suitably to hold the flanges and shall be held together by means of a long nuts & bolts. For concrete roofing or ceiling, ceiling fan hooks shall be made of MS rod of size not less than 16 mm diameter. The shape of the hook can be made like an inverted 'U' of width not more than 1.5cm. Both vertical legs shall be bent horizontally at the outward up to length of 19cm. The height of the hook from the bend shall not be more than 18cm and 13cm shall be projected outside the finished ceiling.

In building with concrete roofs having a low ceiling height i.e. less than 2.5m, ceiling fan shall not be used. If the ceiling permits to recess the fixture, fan with suspension clamp shall be recessed in the ceiling and the clearance from the floor shall not be less than 2.5m. In normal cases, fans shall be hung 2.75m above the floor. There shall minimum clearance between the blade of fan and the ceiling of not less than 23cm. Alternatively, wall fan, cabin fan and pedestal fan be used if the recessed type erection is not feasible.

The point of fan shall be provided as near as possible to the hook. The connection shall be made with flexible cord, coloured red, black and green. The green core shall be connected to the earth terminal. Care shall be taken that the blades rotate in the proper direction.

8.5.2 Exhaust Fans

Exhaust fan shall conform to IS: 2312:1967. The purpose of exhaust fan is to circulate the air i.e. evacuation of unhealthy air and to inlet the fresh air to and from the atmosphere. Such fan is required to be provided in places like: bath room, public toilet, kitchen, workshop, chemical laboratory, go-down and community hall etc.

For fixing an exhaust fan, a circular hole shall be provided on the wall to suit the size of the frame at suitable height below the beam or ceiling and above the lintel level. The hole shall be neatly plastered to the original finish of the wall. The point of exhaust fan shall be provided as near possible to the hole for fixing the fan. The connection shall be made with 3 core, coloured red, black and green. The green core shall be connected to the earth terminal. Care shall be taken that the blades rotate in the proper direction.

The exhaust fan shall be so erected that the blade lies in centre of the wall. Protective wire mesh or any other device shall be provided within the surface of the outside wall. To prevent from corrosion effect, the fan shall be painted with special PVC paint or chlorinated rubber paint.

8.5.3 Fan Regulators

Use or all the fan regulators shall be power saving-oriented example: electronic regulators rated to 300W. The resistance type regulators shall not be preferred for regulating the fan speed due to big space required and high energy consumption during slow running. Besides less power consumption, electronic regulators are usually compact, good looking and easy to fit on small boxes.

8.5.4 Immersion Water Heater and Geyser

Bare heater coil shall not be used in place of immersion water heater. Any type of immersion water heating element shall have minimum initial resistance of not less 40 ohms, power rating of not more than 1000 Watts. The connection of immersion heater shall be made with 3 core, steel and cotton braided flexible cord of size not less than 4sq. mm copper wire. Connection to the socket outlet shall be made by 16 ampere 3 pin plug and third shall be connected to earth wire. Outer insulation rubber, steel and cotton braiding shall be well inside the plug and tightened properly to prevent excessive tension to the connecting terminals.

In case of geyser, the power rating shall not exceed more than 2000Watts. Where ever possible, the geyser shall be placed outside the bathroom. If erected inside the bathroom, care shall be taken to locate at suitable height to avoid touching by the children. The geyser shall be provided with a thermostat and indicating lamp. The connection shall be made with 3 core, steel and cotton braided flexible cord of size not less than 4sq. mm copper wire. Connection to the socket outlet shall be made by 16 ampere 3 pin plug and third shall be connected to earth wire. Outer insulation rubber, steel and cotton braiding shall be well inside the plug and tightened properly to prevent excessive tension to the connecting terminals.

8.5.5 Electric Stove

The power rating of electric shall not exceed more than 2000 watts. Should the rating require to exceed 2000 watts but not exceeding 5000 watts, the wiring shall be carried out with minimum 6 sq.mm, 1.1kV grade, copper wire. Under such condition of wiring, it shall be connected directly to separate distribution mains through earth leakage (RCCB) as well as over current (MCB) protective devices of not more than 32 ampere rating. The connection shall be made with 3 core, steel and cotton braided flexible cord of size not less than 6sq. mm copper wire. The cooking appliance shall be securely connected to earth terminal of not less than 4 sq.mm or 12SWG bare copper conductor. Both phase and neutral wire shall have insulation resistance of not less than 1 mega-ohm.

8.5.6 Room Heater

Power rating of room heater shall not exceed more than 2000 watts. A switch of rating not less than 16 amperes shall be provided as an integral part of the appliance. The connection shall be made with 3 core, steel and cotton braided flexible cord of size not less than 4sq. mm copper wire. Connection to the socket outlet shall be made by 16 ampere, 3 pin plug and third pin shall be connected to earth wire. Outer insulation rubber, steel and cotton braiding shall be well inside the plug and tightened properly to prevent excessive tension to the connecting terminals.

8.5.7 Air Cooler and Refrigerator

Power rating of air cooler and refrigerator shall not exceed more than 2000 watts and 100watts respectively. A switch of rating not less than 16 amperes, thermostat and indicating lamp shall be provided as an integral part of the appliances. In case of air cooler, a selector- switch for low, medium and high shall also be provided. The connection shall be made with 3 core, steel and cotton braided flexible cord of size not less than 4sq.mm copper wire. Connection to the socket outlet shall be made by 16 ampere, 3-pin plug and third shall be connected to earth wire. Outer insulation rubber, steel and cotton braiding shall be well inside the plug and tightened properly to prevent excessive tension to the connecting terminals.

8.5.8 Electric iron, rice/curry cooker and water boiler vacuum cleaner, drier, iron, mixture m/c.

Power rating of electric iron, rice/curry cooker, water boiler, vacuum cleaner, drier, and, mixture shall not exceed 1000W. Separate switch of 6/16 ampere rating and indicating lamp shall be provided as an integral part of the appliances. In case of cooker and boiler, bimetallic operated auto off switch with cook/warm or boil warm indicating lamp are normally provided. The connection shall be made with 3 cores, flexible cord of size not less than 2.5sq.mm copper wire. Connection to the socket outlet shall be made by 6/16 ampere, 3-pin plug. Outer insulation rubber shall be well inside the plug and tightened properly to prevent excessive tension to the connecting terminals.

8.6 Light Emitting Diode (LED)

A light-emitting diode (LED) is a semiconductor light source that emits light when current flows through it. Electrons in the semiconductor recombine with electron holes, releasing energy in the form of photons. The colour of the light corresponding to the energy of the photons is determined by the energy required for electrons to cross the band gap of the semiconductor. White light is obtained by using multiple semiconductors or a layer of light-emitting phosphor on the semiconductor device.

LEDs are current driven devices and the level of light is a function of the current - increasing the current increases the light output. It is necessary to ensure that the maximum current rating is not exceeded. This could give rise to excessive heat dissipation within the LED chip itself which could result in reduced light output and reduced operating lifetime.

Note: For the conventional lighting fixtures, a circuit is determined by the maximum wattage of 800 watt but for the LED lighting circuit is restricted by the maximum numbers of luminaires upto 10.

In a LED circuit, it is recommended to select C-type of MCBs, as it is designed to trip at currents between five and ten times their rated load.

9- CABLES

9.1 Cable Types and Classification

All cables shall conform to IS: 694 as revised from time to time. Conductors of all cables shall be of copper or aluminium. The smallest size of conductor for the final circuit shall have a nominal cross-sectional area of not less than 1.5 sq. mm. The minimum size of cables for power point wiring shall be 4 sq.mm. Types of cable are unsheathed, sheathed copper or aluminium conductors, and can be classified as follows:

a) House wiring cables

House-wiring cable shall conform to IS 694. House wiring cables are available in single core as well as twin core. Conductor of house wiring cable shall be made of aluminium as well as copper. The size of aluminium house wiring ranges from 1.5 sq.mm to 6sq.mm. The size copper house wiring ranges from 1 sq.mm to 6 sq. mm.

b) Flexible cables

Flexible cable shall conform to IS 694. Conductor of flexible shall be made of copper and tinted copper with minimum cross section area up to 0.5sq.mm. Flexible cables are multi-stranded of cross-section area of the strand ranges from 0.2 to 0.5sq.mm. Flexible cables are normally armoured with steel braiding, tough rubber or PVC sheath protected. Unless the flexible cables are protected by armour, tough rubber or PVC sheath, it shall not be used in workshop and other places where they are liable to mechanical damage. Three core flexible cables shall be used for connecting single-phase appliances. The insulation rubber of the core shall normally be colour with red, black and green, denoting for phase, neutral and earth wire respectively.

c) Power cables

Cable for application of low and medium voltage supply are PVC insulated, PVC sheathed, steel wire/strip armoured and non-armoured conforming to IS 1554, part I, 1964. Power cables are available in single core, 2 cores, 3 cores, 3.5 cores and not more than 4 cores. The size ranges from 2.5 to 630 sq.mm for more than one core and 2.5 to 1000 sq.mm single core. Voltage grade for low voltage cable shall be not less than 1.1kV. Cable is manufactured with aluminium conductor as well as copper conductor. Steel wire or strip used for armouring shall be galvanised. The armouring at both end of the cable shall be connected to earth electrode and length of single core cable run shall not exceed 30m.

d) High voltage cables

Cable for application of high voltage supply is paper insulated, XLPE insulated, oil or gas filled, conforming to IS 692, 1962 as revised from time to time. Cable is normally steel wire/strip armoured or lead sheathed. High voltage cable is available in single core, 2 core, 3 core, 31/2 core and not more than 4 cores. The size ranges from 25 to 630 sq.mm for more than one core and 2.5 to 1000sq.mm single core. Voltage grade for 11kV cable shall be not less than 28kV and 33kV shall be 78kV. Cable is manufactured with aluminium conductor as well as copper conductor. Steel wire or strip used for armoring shall be galvanised. The armoring at both end of the cable shall be connected to earth electrode and length of single core run shall not exceed 10m.

