ཁྲིམ་ནང་གློག་ཐག་བཀོལ་ནིའི་གནས་ཚད། ཉེན་སྐྱོང་དབྱེ་ཞག།

BHUTAN STANDARD

INTERNAL HOUSE WIRING STANDARD – SAFETY SPECIFICATIONS

DRAFT STANDARD

TC 03 N 39

BHUTAN STANDARDS BUREAU
The National Standards Body of Bhutan
THIMPHU 11001

ཁྱིམ་ནང་གློག་ཐག་བཙུགས་ནིའི་གནས་ཚད། ཉེན་སྐྱོང་དབྱེ་ཁག།

BHUTAN STANDARD

INTERNAL HOUSE WIRING STANDARD – SAFETY SPECIFICATIONS

PDF Disclaimer

This PDF file may contain embedded typefaces. In accordance with Adobe's licensing policy, this file may be printed or viewed but shall not be edited unless the typefaces which are embedded are licensed to and installed on the computer performing the editing. In downloading this file, parties accept therein the responsibility of not infringing Adobe is licensing policy. The Bhutan Standards Bureau accepts no liability in this area. Adobe of a trademark of Adobe Systems incorporated.

Director General
Bhutan Standards Bureau
Thimphu: Bhutan
Tel:+975-2-325104/325401
Fax: +975-2-323712/328298
www.bsb.gov.bt

Table of Contents

ཁྱིམ་ནང་གློག་ཐག་བཙུགས་ནིའི་གནས་ཚད། ཉེན་སྐྱོང་དབྱེ་ཁག།

BHUTAN STANDARD

INTERNAL HOUSE WIRING STANDARD – SAFETY SPECIFICATIONS

FOREWORD

This Bhutan Standard for internal house wiring –safety specifications was developed by the Working Group of Electrical and Electronics Engineering TC-03 on the recommendations of Technical committee and had been endorsed by the Bhutan Standards Bureau Board.

This standard has been drawn up to provide to the users guidance for internal electrification works. It is designed to ensure that the electrical installations will be functional and fit for purpose from the user's point of view with good electrical safety.

1. Scope

This section of the internal house wiring standard covers the following essential requirements of electrical installation in buildings.

- **1.1.** Lighting requirement in a building
- **1.2.** Wiring system
- **1.3.** Distribution system and switchgear
- **1.4.** Power factor
- **1.5.** Cabling system
- **1.6.** Earthing protection
- **1.7.** Lightning protection
- **1.8.** Inspection and testing

Safety requirements are also covered in respective parts in this standard. All electrical works carried out inside the building shall be as per this internal house wiring standard.

2. Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

2.1. BTS IEC 60227-1: Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V - Part 1: General requirements

2.2. BTS IEC 60335-2-80: Safety of household and similar electrical appliances - Part 2: Particular requirements for fans

2.3. BTS IEC 60502-1: Power cables with extruded insulation and their accessories for rated voltages from 1kV (Um = 1,2 kV) up to 30 kV (Um = 36 kV) - Part 1: Cables for rated voltages of 1 kV (Um = 1,2 kV) and 3 kV (Um = 3,6 kV)

2.4. BTS IEC 61439-1: Low-voltage switchgear and controlgear assemblies - Part 1: General rules

2.5. BTS IEC 62031: LED modules for general lighting - Safety specifications

2.6. BTS IEC 62560: Self-ballasted LED-lamps for general lighting services by voltage > 50 V - Safety specifications

2.7. BTS IEC 62612: Self-ballasted LED lamps for general lighting services with supply voltages > 50 V - Performance requirements

2.8. BTS IEC 62717: LED modules for general lighting - Performance requirements

2.9. BTS IEC 62776: Double-capped LED lamps designed to retrofit linear fluorescent lamps - Safety specifications

2.10. IS 1554 Part 1: PVC insulated (heavy duty) electric cables, Part 1: For working voltages up to and including 1 100 V

2.11.IS 2713(I-III): Tubular Steel Poles for Overhead Power Lines

2.12.IS 4171:1983: Copper rods and bars for general engineering purposes

3. Terms and Definitions

3.1. Accent lighting: Directional lighting to emphasize a particular object or draw attention to a part of the field of view.

3.2. Accessory: Any device associated with the wiring and electrical appliance of an installation e.g. a switch or a lamp.

3.3. Aluminium conductor steel reinforced: In aluminium conductor steel reinforced conductor, aluminium wires surround a core consisting of one or more steel wires.

3.4. Appliance: An energy consuming device or equipment (other than lamp) fixed or portable, in which the electrical energy is converted into light, heat, motion or any other form of energy or substantially changed in its electrical character.

3.5. 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. lighting).

3.6. Armouring: It consists of one or two layers of galvanized steel wire or steel tape, to protect the cable from mechanical injury while laying and during the course of handling.

3.7. Alternating currents: The term alternating current refers to a current that reverses at regular recurring intervals of time and that has alternately positive and negative values**.**

3.8. Arcing contacts (arcing horns): Arcing contacts are the contacts on which the arc is drawn after the main contacts of a switch have parted.