9.2 Cable Size Selection

Cable size shall be selected in accordance with the current carrying capacity, voltage drop, fault current level and the provision for future demand. The selection of cable can also be guided by current rating based on total load considering the future demand as per IS 3961 (part I & II) - 1967, IS 5819- 1970 and 1255-1967. The voltage drop at the dead end or final end shall not be more than 5% regulation or within the limits recommended by IS 732 – 1963. While deciding cable size, the derating factor for type and depth of laying, bunching, ambient temperature, ground temperature and soil resistivity shall be taken into account.

The Building Code of Bhutan (Part II- Building Services)- 2003 can be referred for cable selection guideline charts.

9.3 Cable Storage and Handling

Cable drums shall be store in well drained, hard surface preferably concreted floor so that the drum do not sink in the ground causing rot and damage to the cable drums. It shall be ensured that both ends of the cables are properly sealed to prevent ingress or absorption of moisture or water in the insulation and the cable. The cable shall be store under the roof with proper ventilation to adequately dehumidify the store yard.

During storage, periodical rolling of drum up to 90⁰ shall be done once in three months. The rolling shall be done as per direction of arrow shown on the drum. Cable drums are preferred to be stored on the flanges and not on the flat surface.

When cable drums are required to be shifted to a short distance, it shall be rolled in the direction of arrow indicated on the drum. For transportation over long distance, a shaft shall be inserted in the cable drum hole, tighten with steel rope and use the crane to load and unload the cable drums. Alternative, when the crane is not available, drum shall be rolled carefully by ensuring that the surface material do not damage the cable and using hard wooden battens for loading and unloading.

The cable shall not be bent sharp. Minimum bending radius shall not be less than 15 times its diameter.

9.4 Cable Installation

Prior to laying the cable, proper right off route shall be confirmed. Simultaneously, clearance shall have to be taken from the following authorities.

- a. Municipal Corporation to avoid sewerage and water pipeline.
- b. Telephone and telegraph authorities.
- c. Civil aviation authorities,
- d. Gas pipe line,
- e. Other under takings and
- f. Private land holding owners.

Cable with kinks and straightened kinks or with similar apparent defects, like defective armouring etc. shall not be installed. Cable stored precariously without any proper cap and storage shall be tested properly before installation. Cable run rout shall be as short as possible. However, cross country shall not be permitted to take the shortest rout. The cable running rout shall follow fixed developments such as: parallel to roads, footpaths and water supply line etc. Route identification marks shall be maintained and proper drawing shall be kept in proper custody for future maintenance.

While selecting cable line routs, corrosive soils such as ground surrounding sewerage effluent etc shall be avoided. Where, avoiding corrosive soil is not possible, adequate precaution shall be taken to install the cable. As far as possible, effort shall be made to run the cable of different voltage level in the same trench but in different tray to minimise the cost of laying the cables. When the cable of different voltage level is laid in the same trench, the cable for the highest voltage level shall be at the down most trenches. Power and communication cable shall not run in the same trench. he crossing of power and communication cable shall be made at right angles and where power cable are laid in proximity to communication cable, radial spacing of not less than 60cm.

9.5 Cable Laying

There are four methods of laying the cables such as: buried direct in ground, in pipe, closed ducts or trench, in open duct or on surface depending on environmental conditions. The brief note on all the method and application of laying the cable is described here below.

9.5.1 Directly buried

Normally, cable is directly buried in ground in remote and less clustered settlements. Minimum width and depth of trench shall be not less than 35cm and 75cm respectively. After the cable is laid, dry sand covering of depth not less than 17cm shall be provided over the cable. Unless otherwise specified, mechanical protection over the sand covering with second class brick, stone or prefabricated slab of minimum 5cm thick shall be provided. In case of protection with the brick, it shall be laid breadth-wise i.e perpendicular to the cable. The remaining portion of the trench shall then be back-filled with excavated earth free of sharp- edged stone. The earth so filled shall be properly rammed and watered if necessary, in successive layer of not exceeding 30cm. Unless otherwise specified, a crown of earth of not

less than 100mm in the centre and tapered towards the side shall be left to allow the subsidence.

9.5.2 Laying in pipe

Cable is laid in pipe where the cable line passes through road crossing, termination to a building etc. When metallic pipe is used for mechanical protection of especially single core cable, the pipe shall be properly connected to the earth electrode by adequate size of earth continuity wire. Pipe size shall be so selected that 40% of its space is free.

9.5.3 Laying in closed duct or trench

Laying of cable in closed duct or trench is preferred in the thickly populated urban area. Construction of closed duct or trench includes stone soling, concreting, brick/stone masonry and covering with slab etc. Minimum width and depth of trench shall be not less than 35cm and 75cm respectively. When more than one cable is laid in the same duct or trench, the clearance whether vertical and horizontal shall be maintained as shown in the Table 6 given below:

Table 6: Spacing between cables

Serial No.	Voltage rating	Spacing between cables
1.	0.415kV to 11kV	40cm
2.	11 to 33kV	35cm

9.5.4 Laying on surface or open duct

Laying of cable on surface or open duct is done in workshop, large building complex, power house and switch yard, tunnel, rising mains in buildings through rock ways etc. Saddle or clip is used to fix the cable when laid on surface.

9.6 Cable Termination & Jointing

Cable termination is done with cable termination kit and cable jointing is done with straight through cable jointing box. Termination and jointing of cable shall be carried by a licensed or experienced cable jointer. At the preliminary stage of laying the cable, a proper jointing position shall be selected. Jointing pit shall be of sufficient dimension as to allow easy and comfortable working. Proper tenting with sufficient ventilation shall jointing box etc. be provided during cable jointing operation.

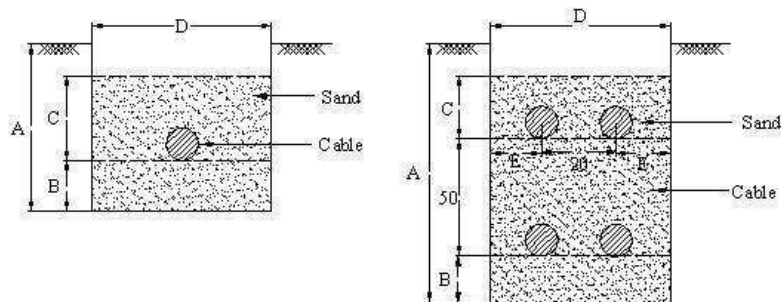
Cable jointing materials and accessories such as: conductor ferrules, solder, flux, insulating materials, protective tapes, filling compound and jointing boxes etc shall be of right quality and correct sizes conforming to relevant standard. Core of the cable have to be identified properly and jointing shall be carried out in proper sequence.

Cable termination shall be carried out by proper type and size of cable gland and termination box. Termination of cable up to 1.1kV grade shall be terminated using compression gland.

The nipple of the gland is first screwed to the switchgear to which the cable is to be terminated and locked with check nut from inside the housing. Compression ring, washer, rubber ring and another washer are slipped in succession over the cable. The cable sheath is removed to desired length and armour strands splayed out. The armour wire is then cut to the overall diameter of second washer. Sharp edges are removed and armour cleaned. a third washer is now slipped on to the trap, trimmed strands and armour between the second and third washer. The cable end is then pushed through the gland nipple. The compression ring is then tightened when the rubber ring will expand and hold the cable tight by the sheath. For the high voltage or oil filled cable joint, the termination box shall be properly sealed with cable jointing compound and there shall be no cavity or pinhole to let ingress the moisture or leakage of oil. All connection shall be done with correct rating cable socket.

Fig. 1

TYPICAL TRENCH DIMENSIONS



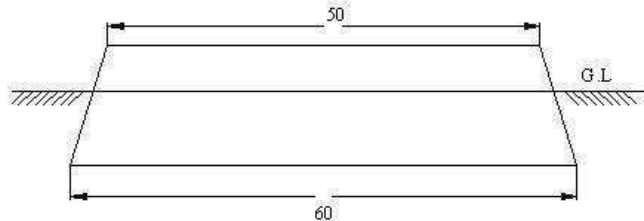
FOR CABLE OF RATING		
REF.	UPTO 1.1 kv	EXCEEDING 1.1 kv
A	75	120
B	8	8
C	17	17
D	35	35

FOR CABLE OF RATING		
REF.	UPTO 1.1 kv	EXCEEDING 1.1 kv
A	$(75 + M1 \times 30)$	$(120 + M1 \times 30)$
B	8	8
C	17	17
D	$(30 + M2 \times 20)$	$(30 + M2 \times 20)$
E	15	15

M1: Number of RDDDL Cables in Vertical Formation
M2: Number of RDDDL Cables in Horizontal Formation
Note: Values Ind icated are Minimum Values

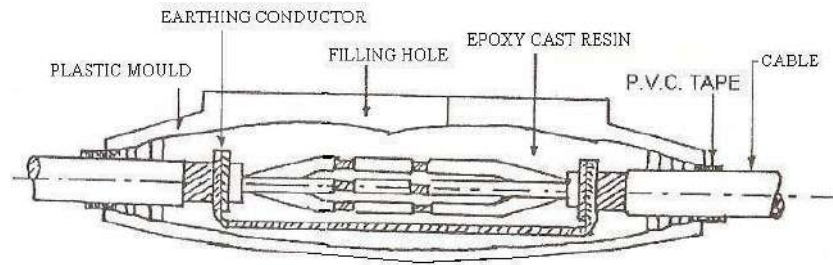
Fig. 2

CONCRETE ROUTE MARKER

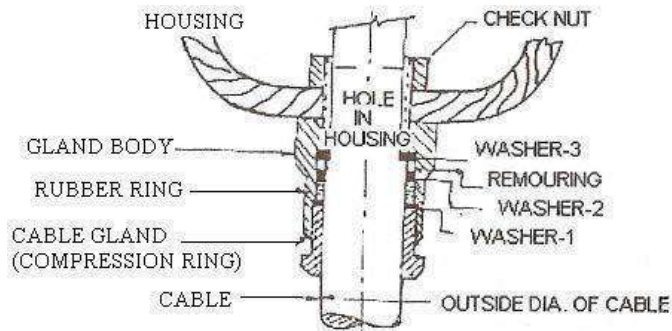


Not to Scale
All Dimensions in cm

TYPICAL EPOXY STRAIGHT JOINT FOR P.V.C CABLE



COMPRESSION TYPE – CABLE GLAND ASSEMBLY



10- CONTROL GEARS

10.1 Main Switchgears, Switchboard and their Location

All main switchgears shall be of metal clad and shall be fixed at close proximity to the point of entry of supply. Open type switchboards shall be placed only in dry situation and in well-ventilated rooms and they shall not be placed in the vicinity of storage batteries and exposed to chemical fumes. Main switchboards shall be placed installed in rooms or cupboards having provision for locking arrangement so as to safeguard against operation by unauthorized personnel. In a damp situation or where inflammable or explosive dust, vapour or gas is likely to be present, the switchboards shall be totally enclosed or made flame-proof as may be necessitated by the particular circumstances.

Switchboards shall not be erected above gas, stoves, or sinks or within 2.5 m of any washing unit in the washing rooms of laundries or in the bathrooms, lavatories, toilets or kitchen. Switchboards, if unavoidably fixed in places likely to be exposed to weather, to drip, or to abnormal moist atmosphere the outlet casing shall be weather proof and shall be provided with glands or brushing or adopted to receive screwed conduit according to the manner in which cables are run. PVC and double-flanged bushes shall be fitted in the holes of the switches for entry and exit of wires.

A switchboard shall be installed so that its bottom is within 1.25 m above the floor unless the front of the switchboard is completely enclosed by a door, or the switchboard is located in a position to which only authorized person(s) have access. Switchboard shall be recessed in the wall if so, specified in the Tender Documents. The front shall be fitted with hinged panel of wood or other suitable material such as Bakelite in wood frame with locking arrangement, the outer surface of the door being flush with walls. Ample room shall be provided at the work for connections and at the front between the switchgear mountings and the door.

Equipment, which are on the front of a switchboard, shall be so arranged that in averting personal contact with live parts is unlikely during the manipulation of switchgears, changing of fuses or like operation. No holes other than the holes by means of which the panel is fixed shall be drilled closer than 1.3 cm from any edge of the panel.

The various live parts, unless they are effectively screened by substantial barriers of non-hygroscopic, non-inflammable insulating material, shall be so spaced that an arc cannot be maintained between such parts and earth. The arrangement of the gear shall be such that they shall be readily accessible and their connections to all instruments and apparatus shall also be traceable.

In every case in which switches and fuses are fitted on the same pole, these fuses shall be arranged that the fuses are not alive when their respective switches are in 'off' position. No fuses other than fuses in instrument circuit shall be fixed on the back of or behind a switchboard panel or frame.

All the metal switchgears and switchboards shall be painted, prior to erection with coat of antirust primer. After erection, they shall be painted with two coats of approved enamel or

aluminum paint as required on all sides wherever accessible. All switchboards connected to medium voltage and above shall be provided with “*Danger Notice Plate*” conforming to the Standards.

10.2 Types of Switchboards

Metal clad switchgears shall preferably be mounted on any of the types of boards mentioned below.

10.2.1 Hinged Type Metal Boards

Such metal boards shall be suitable for mounting of metal clad switchgears consisting of not more than one switchgear and ICDB 4 way or 6 way 15 amperes per way. Metal boards shall consist of box made of sheet metal not less than 3 mm thick and shall be provided with a hinged cover to enable the board to be swung open for the examination of the wiring at the back. The joints shall be substantially welded.

Alternatively, metal boards may be made of suitable size angle iron of minimum size 35 mm x 35 mm x 6 mm or channel iron of minimum size 353 mm x 25 mm x 6mm frame work suitably mounted on front with a 3mm thick M.S. Plate and on the back with 1.5 mm M.S. sheet. In case of wood casing or wood batten systems of wiring, 2.5 cm teak wood battens may replace the top and bottom members. The front sheet shall be provided with suitable hinges to enable the board to be swung open for examination of wiring. The joints shall be substantially welded.

The boards shall be securely fixed to the wall by means rag bolts and shall be provided with a locking arrangement and earthing stud. All wires passing through the metal boards shall be bushed. There shall be a clear distance of 3 cm between the front and back sheets. More space shall be allowed whenever necessary. A wooden board of thickness not less than 6 mm may be provided at the back. No control gears shall project beyond any edge of the panel. No fuse body shall be mounted within 2.5 cm of any edge of the panel.

10.2.2 Fixed Type Metal Boards

Such boards shall be suitable for large switchboards for mounting large number of switchgears and /or higher capacity metal clad switchgear. These shall consist of an angle or channel iron frame fixed on the wall or on the floor and supported on the wall at the top. There shall be a clear distance of 1 m in front of the switchboard and a working distance of 1 m behind the switchboard.

The connections between the switchgear mounting and the outgoing cable up to the wall shall be enclosed in a protection pipe.

The detailed dimensions and design of metal boards and angle iron frame work for switchgears, including the disposition of the various mountings, which shall be symmetrically and neatly arranged for arriving at the overall dimensions shall be prepared and submitted beforehand and shall have the prior approval of the Engineer.

10.3 Marking of Apparatus

When a board is connected to voltage higher than 250 volts, all the terminals or leads of the apparatus mounted on it shall be marked in the following colours to indicate the different poles or phases to which the apparatus or its different terminals may have been connected.

A.C	D.C
Three phase: Red, Yellow, Blue	Three wired system, 2 outer wires: Red (+) and Yellow (+/equalizer), Blue(-)
Neutral: Black	Neutral: Black

Where four-wire three-phase wiring is done, the neutral shall preferably be in one colour (Black) and the other three wires in another colour (Red, Yellow and Blue).

Where a board has more than one switchgear, each such switchgear shall be marked to indicate which section of the installation it controls. The main switchgear shall be marked as such, where there is more than one main switchboard in the building, each such switchboard shall be marked to indicate which section of the installation and building it controls.

All marking required under this rule shall be clear and permanent. All distribution boards shall be marked 'Lighting' or 'power' as the case may be and also marked with the pressure and number of phases of the supply. Each shall be provided with a circuit list giving details of each circuit that it controls and the current rating of the circuit and the size of the fuse element.

10.4 Main and Branch Distribution Boards and their Location

Unless otherwise specified, main and distribution fuse boards shall be of the metal clad type. Main distribution boards shall be controlled by a Residual current circuit breaker (RCCB/ELCB). Each outgoing shall be provided with a single pole circuit breaker for lighting 6Ampere and for power circuit 12.5Ampere to 16Ampere. Linked switch fuse unit with HRC fuse or a circuit breaker shall control branch distribution boards. The earthed neutral conductor shall be connected to a common link and be capable of being disconnected individually for testing purposes. At least one spare circuit of the same capacity shall be provided on each branch distribution board.

The distribution fuse board shall be located as near as possible to the centre of the load they intended to control. These shall be of metal clad type, but, if exposed to weather or damp situations, they shall be of the weatherproof type and if installed where exposed to explosive dust, vapour or gas, they shall be flameproof type.

Where two or more distribution fuse boards feeding low pressure, circuits are fed from a supply at medium voltage, these distribution boards shall be:

- a) Fixed not less than 2 m apart; or

- b) Arranged so that two cannot be opened at a time, namely they are interlocked and the metal case is marked “danger-400 Volts”; or
- c) Installation in a room or enclosure accessible to only authorized person(s).

Single pole and neutral (SPN)/Triple pole and neutral (TPN) distribution boards shall be invariable, of single pole miniature circuit breaker (SPMCB) outgoing control.