3.9. Base: A base of a switch is the main member to which the conducting parts or insulator units are attached. It may also have parts of the operating or control mechanism attached.

3.10.Binding wire: Annealed aluminium wire is used for fastening conductor to pin and shackle insulator.

3.11.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.

3.12.Bus bar: A heavy, rigid conductor used for high voltage feeders**.**

3.13.Bunched: Cable are said to be bunched when two or more are contained within a single conduit, duct, or groove or if not enclosed, are not separated from each other.

3.14.Cables: A length of one or more than one insulated conductors, which are laid up together and surrounded by a protecting cover.

3.15.Circuit breaker: A device, capable of making and breaking the circuit under all conditions and unless specified otherwise, so designed as to break the current automatically under abnormal conditions.

3.16.Conductor: A substance, which offers low resistance to the passage of electric current.

3.17.Cross arms: It provides support to the insulators.

3.18.Conduit: A tubular raceway for data or power cables. Metallic conduit is common, although non-metallic forms may also be used.

3.19.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.

3.20. Decorative lighting: Decorative lighting is determined by the aesthetic and architectural considerations; utility lighting is primarily on economic considerations.

3.21.Earthing: Earthing or grounding is the term, used for electrical connection to general mass of earth.

3.22.Earth Leakage Current: A current, which flows to earth or to extraneous conductive parts in a circuit, which is electrically bound.

3.23.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.

3.24.Earth wire: A conductor connected to earth and usually situated in proximity to the associated live conductors.

3.25.Earth electrode: A metal plate or pipe, which is electrically, connected to the general mass of earth.

3.26.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.

3.27.Flood lighting: It is the term used for lighting of construction projects, parking areas, recreation and sports ground, etc.

3.28.Fixture: The assembly that houses a lamp or lamps, and which may include a housing, a mounting bracket or pole socket, a lamp holder, a ballast, a reflector or mirror, and or a refractor, lens, or diffuser lens.

3.29.Fuse: A strip of wire or metal inserted in series with a circuit, which, when it carries an excess of current over its rated capacity, will burn out.

3.30.Fluorescent lamp: The lamp is filled with low-pressure argon gas and a drop of mercury.

3.31.Girder clips: It is used to fix the conduit to the wooden plugs in the wall.

3.32.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.

3.33.Grounded: Conducted to earth or to some conducting body that serves in place of the earth.

3.34.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.

3.35.High Intensity Discharge Lamps (HID): A general group of lamps consisting of mercury, metal halide, high-pressure sodium, and low-pressure sodium lamps.

3.36.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.

3.37.Insulator: A device for fastening and supporting a conductor. Glass and porcelain are employed almost universally for supporting overhead wires.

3.38.Lamp: The component of luminaries that produces the actual light.

3.39. Light Emitting Diode: Solid state device embodying a p-n junction, emitting optical radiation when excited by an electric current.

3.40.Lighting arrester or a surge diverter: It is a protective device, which conducts the high voltage surges on the power system to the ground.

3.41.Live Part: A conductor or conductive part intended to be energised in normal use including a neutral conductor but, by convention, not a protective and neutral conductor.

3.42.Luminaires: A complete lighting system, including a lamp or lamps and a fixture.

3.43.Mercury vapour lamps: In this lamp, the discharge tube is filled in a bulb of hard glass provided with an internal mirror reflector.

3.44.Megger: A test instrument for measuring the insulation resistance of conductors and other electrical equipment; specifically, a mega-ohm (million ohms) meter.

3.45.Mercury lamps: An electric discharge lamp in which the major portion of the radiation is produced by the excitation of mercury atoms.

3.46.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.

3.47.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.

3.48.Reflector lamps: A reflector lamp is provided with high quality internal mirror, which follows exactly the parabolic shape of the lamp.

3.49.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.

3.50.Serving: The protective material over the metal sheathing or the wire armour of a cable is known as serving.

3.51.Struts: Struts may be used, where it is not possible to use stay wires due to limitation of space.

3.52. Socket outlet: A device carrying three metallic contacts designed for engagement with corresponding plug pins and arranged for connections to fixed wiring.

3.53. 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.

3.54. Switch: A device of making, breaking, or changing the connections in an electric current.

3.55. Surge: A short duration high voltage condition. A surge lasts for several cycles where a transient last less than one-half cycle.

3.56. 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.

3.57. Thyrite type arrester: Thyrite type arresters incorporate non-linear resistors and are extensively used on systems operating at high voltages.

4. General requirements

Electrical installations should be planned in a systematic manner. Before commencement of work, the following points should be taken into consideration.

4.1. Lighting requirement during day and night time

4.2. Heating and cooling requirement in various areas

4.3. Distribution boards (DBs)

All necessary circuits and sufficient spares should be planned on main and sub distribution boards. If some additional load is to be catered in the future, the necessary circuit provision should be available.

4.4. Safety aspects

Safety measures shall be followed.

4.5. Energy conservation

The use of energy efficiency appliances and luminaries shall be encouraged.

4.6. Requirement of captive generation and un-interrupted power supply

If un-interrupted power supply is required, then proper changeover facility to facilitate smooth shifting of load on DG sets and proper wiring of emergency requirement should be planned.

4.7. Requirement of telephone socket, internet socket, television points etc.

These requirements should be planned at all the possible locations.

5. Distribution System and L.T Switchgears

5.1. Switchgear Components

LV Switchgear devices and their relative merits and demerits are elaborated in this section. The equipment should be selected based on the requirement of the system. The equipment selection should be based on the future expansion and safety of the system.

5.1.1 Moulded Case Circuit Breaker (MCCB)

MCCB's are available up to 3200 A rating. MCCB's are also available in fixed type and draw out versions. MCCB's are available with following add on protections.

(a) Short circuit protection

(b) Instantaneous and inverse definite minimum time over current protections

(c) Under voltage protection

(d) Earth fault protection

It is recommended that MCCB's should be used as replacement to switch fuse units to have fuse less system. Normally, MCCB's should be used from 63 A to 800A.

5.1.2 Switch Fuse Unit (SFU)

SFU offer very reliable protection against short circuit and over current. Other protections against earth leakage and residual current are not possible in SFU. Two types of fuses can be used in SFU, viz. high rupturing capacity (HRC) and re-wirable type (kit kat fuse).

5.1.3 Miniature Circuit Breaker (MCB)

MCB provides protection against over current. They are available from 6 A to 63 A. MCB's are of single pole (SP), single pole & neutral (SPN), double pole (DP), triple pole (TP), triple pole & neutral (TPN), and four pole (FP).

5.1.4 Residual Current Circuit Breaker (RCCB)

RCCB provides protection against earth leakage and residual current. RCCB are available from 6 A to 63 A with sensitivity of 30 mA to 300 mA.

5.2. Main Switchgear, Main Distribution Board (MDB) and their Location

Main switchgear shall be metal clad and shall be fixed at close proximity to the point of entry of supply.

MDBs shall be placed only in dry and well-ventilated rooms. They shall be made of metal clad panels having provision for locking arrangement so as to safeguard against operation by unauthorized personnel. They shall not be placed in the vicinity of storage batteries and exposed to chemical fumes.

In a damp situation or where inflammable or explosive dust, vapour or gas is likely to be present, the switchboard shall be totally enclosed or made flameproof as may be necessitated by the particular circumstances

MDBs, 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 adapted 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 enclosure for entry and exit of wires.

The MDB may be floor mounted or wall mounted depending on the size. Sufficient space shall be maintained around the switchboard to carry out the repair and maintenance work.

The wall mounted switchboards shall be recessed wherever possible with suitable locking arrangements.

The various live parts, unless substantial barriers of non-hygroscopic, non-inflammable insulating material effectively screen them, shall be so spaced to avoid arcing between such parts and earth.

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

All switchboards connected to medium voltage and above shall be provided with “Danger Notice Plate”.

5.2.1 Types of switchboards

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

(a) **Hinged type metal boards**

(b) **Fixed type Metal boards**

(c) **Compartmentalized panel boards**

5.2.2 Marking of Apparatus

When a board is connected to a voltage higher than 230 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.

Alternating Current	Direct Current
Three phases: Red, Yellow & Blue	Three wired system, 2 outer wires: Red positive & Blue negative
Neutral: Black	Neutral: Black

In a three phase, four-wire system, the neutral shall be black in colour.

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 MDB in the building, each such switchboard shall be marked to indicate which section of the installation and building it controls.

All marking should be clear and permanent. All distribution boards shall be marked ‘Lighting’ or ‘Power’ as the case may be.

Each switchboard shall be provided with its detailed single line diagram.

5.2.3 Sub distribution boards and their location

Unless otherwise specified in the Special Specification, sub distribution fuse boards shall be of the metal clad type.
Sub distribution board 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.
Sub distribution board shall be installed above 1.25 m from 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 persons have access.

Sub distribution boards shall be controlled by a circuit breaker. Each outgoing circuit shall be provided with a circuit breaker on the phase or live conductor. 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 sub distribution board.

The sub distribution board shall be located as near as possible to the centre of the load they control.

These shall be of metal clad type, but, if exposed to weather or damp conditions, they shall be of the weatherproof type and if installed where exposed to explosive dust, vapour or gas, they shall be of the flameproof type.

5.2.4 Wiring of Sub distribution boards (SDB)

In wiring a sub distribution board, the total load of the consuming devices shall be divided, as far as possible, evenly between the number of ways of the board, leaving the spare circuit for future extension.

All connections in distribution board shall be neatly arranged in a definite sequence, following the arrangement of the apparatus mounted thereon, avoiding unnecessary crossing.

Cable should be terminated in the panel with proper type lug only. The lugs should be crimped properly by preferably a hydraulic tool or hand crimping tool. All bare conductors shall by rigidly fixed in such a manner that a clearance of at least 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^{o}.

A pilot lamp shall be fixed and connected through an independent single pole switch and fuse to the bus of the board.