10.5 Control at Point of Entry of Supply

There shall be linked main switchgear with HRC fuse on each live conductor of the supply mains at the point of entry. The wiring throughout the installation shall be such that there is no break in the neutral wire except in the form of linked switchgear. The neutral shall also be distinctly marked.

The main switchgear shall be situated as near as practicable to the termination of service line and shall be easily accessible without the use of any external aid. On the main switchgear, where the conductors include an earth conductor (neutral) of a two-wire system, an earthed neutral conductor of a multi-wire system, which is to be connected thereto, an indication of a permanent nature shall be provided to identify the earth neutral conductor.

Cables shall be connected to terminals only by *soldering lugs/crimping lugs with appropriate thimbles up to 200Amperes*, unless the terminals are of such a form that they can be securely clamped without cutting the cable strands. All bare conductors shall be rigidly fixed in such a manner that a clearance shall be 2.5 cm is maintained between conductors of opposite polarity or phase and between the conductors and any materials other than insulating material. In a hinged board, the incoming and outgoing cables shall be neatly bunched and shall be capable of swinging through an angle of not less than 90°. A pilot lamp shall be fixed and connected through an independent single pole switch and fuse to the bus of the board.

10.6 Bus-Bars and Bus-Bar chambers

10.6.1 Bus Bar Chambers

Bus bar chamber shall be fabricated with M.S. angles for frame work and covered all round with sheet steel of thickness not less than 1.5 mm in a box form. It shall be provided with detachable covers on all sides netted with dust excluding gasket, secured with sufficient numbers of cadmium plated iron screws to ensure that the covers are dust tight. Bus bar chambers for bus bar of more than 90 cm length shall have horizontal and vertical stiffeners welded to the main frame.

Alternatively, the bus bar chamber shall be made of steel sheet of thickness not less than 3 mm with detachable covers on all sides excluding gasket. The joints shall be continuous welded. The detachable cover shall be secured to the box with sufficient number of cadmium plated iron screws to ensure dust tightness. This type of bus bar chamber shall be restricted for bus bars upto 90cm. length. Bus bar chambers size upto 90 cm shall have detachable end covers so that the same can be extended. The bus bar chamber shall be painted with a coat of primer red oxide paint and finished with two coats of enamel paint of approved shade.

10.6.2 Bus Bars

Bus bars shall be made of copper/aluminium alloy/wrought aluminium bars conforming to IS: 4171:1983 and shall be of sufficient cross section so that a current density of 130 amperes/sq.cm is not exceeded at nominal current rating copper bus bar is not advisable of rating more than 200Ampere. The cross section of the neutral bus bars shall be the same as that of the phase bus bar of capacities up to 200 amperes, and for higher capacities the neutral bus bar must not be less than half the cross section of that of the phase bus bar. The recommended sections of bus bars are given in Table 7 below.

10.6.3 Bus-Bar Supports and Attachments

10.6.3.1 Supports

Bus bars shall be firmly fixed on supports constructed from a suitable insulated material such as Phenolic laminated sheet. Alternatively, bus bars shall be supported on insulators of suitable lengths conforming to relevant Indian Standards. The supports shall be sufficiently robust to effectively withstand electromechanical stresses produced in the event of short circuit.

10.6.3.2 Connections to Bus Bars

Connections to bus bars of ratings more than 200 amperes shall be made with clamping arrangement with bolts and nuts and for bus bars of smaller ratings, use of holes drilled into the bus bars may be made. The bolts and nuts used for connections to bus bars shall be made of aluminium alloy, tinned forged brass or galvanized iron. Suitable precaution shall be taken against heating due to bimetallic contact. Further for tapping off connections from bus

bars, PVC insulated wire may be used for current capacities upto 100 amperes and for higher current capacities solid conductors/strips suitably insulated with PVC sleeve/ tape shall be used.

10.6.3.3 Clearances

The minimum clearances to be maintained for open and enclosed indoor air insulated bus bars/electrically non-exposed and working at system voltages upto 600 volts shall be as follows:

Between	Minimum Clearances
Phase to Earth	26 mm
Phase to Phase	32 mm

10.6.4 Bus Bar Markings

10.6.4.1 The colours and letters (or symbols) for bus bars

Main bus bar connection and Auxiliary wiring etc. shall conform to relevant Indian Standards. A brief from I.S. 375-: 1963 (superseded by I.S. 5578:1984 and I.S. 11353:1985) is given below for board guidelines.

(a) For A.C. Bus Bars & main Connections

Bus Bar and Main Connections	Colour	Letter/Symbol
Three phase	Red, Yellow, Blue	R,Y,B
Two Phase	Red, Blue	R,B
Single phase	Red	R
Neutral connection	Black	N
Connection to Earth	Green	E
Phase variable (such as connection to motors)	Grey	Gy.

(a) For D.C. Bus Bars & main Connections

Bus Bar and Main Connections	Colour	Letter/Symbol
Positive	Red	R or +
Negative	Blue	B or -
Neutral Connection	Black	N
Equalizer	Yellow	Y
Phase variable (such as connection to reversible motors)	Grey	Grey or Gy.

10.6.4.2 *Phase sequence and polarity*

Bus bars and main connections, when marked shall be marked in accordance with the following table to indicate the order in which the voltages in phases reach their maximum values.

System	As indicated by colours or letter	Phase sequence as vectorially
Three phase	Red, Yellow, Blue	R.Y.B.
Two phase	Red, Blue	R.B.

10.7 Arrangement of Bus Bars and Main Connections

Bus bars and main connections, which are substantially in one plane, shall be arranged in order given as follows: -

10.7.1 *A.C. System*

1. The order of phase connections shall be Red, Yellow and Blue.
2. When the run of the conductors is horizontal, the Red shall be on the top or on the left or farthest away as viewed from the front.
3. When the run of the conductors is vertical, the Red shall be on the left or farthest away as viewed from the front.
4. When the system has a neutral connection in the same plane as the phase connections, the neutral shall occupy an outer position.
5. Unless the neutral connections can be readily distinguished from the phase connections, the order shall be Red, Yellow, Blue and Black.

10.7.2 *D.C. System*

1. When the run of the conductors is horizontal, the Red shall be on the top or on the left or farthest away as viewed from the front.
2. When the run of the conductors is vertical, the Red shall be on the left or farthest away as viewed from the front.
3. When the system is 3-wire with the conductors in the same plane, the neutral shall occupy the middle position.

Table 7: Aluminium/Copper Bus-Bar sections

Current ratings in amperes upto	Recommended rectangular cross-section			
	Aluminium		Copper	
	No. of strips/phase	Size in mm	No. of strips/phase	Size in mm
100	1	20x5	1	20x3
200	1	30x5	1	25x5
300	1	50x5	1	40x5
400	1	50x6	1	50x5
500	1	75x6	1	60x5
600	1	80x6	-	-
800	1	100x6	-	-
1000	1	100x10	-	-
1200	1	125x10	-	-
1600	2	100x10	-	-
2000	2	125x10	-	-
2500	3	125x10	-	-

11- COMPOUND/STREET LIGHTING WORK

11.1 Outdoor Fittings

External and road -lamps shall have weatherproof fittings of approved design so as to effectively prevent the admission of moisture. An insulating distance piece of moisture proof material shall be inserted between the lamp holder nipple and the fitting. Flexible cord conductors and cord grip lamp holders must not be used where exposed to weather. In verandas and similar exposed situations where pendants are used, they shall be of fixed rod type.

11.2 Steel Tubular Poles

Steel tubular poles shall conform to I.S. 2713-1964. This shall be of seamless/swaged and welded type as specified and shall be in three stepped sections. Unless otherwise specified, $1/6^{\text{th}}$ of the length of the pole plus 15 cm from its base shall be coated with black bituminous paint, both internally and externally. The remaining portion of the poles shall be painted with one coat of red oxide on its external surface. The pole shall be complete with a cap and base plate. Spacing of the poles shall be such that in a residential area adequate street lighting can be provided.

The depth of foundation for steel poles shall be as per design or as directed by the Engineer but not less than $1/6^{\text{th}}$ the length of the pole. It shall be fixed in cement concrete 1:3:6, 40 mm aggregates, foundation with not less than 200 mm thick layer of concrete all around the support or as directed by the Engineer or as per the drawing supplied.

12- EARTHING

12.1 Types of Earth Electrodes

The Earth electrodes shall be of the following types:

- (a) Pipe earth electrode.
- (b) Plate earth electrode.
- (c) Strip or conductor earth electrode.
- (d) GEE slab earthing.

12.2 Selection of Earth Electrode

G.I. pipe or G.I. plate earth electrode shall be used except when it is unavoidable to use copper earth electrode due to corrosive soil conditions for direct current system or for large capacity substations. Strip or conductor electrode is recommended for hard and rocky soils and in locations where there are limitations to the use of the pipe or plate electrode. Where the soil is highly corrosive, the earth electrode shall be of copper. Where soil contains sulphur, copper electrode shall be adequately tinned.