5.3. Specification for Bus Bar and Bus Bar Chambers

5.3.1 Bus Bars

Bus bars shall be made conforming to BTS/BTS IEC 61439/IS: 4171:1983. The cross section of the neutral bus bars of capacities up to 200 amperes and for higher capacities the neutral bus bar must not be less than half the cross section of the phase bus bar. The recommended sections of bus bars are given in the Table 5.1 and 5.2.

Table 5.1 Cross sections for Aluminium Busbar

Current ratings(Amperes)	Recommended rectangle Cross section(mm)	Recommended Circular Section (mm)	
		Nominal Diameter	Nominal Thickness
100	25 X 6		
200	38 X 6		
300	51 X 6	25	3.38
400	63 X 6	32	3.56
500	76 X 6	32	3.56
600	102 X 6	38	3.68
700	102 X 6	51	3.91
800	127 X 6	51	3.91
900	127 X 6	63	5.16

Table 5.2 Cross sections for Copper Busbar

Current ratings (Amperes)	Recommended rectangle cross section (mm)	Recommended circular section (mm)	
		Nominal Diameter	Nominal Thickness
100	25 X 3		
200	38 X 3		
300	51 X 3	25	3.38

5.3.2 Bus Bar Chambers

Bus bar chamber shall be fabricated with MS 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 sheet steel of thickness not less than 3 mm with detachable covers on all sides and dust excluding gasket. The joints 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 up to 90cm length and shall have detachable end covers for extension. 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.

5.3.3 Bus Bar supports and attachments

(a) 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 BTS/IEC/IS. The supports shall be sufficiently robust to effectively withstand electromechanical stresses produced in the event of short circuit.

(b) 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 up to 100 amperes and for higher current capacities solid conductors/strips suitably insulated with PVC sleeve/ tape shall be used.

(c) Clearances:

The minimum clearances to be maintained for open and enclosed indoor air insulated bus bars/electrically non-exposed and working at system voltages up to 600 volts shall be as given in table 5.3.

Table 5.3 Minimum Clearances between Bus Bars

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

5.3.4 Bus Bar Markings

The colours and letters (or symbols) for bus bars: Main bus bar connection and Auxiliary wiring etc. shall conform to BTS/IEC/IS 375-: 1963 and IS 5578:1984 and IS 11353:1985).

Table 5.4 Colours and letters for AC Bus Bars & main Connections

Bus Bar and Main Connections	Colour	Letter/Symbol
Three phase	Red, Yellow, Blue	R.Y.B.
Two Phase	Red-Blue, Red-Yellow	R-B, R-Y
Single phase	Red	R
Neutral connection	Black	N
Connection to Earth	Green	E

Table 5.5 Colours and letters for D.C. Bus Bars & main Connections

Bus Bar and Main Connections	Colour	Letter/Symbol
Positive	Red	R or + (Plus)
Negative	Blue	B or – (minus)
Neutral connection	Black	N
Equalizer	Yellow	Y

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.

Table 5.6 Colours and letters for Phase sequence & polarity connections

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

5.3.5 Arrangement of Bus Bars and Main Connections:

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

(a) **AC System**

(i) The order of phase connections shall be Red, Yellow and Blue.

(ii) 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.

(iii) When the run of the conductors is vertical, the Red shall be on the left or farthest away as viewed from the front.

(iv) When the system has a neutral connection in the same plane as the phase connections, the neutral shall occupy an outer position.

(v) Unless the neutral connections can be readily distinguished from the phase connections, the order shall be Red, Yellow, Blue and Black.

(b) **D.C. System**

(i) 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.

(ii) When the run of the conductors is vertical, the Red shall be on the left or farthest away as viewed from the front.

(iii) When the system is 3-wire with the conductors in the same plane, the neutral shall occupy the middle position.

6. Power Factor

Power factor of the system shall be maintained at minimum of 0.85.

6.1. Installation of Capacitor

To improve the power factor capacitors are generally factory fitted with good lighting fixtures and ceiling fans. External capacitors are required for induction motors and transformers. Capacitors can be connected across the motor. Group controlled capacitors shall be provided if many motors are installed. The switchgear protection device i.e. MCCB, SFU or MCB shall be selected for capacitor duty.

6.2. Type of Capacitors

6.2.1 Mixed dielectric type

They are normally used in industrial applications and manufactured from high-grade polypropylene film together with a high-grade capacitor tissue paper. High purity aluminium is used as conductor between mixed dielectric layers.

6.2.2 All propylene type

They are normally used in industrial applications. High-grade special polypropylene film is used as dielectric. They offer very low losses.

6.2.3 Metallised propylene type

These capacitors are popular in residential and low duty application. High-grade special metallised polypropylene film is used as dielectric. They also offer very low losses.

7. Cabling

7.1. Cables

All cables shall conform to BTS IEC 60227. Conductors of all cables shall be of copper. The smallest size of conductor for the final circuit shall have a nominal cross sectional area of not less than 1 sq. mm for copper conductor cable. Types of cables are classified as follows:

7.2. House wiring cables

House-wiring cable shall conform to BTS IEC 60227. House wiring cables are available in single core as well as twin core. Conductor of house wiring cable shall be made of copper. The size of copper house wiring ranges from 1 sq. mm to 10 sq. mm.Current carrying capacity of PVC insulated copper conductor 660 V/1100 V grade wires are given in table 7.2 and 7.3

7.3. Flexible cables

Flexible cable shall conform to BTS IEC 60227. Conductor of flexible cable shall be made of copper and tinted copper with minimum cross section of 0.5sq.mm. Flexible cables are multi-stranded of cross-section area of the strand ranges from 0.2 to 0.5sq.mm. The insulation rubber of the three core flexible cable shall normally be coloured red, black and green, denoting phase, neutral and earth wire respectively. Current carrying capacity of PVC insulated copper conductor 660 V/1100 V grade flexible wires are given in table 7.1

Table 7.1 Current carrying capacity of PVC insulated copper conductor 660 V/1100 V grade flexible wires

Wire details		Cross section in sq. mm	Current in ampere
Single and multicore round		0.5	4
		0.75	7
		1	11
		1.5	14
		2.5	26
		4	29
Single core		6	33
		10	45

7.4. Power cable

Cable for application of low and medium voltage supply are PVC insulated, PVC sheathed, steel wire/strip armoured and non-armoured conforming to BTS IEC 60502. Power cables are available in 1 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 for single core. Voltage grade for low voltage cable shall be not less than 1.1 kV. Cable is manufactured with aluminium conductor as well as copper conductor. Steel wire or strip used for armouring shall be galvanized. The armouring at both ends of the cable shall be connected to an earth electrode and the length of single core cable run shall not exceed 30m. Incoming cable (service mains)should be selected for future loads.

Table 7.2 and 7.3 gives current carrying capacity of various cables of 1.1 kV grade.

Table 7.2: Current Rating in Amps for 650/1100 V Unarmoured or Non-Magnetic Armoured PVC Cables as per IS 1554(I)

Nominal Area Of Conductor (Sq. mm.)	3core, 3.5core, 4core				2core				3 Single Core			
	Laid In Ground		Laid In Air		Laid In Ground		Laid In Air		Laid In Ground		Laid In Air	
	Copper	Aluminium	Copper	Aluminium	Copper	Aluminium	Copper	Aluminium	Copper	Aluminium	Copper	Aluminium
1.5	21	16	17	13	23	18	20	16	22	17	20	15
2.5	27	21	24	18	32	25	27	21	30	24	27	21
4	36	28	30	23	41	32	35	27	39	31	35	27
6	45	35	39	30	50	40	45	35	49	39	44	35
10	60	46	52	40	70	55	60	47	65	51	60	47
16	77	60	66	51	90	70	78	59	85	66	82	64
25	99	76	90	70	115	90	105	78	110	86	110	84
35	120	92	110	86	140	110	125	99	130	100	130	105
50	145	110	135	105	165	135	155	125	150	120	165	130
70	175	135	165	130	205	160	195	150	190	140	205	155
95	210	165	200	155	240	190	230	185	220	175	245	190
120	240	185	230	180	275	210	265	210	250	195	280	220
150	270	210	265	205	310	240	305	240	280	220	320	250
185	300	235	305	240	350	275	350	275	305	240	370	290
240	345	275	355	280	405	320	410	325	345	270	425	335
300	385	305	400	315	450	355	465	365	375	295	475	380
400	425	335	455	375	490	385	530	420	400	325	550	435
500	470	370	540	425	520	415	575	455	425	345	590	480
630	515	405	610	480	565	460	655	520	470	390	660	550
800									530	440	770	640
1000									590	490	865	720

Table 7.3: Current Rating in Amps for 650/1100 V Unarmoured or Non-Magnetic Armoured HR PVC Cables as per IS 1554(I)

Nominal Area Of Conductor (sq. mm.)	3core, 3.5core, 4core				2core				3 Single Core			
	Laid In Ground		Laid In Air		Laid In Ground		Laid In Air		Laid In Ground		Laid In Air	
	Copper	Aluminium	Copper	Aluminium	Copper	Aluminium	Copper	Aluminium	Copper	Aluminium	Copper	Aluminium
1.5	23	18	20	16	31	24	26	20	25	20	21	16
2.5	32	25	28	21	41	32	34	27	33	26	28	22
4	41	32	38	29	52	41	46	36	44	34	38	30
6	51	40	47	37	68	53	58	45	53	42	48	38
10	68	53	65	50	89	69	82	63	72	56	67	51
16	90	70	86	67	114	89	106	84	91	72	89	70
25	114	90	113	90	147	115	149	113	119	92	122	95
35	137	110	140	109	178	138	180	140	142	110	149	118
50	164	128	171	131	211	161	217	172	169	133	177	141
70	201	156	213	168	257	198	276	213	207	161	230	181
95	243	188	263	204	307	239	340	268	248	193	290	227
120	275	216	308	240	344	271	395	309	285	220	335	263
150	307	239	349	272	385	303	449	354	315	248	386	300
185	349	271	404	318	437	345	518	409	355	280	450	350
240	399	312	481	377	505	399	617	490	411	326	530	418
300	446	354	544	431	569	450	717	563	462	368	617	481
400	505	404	627	500	634	515	826	663	524	418	717	563
500	550	450	708	572	706	579	944	763	591	469	817	654
630	616	515	808	672	790	653	1090	900	662	542	935	763
800									735	607	1062	881
1000									798	671	1190	1000

7.5. 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. The voltage drop at the dead end or final end shall not be more than 6% regulation. When deciding cable size, the derating factor for type and depth of burial, bunching, ambient temperature, ground temperature and soil resistivity shall be taken into account.