12.3 Arrangement for Earthed Electrode

12.3.1 Pipe Earth Electrode

G.I. pipe shall be of medium class, 40 mm diameter and 4.5 m in length. Galvanization of the pipe shall conform to the relevant Indian Standards. G.I. pipe electrodes shall be cut tapered at the bottom and provided with holes of 12 mm diameter drilled not less than 7.5 cm from each other up to 2 m of length from bottom. The electrode shall be buried in the ground vertically with its top not less than 20 cm below the ground level.

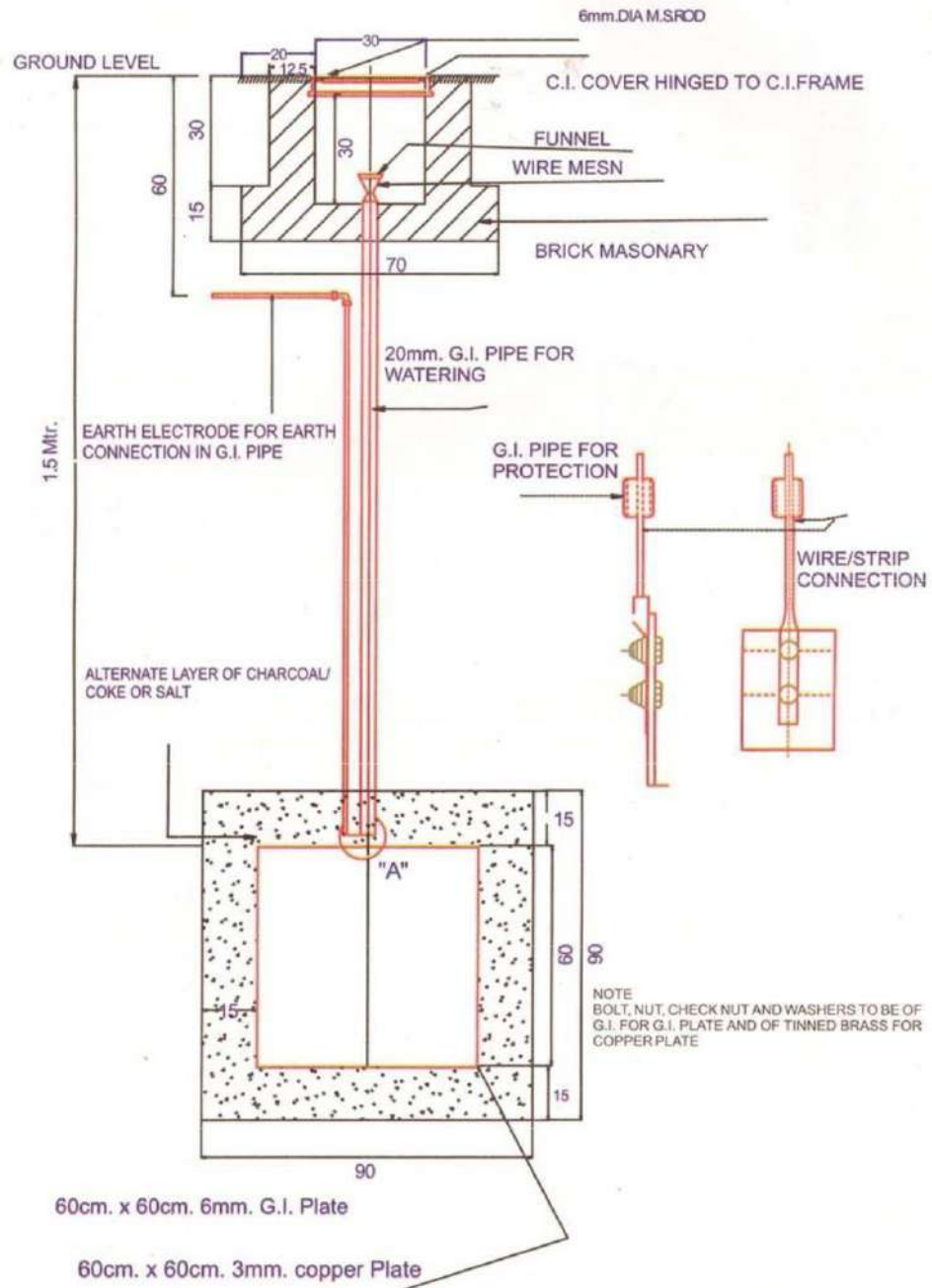
12.3.2 Plate Earth Electrode

For plate electrodes minimum dimensions of the electrodes shall be as under:

- (a) G.I. plate Electrode – 60 cm X 60 cm X 6 mm thick.
- (b) Copper plate Electrode – 60 cm X 60 cm X 3 mm thick.

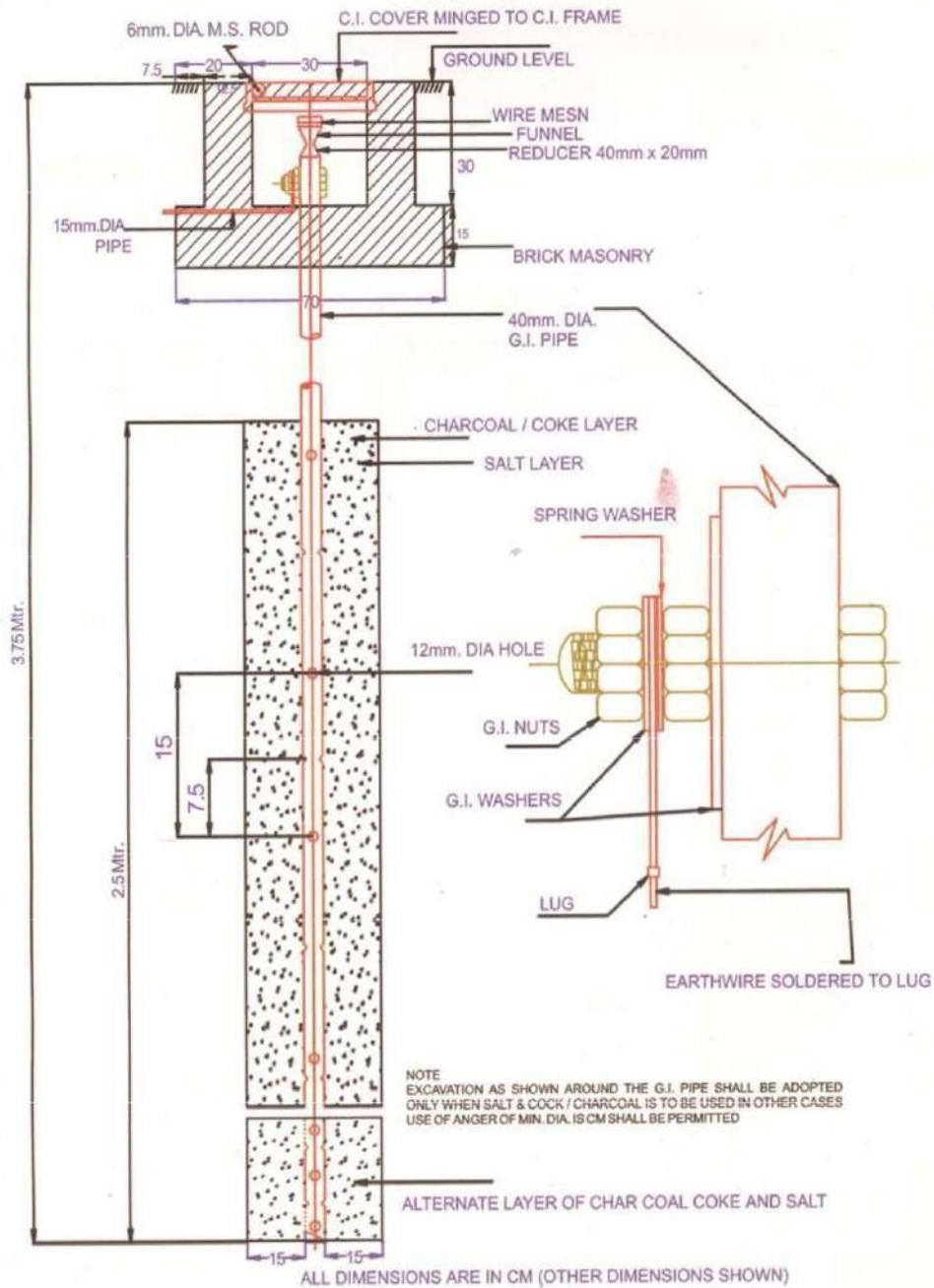
The electrode shall be buried in ground with its face vertical and top not less than 3 m below ground level.

METHOD OF PLATE EARTHING



ALL DIMENSION ARE IN CM. (OTHER DIMENSION SHOWN)

METHOD OF PIPE EARTHING



12.3.3 Strip or Conductor Electrode

Strip electrodes shall not be less than 25 mm x 4 mm of galvanized iron and 20mm x 3mm of copper. For conductor electrode the size of round conductor shall be not less than 6 SWG of G.I. and 8 SWG of copper.

The length of buried strip or conductor earth electrode shall be not less than 15 m. This conductor length shall be increased if necessary, on the basis of the information available about soil resistance, so that the required earth resistance is obtained.

The Electrode shall be buried in trench not less than 0.5m deep. If conditions necessitate use of more than one strip or conductor electrode, they shall be laid as widely distributed as possible preferably in a single straight or circular trench or in a number of trenches radiating from one point. so that required earth resistance is obtained.