$I = kW / (V_P x\ pf)$ for single phase

$I = kW / (\sqrt{3} x\ V_L x\ pf)$ for three phase

Where

I = Current in amperes
KW = Kilowatt
V_P = Phase Voltage in volts
V_L = Line Voltage in volts
pf = Power factor without external capacitor

If many cables are laid together then a grouping factor will be applicable on the current. Grouping factor for cables is given in table 6.4. As the ambient temperature is not more than 40^0 C in Bhutan and the ground temperature at 75 cm depth is not more than 30^0 C, correction factors will not be applicable on these accounts.

If the overall de-rating factor is k, then the cable should be selected from Table 7.1 & 7.2. The current carrying capacity of the selected cable will be reduced by k times.

Table 7.4 Group rating factor for multi-core cables					
(a)Cables laid inside concrete trench with removable covers where air circulation is restricted, the cables separated by 1 cable diameter horizontally and the trays are in tiers with 30 cm gap between them. The clearance from wall is 25 cm.					
No. of cable trays in tier	No. of cables				
	1	2	3	6	9
1	0.95	0.90	0.88	0.85	0.84
2	0.90	0.85	0.83	0.81	0.80
3	0.88	0.83	0.81	0.79	0.78
6	0.86	0.81	0.79	0.77	0.76
(b) Cables laid on cable trays exposed to air, the cables separated by 1 cable diameter horizontally and the trays are in tiers with 30 cm gap between them. The clearance from wall is 25 cm.					
No. of cable trays in tier	No. of cables				
	1	2	3	6	9
1	1	0.98	0.96	0.93	0.92
2	1	0.95	0.93	0.90	0.89
3	1	0.94	0.92	0.89	0.88
6	1	0.93	0.90	0.87	0.86
(c)Cables laid on cable trays exposed to air, the cables touching and the trays are in tiers with 30 cm gap between them. The clearance from wall is 25 cm.					
No. of cable trays in tier	No. of cables				
	1	2	3	6	9
1	1	0.84	0.80	0.75	0.73
2	1	0.80	0.76	0.71	0.69
3	1	0.78	0.74	0.70	0.68
6	1	0.76	0.72	0.68	0.66

7.6. Cable storage and handling

Cable drums shall be stored on well-drained, hard surface preferably concrete floor so that the drum does 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 stored under a roof with proper ventilation to adequately dehumidify the store yard.

During storage, periodical rolling of the drum up to 90^0 shall be done once in three months. The rolling shall be done as per direction of the 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 a short distance, it shall be rolled in the direction of the 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 crane used to load and unload the cable drums.

Alternatively, when a crane is not available, the drum shall be rolled carefully by ensuring that the surface material does 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.

7.7. Cable installation

Prior to laying the cable, proper right of route shall be confirmed. Simultaneously, necessary clearance shall be obtained from relevant agencies.

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. The Cable route shall be as short as possible. However, cross-country shall not be permitted to take the shortest route. The cable route shall follow fixed developments such as parallel to roads, footpaths and water supply line etc. Route identification marks shall be maintained and proper drawings shall be kept in proper custody for future maintenance.

While selecting cable line routes, 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 cables of different voltage level in the same trench but in different trays to minimize the cost of laying the cables. When a cable of different voltage level is laid in the same trench, the cable of the highest voltage level shall be at the lowest level. Power and communication cables shall not run in the same trench. The crossing of power and communication cables shall be made at right angles and where power cables are laid in proximity to communication cables, radial spacing of not less than 60 cm shall be provided.

7.7.1 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 the environmental conditions. The brief description on the above methods and application of laying the cable is described below.

(a) 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 35 cm and 75 cm respectively. After the cable is laid, dry sand to a depth not less than 17 cm shall be provided over the cable. Mechanical protection over the sand covering with second-class brick, stone or prefabricated slab of minimum 5 cm thick shall be provided. In case of protection with 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 layers not exceeding 30 cm. 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 for subsidence. Cable markers must be provided at every 25 m and at every bend in the ground. Cables should not be laid in the ground without showing the route on a drawing.

(b) 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.

(c) Laying in closed duct or trench

Laying of cable in closed duct or trench is preferred in the densely 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 more 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 below:

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

(d) Laying on surface or open duct

Laying of cable on the 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 the surface.

7.7.2 Cable Termination & Jointing

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

A Cable joint should be provided only if the length of LT cable is more than 200 m for size above 240 sq. mm or more than 300 m for size above 150 sq.mm or more than 500 m for size below 150 sq. mm. Cable drums are easily available for the above-mentioned length.

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

Cable termination should be carried out by using the proper type and size of cable glands and lugs. Termination of cables up to 1.1 kV grade shall be done by using compression gland. All outdoor terminations should be done by double compression glands only. Indoor terminations should preferably be done by double compression glands but single compression glands may be acceptable.

The nipple of the gland is first screwed to the switchgear to which the cable is to be terminated and locked with a check nut from inside the housing.

The Compression ring, washer, rubber ring and another washer are slipped in succession over the cable. The cable sheath is removed to the desired length and armour strands splayed out. The armour wire should then be cut to the overall diameter of the second washer. Sharp edges should be removed and armour should be 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 high voltage cables, the termination box shall be properly sealed with cable jointing compound and there shall be no cavity or pinhole to allow ingress of the moisture or leakage of oil. All connections shall be done with correct rating cable socket.

8. Wiring

8.1. Internal Wiring Practices

8.1.1 Circuit Wiring

Circuit wiring shall mean the portion of wiring from the sub distribution board to the switchboards. Where the circuit wiring is looped to more than one switchboard, the wire size should remain the same. The measurement of the circuit wiring shall be on a linear basis and the unit shall be in meters. There shall not be more than 8 points and the load shall not exceed 800Watts.
The size of wire for circuit wiring is 2.5 sq. mm.

8.1.2 Sub-Main wiring

Sub-main wiring is the wiring from the outgoing terminal of the main switchboard to the sub distribution board (s). The measurement of such circuit wiring shall be on a linear basis and the unit shall be in meters.

8.1.3 Power Sub Distribution Board Wiring

In a large building/premises where the provision of MDB and sub distribution board alone is not feasible, a power Sub Distribution Board needs to be provided. The power Sub distribution Board wiring shall be from the out-going terminal of the MDB (control panel bus bar) to the incoming terminal of the power Sub distribution Board. The measurement of such circuit wiring shall be on a linear basis and the unit shall be in meters.

8.1.4 System of wiring

When the demanded load of the building or premises exceeds more than 12kW, three phase wiring shall be carried out. Lighting circuit and power circuit shall be separated from the Sub distribution board in all types of wiring. Connected load of the circuit shall be equally distributed. In case of three-phase wiring, balancing the load among the phases shall be carried out in such a way that the difference in the loading of each phase does not exceed 5% Due consideration shall be given to neatness, good appearance, safety and electrically and mechanically sound connections.

8.1.5 Joints & Looping back

The wiring shall be done in the “Looping system”. Both live and neutral conductors shall be looped at the switch box. Where a joint box is unavoidable, mechanically and electrically sound connectors shall make all joints in a suitable and proper junction box. In both systems of wiring no bare or twisted 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. Brass connectors are suitable for mechanical and electrical connections.

8.1.6 Passing through wall

When conductors pass through walls, care shall be taken to see that wires pass freely through protective pipe or box and that wires pass through in a straight line without any twist or cross in the wires. Any one of the following methods may be adopted:

(a) A box made of hard wood or equivalent extending through the entire thickness of the wall and buried in the wall with hole suitably made to pass the conductor easily.

(b) A suitable conduit approved by the Engineer that permits easy drawing in. The ends of the conduit shall be smoothly filled or neatly bushed to prevent insulation damage.

8.1.7 Passing through floor

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

8.1.8 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. Where the bunching of the return wire is not possible, the pipe shall be properly bonded with the earth wire.

8.1.9 Conduit joints

Conduit pipes shall be joined by means of a threaded conduit socket or accessories only. In long straight run conduits couplers/inspection boxes at reasonable intervals shall be provided. The end of the pipe shall be properly threaded and each joint shall be coupled with proper jam nuts. The entire threaded portion shall be treated with preservative compound to protect from rust. Use of bends or elbows shall be avoided as far as possible.

Wherever possible, the pipe itself shall be bent with a bigger radius to permit easy drawing of the conductor. Cut edges of the conduit shall be filled properly to maintain smooth edges to avoid damage to insulation.

8.1.10 Protection against Condensation

Condensation will take place where the recessed conduit is fixed on the bathroom or kitchen floor and accessible to water or sewerage pipeline. In order to protect from condensation, the layout of conduit should be such that any condensation or sweating inside the conduit can be drained out. A junction box may have to be provided to drain out the condensed water. At the same time, suitable precaution shall be taken to prevent entry of insects inside the conduit.

8.1.11 Protection of conduit against rust

If the materials are 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 the 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 the bare threaded portion is treated with anticorrosive preservation or covered with an approved plastic compound.

8.1.12 Painting of conduit 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 pipe, HDPE pipe and casing capping unless otherwise specified.

8.1.13 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 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 SWG for conduits up to 25 mm dia. and not less than 20 SWG for larger diameters.