12.4 Method of Installing Watering Arrangement

In the case of plate earth electrode, a watering pipe of 20 mm diameter at least medium class G.I. pipe shall be provided and attached to the electrodes. A funnel with mesh shall be provided and attached to the top of this pipe for watering the earth. In the case of pipe electrode, a 40 mm x 20 mm reducer shall be used for fixing the funnel. The watering funnel attachment shall be housed in masonry enclosure of not less than 30 cm x 30 cm x 30 cm. A cast iron/M.S. frame with cover having locking arrangement shall be suitably embedded in the masonry enclosure hinged with 30cmx30cm C.I/MS cover having locking arrangement.

12.5 Location for Earth Electrode

An earth electrode shall not be situated less than 1.8 m from any building. Care shall be taken that the excavations for earth electrode may not affect the column footings or foundation of the building; in such cases electrodes may be farther away from the building. The location of the earth electrode will be such where the soil has reasonable chance of remaining moist, as far as possible. Entrances, Pavements and roadways, are definitely avoided for locating the earth station/earth electrode.

12.6 Artificial Treatment of Soil

In case there is no option of site, earth electrode resistance shall be reduced by artificial chemical treatment of the soil. For this purpose, the most commonly used substances are sodium chloride (common salt), calcium chloride, sodium carbonate, copper sulphate and salt mixed with soft coke or charcoal in suitable proportion. But before any chemical treatment is applied, possible corrosive effect on the electrode material and connections must be taken into consideration. When this treatment is resorted to, the electrode shall be surrounded by charcoal/coke and salt. This treatment of soil shall be as specified in the Schedule of work and in such cases, excavation for earth electrode shall be as per dimensions of standard earthing drawing.

12.7 Number of Earth Electrodes for Installation

Metallic covers or supports of all medium pressure or HT apparatus or conductors shall, in all cases be connected to not less than two separate and distinct earths including electrodes. The number of earthing electrodes for substations having one transformer or one generating set shall be not less than four (two for neutral and two for earthing the metal frame). Separate earth electrodes shall be provided for lighting arresters/lighting conductor.

12.8 Resistance of Earth

No earth electrode shall have a resistance greater than 5Ω as measured by an approved earth testing apparatus. In rocky soils, the resistance may be upto 8Ω .

12.9 Size of Earthing Lead

12.9.1 Main earthing Lead

Main earthing lead shall be of G.I. wire, in the case of G.I. pipe earth electrode, G.I. wire/G.I. strip, in case of G.I. strip or G.I. plate earth electrode and copper wire or copper strip in the case of copper earth electrode. For all electrical installations except sub-stations and generating station, the earthing lead shall not be less than 8 SWG of copper or 6 SWG G.I. wire, copper strip 20mm x 3mm in case of copper earth plate and G.I. strip 25 mm x 4 mm in case G.I earth plate.

12.9.2 Size of Earth Lead for Substations/Generating Stations

The recommended size of copper earth bus in case of generating station and sub-stations shall be as shown in the table below.

Capacity of transformer/generating set	size of copper strip in mm
(a) Upto 300 KVA	20 x 4
(b) Above 300 KVA but not exceeding 500 KVA	32 x 5 or 40 x 4
(c) Above 500 KVA but not exceeding 800 KVA	40 x 6.3 or 50 x 5
(d) Above 800 KVA but not exceeding 1000KVA	50 x 6.3

12.9.3 Size of Earth Continuity Conductor

The nominal minimum cross-sectional area of an earth continuity conductor not contained within a cable or flexible cord shall be 15/14 SWG copper or 14/12 SWG of G.I.

12.10 Method of Connecting Earth Lead to Earth Electrode

In the case of plate earth electrode, the earthing lead shall be welded/securely bolted to the plate with two bolts, nuts, checkouts and washers. In the case of pipe earth electrode, it shall be connected by means of G.I through bolt, nuts and washers and cable socket. All materials used for connecting the earth lead with electrode shall be G.I. in case of G.I. pipe and G.I. plate earth electrodes and of tinned brass/brass in case of copper plate electrode. The earthing lead shall be securely connected at the other end to the main board. Loop earthing shall be provided for all mountings of main board and other metal clad switches and distribution fuse boards with not less than 8 SWG copper/G.I.

The nominal minimum cross-sectional area of an earth continuity conductor not contained within a cable or flexible cord shall be 15/14 SWG copper or 14/12 SWG G.I.

12.11 Protection of Earthing Lead

The earthing lead from electrode onwards shall be suitably protected from mechanical injury by a 15 mm diameter G.I. pipe in case of wire and 40 mm diameter medium class G.I. pipe in case of strip. Portion of this protection pipe within the ground shall be buried atleast 50 cm deep. In case of road crossing and pavements shall be buried 0.6 to 0.7m.

12.12 Ground & Electrode Enhancement (GEE) Slabs.

GEE slabs are precast electrodes that are made of an electrically conductive cement composite comprising of eight different materials in fixed proportion and orientation. It is essentially based on conductive particles, long and short conductive fibres, conductive mesh suspended in the cement material with a large conductor running through the middle. Electrical faults are discharged from the central conductor through the conductive cement body and into the surrounding soil. The large contact surface area of the GEE slabs with the surrounding soil facilitates efficient fault current dissipation. The GEE slabs provide a safe, reliable, durable and maintenance-free earthing installation. They provide minimum variations in earthing resistance even during dry seasons since they are hygroscopic and absorb moisture from the surrounding soil. The slightly alkaline conductive concrete body protects the metallic conductors encased within from corrosion and is therefore very durable (i.e. just as in the case of steel rebars encased within concrete columns and beams). Unlike normal concrete, the GEE slabs are very conductive electrically and also provide lower surge impedance (which matters more than resistance for protection against power surges). The installation is also simple and basically involves digging a trench, and burying some interconnected GEE slabs in good soft soil.

Physical features

- (i) Length x Breadth = 5 ft x 1 ft (i.e. including 6 inches GI flat projection from each of the two ends), thickness = 4 to 5 cm
- (ii) Weight = 25 kgs (+2kg /- 1 kg)
- (iii) One 12mm hole provided at each end of GI flat for bolting

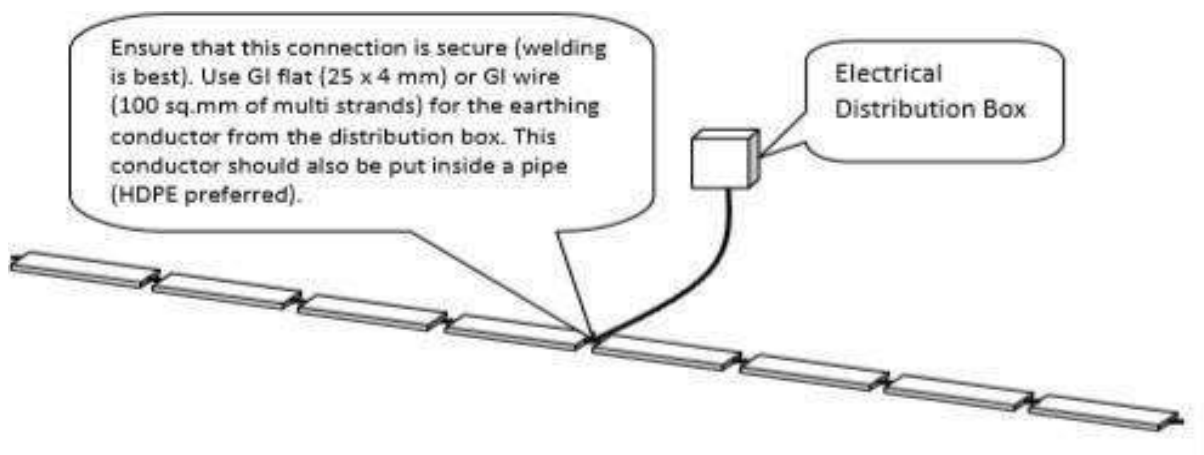
12.12.1 Installation manual for Ground & Electrode Enhancement (GEE) slabs (House earthing)

Procedure:

- (1) Dig a trench (70-75 cm deep and 50 cm wide)
- (2) **If the trench is very rocky or sandy**, spread a layer of salt (about 50 kgs) at the bottom. This is to lower the soil resistivity. However, if the trench is not rocky or sandy, no salt is required.
- (3) Spread 7-8 inches of good soft soil (preferably sieved and do not use rocky and sandy soil) at the bottom of trench.
- (4) Soak/drench the GEE slabs in water and lay the GEE slabs
- (5) Connect the GEE slabs end to end and bolt securely (in addition, it is recommended to weld all joints permanently)
- (6) Cover all joints and bare conductors with cement mortar (after connecting securely the earthing conductor from Distribution Box).
- (7) Now cover GEE slabs with 7-8 inches of good soft soil and tamp down gently with feet.
- (8) Complete the installation by backfilling the rest of the trench with the excavated soil.
- (9) Add water to expedite soil compaction (preferably the next day to avoid damage to the fresh cement mortar).

Notes:

- (i) The earthing resistance will continue to drop as the soil slowly compacts firmly around the GEE slabs (this may take a few weeks).
- (ii) The number of GEE slabs required per earthing installation will depend on the site soil conditions but generally 8 numbers has been found to be adequate for one house earthing installation.



13- PAINTING

13.1 Preparation of the surface

The surface shall be thoroughly cleaned and dusted before painting is started. The proposed surface shall be inspected by the Engineer or his authorized agent and shall have received the approval before painting is commenced.

13.2 Application

Paint shall be applied by spraying or with brush. The paint shall be spread as smooth and even as possible. Particular care shall be paid to rivets, nuts, and bolts and over lapping. Before drawing out, it shall be continuously stirred in the smaller containers with a smooth stick while it is being applied.

13.3 Scope

Painting on old surface in indoor situations will not include primer coat except where specially mentioned. However, where rust has formed on iron and steel surfaces the spots will be painted with one anti-rust primer coat prior to finish coat of painting.

13.4 Painting of Conduit and Accessories

After installation, all accessible surface of conduit pipe, fittings, switch and regulator boxes etc. shall be painted with two coats of approved enamel paint or aluminium paint as required to match the finish of surrounding wall, trusses etc.

14- TESTING OF INSTALLATION

On completion of installation the following tests shall be carried out:

- (a) Insulation Resistance Test.
- (b) Polarity Test of Switch.
- (c) Earth Continuity Test.
- (d) Earth Electrode Resistance Test.

14.1 Insulation Resistance Test

The insulation resistance shall be measured by applying between earth and the whole system of conductors or any section there -off with all fuses in place and all switches closed, and except in earth concentric wiring all lamps in position or both poles of the installation otherwise electrically connected together, a direct current pressure of not less than twice the working pressure provided that it need not exceed 500 volts for medium voltage circuits. Where the supply is derived from the three wire D.C. or a poly phase A.C. system, the neutral pole of which is connected to earth either direct or through added resistance, the working pressure shall be deemed to be that which is maintained between the phase conductor and the neutral.

The insulation resistance shall also be measured between all conductors connected to one pole or phase conductor of the supply and all the conductors connected to the neutral or to the other pole or phase conductors of the supply with all lamps in position and switches in “off” position. The insulation resistance in Megaohms shall not be less than 50 Megaohms divided by the number of outlets or when PVC insulated cables are used for wiring 12.5 Megaohms divided by number of outlets.

Where a whole installation is being tested, a lower value than that given by the formula, subjected to a minimum of 1 Megaohm is acceptable. A preliminary and similar test may be made before lamps, etc. are installed, and in this event the insulation resistance to earth should be not less than 100 Megaohms divided by the number of outlets or when PVC insulated cables are used for wiring 25 Megaohms divided by number of outlets.

The term “outlet” includes every point along with every switch except that a switch combined with socket outlet, appliance or lighting fitting is regarded as one outlet.

Control rheostats, heating and power appliances and electric signs may, if required, be disconnected from the circuit during the test. In that event the insulation resistance between the case or frame work, and all live parts of each rheostat, appliance and sign, shall be not less than half a Megaohm.

14.2 Polarity Test of Switch

In a two-wire installation a test shall be made to verify that all switches in every circuit have been fitted in the same conductor and such conductor shall be labelled or marked for connection to the phase conductor or to the non-earthed conductor of the supply. In a three wire or a four wire, installation test shall be made to verify that every non-linked single pole switch is fitted in a conductor which is labelled or marked for connection to one of the phase conductors of the supply. A test lamp, one lead of which is connected to the earth, shall test the terminals of all switches. Glowing of test lamp to its full brilliance, when the switch is in “on” position irrespective of appliance in position or not, shall indicate that the switch is connected to the right polarity.

14.3 Earth Continuity Test

The earth continuity conductor including metal conduits and metallic envelopes of cables in all cases shall be tested for electric continuity and the electrical resistance of the same along with the earthing lead but excluding any added resistance or earth leakage circuit breaker measured from the connection with the earth electrode to any point in the earth continuity conductor in the completed installation shall not exceed one ohm.

14.4 Measurement of Earth Electrode Resistance

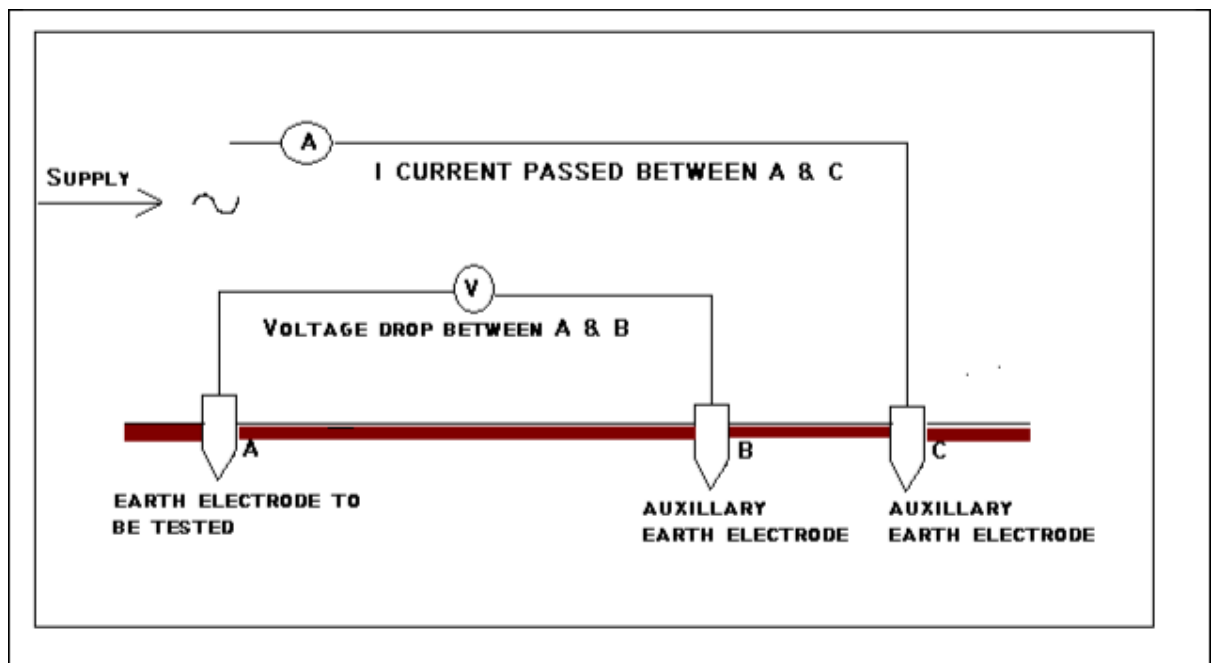
Two auxiliary earth electrodes besides the test electrode are placed at suitable distance from the test electrode (see figure below). A measured current is passed between the electrode ‘A’ to be tested and an auxiliary current electrode ‘C’ and the potential difference between the electrode ‘A’ and auxiliary potential electrode ‘B’ is measured. The resistance of the test electrode ‘A’ is then given by:

$$R = \frac{V}{I}$$

Where, *R* is Resistance of the test electrode in ohms.

V is Reading of the voltmeter in volts.

I is Reading of the ammeter in amperes.



Stray currents flowing in the soil may produce serious errors in the measurement of earth resistance. To eliminate this, hand driven generator is used. If the frequency of the supply of hand driven generator coincides with the frequency of stray current there will be wandering of instrument pointer. An increase or decrease of generator speed will cause this to disappear. At the time of test, the test electrode shall be separate from the earthing system.

The auxiliary electrodes shall be of 13 mm diameter mild steel rod driven upto 1 m into the ground. All the three electrodes shall be so placed that they will be independent of the resistance area of each other. If the test electrode is in the form of rod, pipe or plate, the auxiliary current electrode 'C' shall be placed atleast 30 m away from it and the auxiliary potential electrode 'B' shall be placed mid-way between them.

Unless three consecutive readings of test electrode resistance agree the test shall be repeated by increasing the distance between electrodes A and C upto 50 m and each time placing the electrode B mid-way between them. On these principles "Megger Earth Tester" containing a direct reading ohm-meter, a hand driven generator and auxiliary electrodes are manufactured for direct reading of earth resistance of electrode.

15- PROTECTION OF BUILDING AGAINST LIGHTNING

Protection of buildings against lightning shall generally be done in accordance with I.S. 2309: 1989. A brief of the same is given below for guidance. Protection of special structures like trees, livestock in fields, structures supporting overhead lines, structures with highly combustible roof etc. shall be strictly done in accordance with I.S. 2309: 1989.

15.1 Principle of Protection

The principle for protection of buildings against lightning is to provide a conducting path between earth and the atmosphere above building through which lightning discharge may enter the earth without causing damage to the building. If adequately earthed metal parts of proper proportions are provided and spread properly on and around the building, damage can be largely prevented. The required conditions of protection are generally met by placing all the air terminals whether in the form of vertical finals or horizontal conductors on the upper most part of the buildings or its projections with lightning conductors connecting the air terminals with each other and to the earth.

15.2 Zone of Protection

The zone of protection of a lightning conductor provides protection against a direct lightning strike by diverting the stroke itself. For a single vertical conductor, this zone is described as a cone with its apex at the highest point of the conductor and with an angle, called as protective angle, between the side of the cone and the conductor. In general, for the purpose of providing an acceptable degree of protection the protective angle of any single component part of an air termination network, namely, either one vertical or one horizontal conductor is considered to be 45° . Between two or more vertical conductors of equal height spaced at a distance not exceeding twice their height, the equivalent protective angle within the space bounded by the air terminations may be taken as 60° to the vertical, while the protective angle away from the conductors is still taken as 45° to the vertical.

15.3 Materials and Dimensions

The materials of lightning conductors, down conductors, earth termination etc. of the protective system shall be reliably resistant to corrosion or be adequately protected against corrosion. The materials recommended are:

Copper: Solid or flat copper strip of 98% conductivity conforming to relevant I.S. Specifications shall be used.

Copper clad Steel: Copper clad steel with copper covering permanently and effectively welded to the steel core shall be used. The proportion of copper and steel shall be such that the conductance of the material is not less than 30% of conductance of the solid copper of the same total cross-sectional area.

Galvanized Steel: Steel thoroughly protected against corrosion by a zinc coating shall be used.

Aluminium: Aluminium 99% pure and with sufficient mechanical strength and protected against corrosion shall be used. Aluminium should not be used under ground or in direct contact with walls.

All air terminations shall be of G.I. and all down conductors shall be of G.I. or aluminium except where the atmospheric conditions necessitate the use of copper or copper clad steel for air terminations and down conductors.

The recommended shape and minimum sizes of conductors for use above and below ground are given in Table below.

Shapes and Minimum sizes of Conductors for use above Ground

Sl.No.	Material & Shape	Minimum size
1.	Round copper wire clad steel wire	6 mm diameter
2.	Stranded copper wire	50 sq.mm or 7/3 mm dia
3.	Copper strip	20 mm x3 mm
4.	Round galvanized iron wire	8 mm diameter
5.	Galvanized iron strip	20 mm x 3 mm
6.	Round aluminium wire	8 mm diameter
7.	Aluminium strip	25 mm x 3 mm

Shapes and Minimum Sizes of Conductors for use below Ground

Sl.No.	Material & Shape	Minimum Size
1.	Round copper wire or Copper clad steel wire	8 mm diameter
2.	Copper strip	32 mm x 6 mm
3.	Round galvanized iron wire	10 mm x 6 mm
4.	Galvanized iron strip	32 mm x 6 mm

15.4 Design Considerations

When designing and installing lightning conductors, the following items should be taken into consideration:

1. The entire lightning protective system should be mechanically strong to withstand the mechanical forces produced in case of a lightning strokes.

2. The lightning protective system should be so installed that it does not spoil the architectural or aesthetic beauty of the building.
3. For the purpose of lightning protection, the vertical and horizontal conductors are considered equivalent and the use of pointed air terminations or vertical finals is, therefore, not regarded as essential. An air termination may consist of a vertical conductor, single horizontal and vertical conductors for the protection of bigger buildings.
4. A vertical air termination where provided need not have more than one point and shall project atleast 30 cms above the project, salient point or network on which it is fixed.
5. Horizontal air terminations should be so interconnected that no part of the roof is more than 9 m away from the nearest horizontal conductor. For a flat roof horizontal air termination along the outer perimeter of the roof is used. For a roof of larger area a network of parallel horizontal conductors shall be installed.
6. Horizontal air terminations should be coursed along contours such as ridges, parapets and edges of flat roof, and where necessary over flat surfaces in such a way as to join each air termination to the rest and should themselves form a closed network.
7. All metallic finals, chimneys, ducts, vent pipes, railings, gutters, metallic flagstaff etc. on or above the main surface of the roof of the structure shall be bonded to, and form part of, the air termination network. If portions of a structure vary considerably in height, any necessary air termination or air termination network of the lower portions should in addition to their own conductors, be bonded to the down conductors of the taller portions.
8. All air terminals shall be effectively secured against overturning either by attachment to the object to be protected or by means of substantial braces and fixings which shall be permanently and rigidly attached to the building. The method and nature of the fixings should be simple, solid and permanent, due attention being given to climatic conditions and possible corrosion.

15.5 Down Conductors

The number and spacing of down conductors shall largely depend upon the size and shape of the building and upon aesthetic considerations. The minimum number of down conductors may however, be decided on the following considerations.

1. A structure having a base area not exceeding 100 sq.m may have one down conductor only, if the height of the air termination provides sufficient protection. However, it is advisable to have atleast two down conductors except for very small buildings.
2. For structures having a base area exceeding 100 sq.m the number of down conductors required should be worked out as follows:
 - One for first 100 sq.m plus one more for every additional 300 sq.m or part thereof or,
 - One for every 30 m of perimeter. The smaller of the two shall apply.

Down conductors should be distributed round the outside walls of the structure. They shall preferably be run along the corners and other projections; due consideration being given to the location of air terminations and earth terminations. Lift shafts shall not be used for fixing down conductors. In deciding on the routing of the down conductor, its accessibility for inspection, testing and maintenance should be taken into consideration.

15.6 Joints and Bonds

The lightning protective system shall have as few joints in it as possible. Wherever joints in the down conductor above ground level are necessary they shall be mechanically and electrically effective. In the down conductor below ground level there shall be no joint. The joints may be clamped, screwed, bolted, riveted, sweated, braced or welded. The bonding of the external metal forming part of a structure or drain water pipe shall have a cross sectional area not less than that employed for the main conductors. Gas pipe, however, in no case shall be bonded to the earth termination system.

15.7 Fasteners

Conductors shall be securely attached to the building or other object to be protected by fasteners, which shall be substantial in construction, not subjected to breakage and shall be of galvanized steel or other suitable materials with suitable precautions to avoid corrosion. The lightning conductors shall be secured at not more than 1.20 m apart for horizontal run and 1.00 m for vertical run.

15.8 Earth Terminations

Each down conductor shall have an independent earth termination. The interconnection of all the earth termination shall be preferable. It should be capable of isolation for testing purposes by 'testing joints'.

15.9 Earth Electrode

Earth electrodes shall be constructed and installed in accordance with the clauses under Earthing. The whole of the lightning protective system should have a combined resistance to earth not exceeding 10Ω before any bonding has been affected to metal in or on a structure or to surface below ground.

16- SAFETY PROCEDURE

The control switches and distribution boards duly marked, the distribution diagrams of sub-stations prominently displayed, sub-station premises, main switch rooms and Distribution Board enclosure are kept clean. Particular care should be taken to prevent the sub-station to be used as store for inflammable materials, broken furniture, wastage materials.

Rubber or insulation mats should be provided in front of main switchboards or any other control equipment of medium voltage and above.

Necessary number of caution boards such as “*Man on Line, Do Not switch ON*” should be readily available in each sub-station, enquiry office and important installations.

Charts (one in English and one in Dzongkha) displaying methods of giving artificial respiration to a recipient of electrical shock should be prominently displayed at appropriate places. Electrical wiring and control switches should be periodically inspected and any defective wiring, broken parts of switches that will expose live parts should be replaced immediately to make the installations safe for the user.

No work shall be undertaken on **Live** installations or on installations which could be energized unless one another person is present to immediately isolate the electric supply in case of any accident and to render First Aid if necessary.

When working on or near live installations suitably insulated tools should be used and special care should be taken to see that those tools accidentally do not drop on live terminals causing shock or dead short.

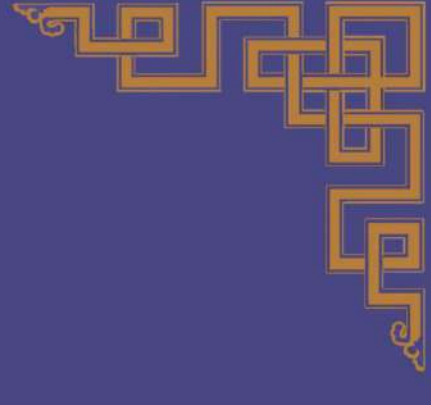
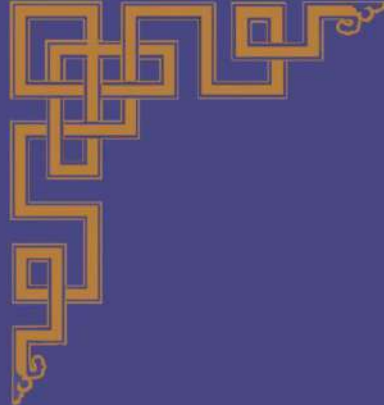
The electrical switchgears and distribution boards should be clearly marked to indicate the areas being controlled.

Before starting any work on the existing installation, it shall be ensured that electric supply to that portion in which work is undertaken is cut off.

Before energizing on an installation after the work is completed, it should be ensured that all tools have been removed and accounted, no person is present inside any enclosure of the switchboard etc., any earthing connection made for doing the work has been removed.

In case of electrical accidents and shock, the electrical installation on which the accident occurred should be switch off immediately removed from the live installation by pulling him with the help of his coat, shirt, wooden rod, broom handle or with any other dry cloth or paper. He should be removed from the place of accident to a nearby safe place and artificial respiration continuously given.

These instructions should be explained in Dzongkha or English or in other local languages to those who are not familiar with such requirements.





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