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

Table 8.1 Width and thickness of the ordinary clips or glider clips and clamps

Sl No.	For clamps or ordinary clips		
	Size of conduit	Width of saddle clips	Thickness of clip
1	20 mm	20 mm	20 SWG
2	25 mm	20 mm	20 SWG
3	32 mm & above	25 mm	18 SWG

8.1.14 Glider Clips

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

8.1.15 Bends in conduit

All necessary bends in the system including diversion shall be done by bending pipes or by inserting suitable solid or inspection type threaded bends or junction box. As far as possible, conduit fittings and accessories shall not be exposed to weather. Where necessary solid type bends shall be used. Radius of bends in conduit pipes shall not be less than 7.5 cm

8.1.16 Erection and earthing of conduit

Fixing of conduit shall be completed in all respects before the wires are drawn. After completing the fixing of conduit, it shall be tested for mechanical rigidity and electrically sound continuity throughout its running length. Gas or water pipe shall not be used as an 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 be properly bonded to conduit pipe where possible to ensure uniform grounding effect.

8.1.17 Recessed conduit-wiring system

Recessed conduit wiring systems shall comply with all the requirements of surface conduit wiring systems except for the requirements specified in the following clauses.

8.1.18 Making of chase

The chase in the wall shall be neatly made and of 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.

8.1.19 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 rusting.

8.1.20 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 for condensation and heat radiation.

8.2. Wiring System

The wiring shall be carried out as per the design. Power and lighting circuit wirings shall be drawn separately. 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, open wiring run above the false ceiling shall be allowed. In all types of wiring, due consideration shall be given to neatness, good appearance and safety.

8.2.1 Batten Wiring

(a) General

This system of wiring is suitable for low voltage installation and shall not be used in places exposed to sun, rain and dampness except with special protective covering.

(b) Batten wiring system

PVC insulated and sheathed cables on the timber surface, plastered brick or stone masonry walls and ceiling shall be run on well-seasoned, straight hardwood battens properly varnished on four sides. Where wiring is to be carried along the face of rolled steel joists, a wooden batten of adequate width shall first be laid on the joist and clipped to it as prominent as possible. The wiring shall then be fixed to this backing as per usual practice.

(c) Fixing wooden batten

Hard wood battens of thickness up to 12mm shall be rigidly screwed/nailed at 500mm intervals with suitable screws of 40mm length for plastered brick/stone masonry walls and plastered RCC ceilings, turned in PVC sleeves inserted in neatly drilled holes of appropriate size. For wooden surface, the batten shall be fixed directly with 32mm screws/nails. Providing and fixing of wooden battens shall include bends, elbows, corners, round blocks link and clips etc. including painting/varnishing and shall be run in horizontal or vertical position as required. The varnished batten shall be provided with panel pins at 150mm gaps both in horizontal and vertical laying. The unit of measurement shall be in meters, measured to the nearest cm. The sizes of wooden batten required are given below:

(i) 13 mm x 10mm thick,

(ii) 19 mm x 10 mm thick

(iii) 25 mm x 10 mm thick

(iv) 32 mm x 10 mm thick

(v) 40 mm x 12 mm thick

(vi) 50 mm x 12 mm thick

(d) Fixing links and clips

Link clips shall be nailed with 12mm panel pins to the wooden batten at 150mm intervals both in horizontal and vertical positions. The clips shall be of Aluminium alloy of size: 0.32mm thick for lengths from 25 to 40mm and 0.40mm thick for lengths from 50 to 80mm. The width shall not be less than 8mm. Wires to be clipped with clips of different sizes are shown in the table below:

Table 8.2 Wires to be clipped with clips of different sizes

Wire size	**Clip size of 20 to 40 mm**		**Clip size of 50 to 80 mm**	
	Twin core	**Single core**	**Twin core**	**Single core**
1.5 mm ^{2}	2	3		
2.5 sq. mm ^{2}	1	2		
4 mm ^{2}			2	3
6 mm 2			1	2

(e) Fixing the wires on the batten

The wire shall be properly dressed, straightened and neatly clipped on the battens. Care shall be taken that the links do not come out from the clips. When more than one clip is required on the same batten, the spacing between the clips has to be so arranged that no gap is visible after clipping the wires.

(f) Providing earth continuity wires

The earth continuity wire shall be provided in the link clip throughout the length of wiring. The size of earth continuity wire shall not be less than 1.5 sq. mm (16SWG) and 2. 5sq.mm (14SWG) PVC insulated/bare copper wire for light and power circuits 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.

8.2.2 PVC Casing and Capping

(a) 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. In damp or poorly ventilated places PVC casing and capping wiring shall be done with 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 1.5mm for sizes up to 25mm and 1.6mm 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 includes bends, elbows, tees, inside and outside corners, round blocks and painting. It can be run 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.

(b) 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 (16 SWG) and 2. 5sq.mm (14 SWG) PVC insulated/bare copper wire for light and power circuits 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. When bare conductor is used for earth continuity it should be provided outside the conduit.

(c) Size and Measurement

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

(i) 12mm x 12mm x 1.2mm thick,

(ii) 20mm x 12mm x 1.2mm thick,

(iii) 25mm x 12mm x 1.2mm thick,

(iv) 32mm x 12mm x 1.5mm thick,

(v) 40mm x 12mm x 1.5mm thick,

(vi) 50mm x 12mm x 1.5mm thick,

8.2.3 PVC Conduit/HDPE pipes

(a) 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 conform 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 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 a spacing of not more than 50cm. Saddles shall be provided at the ends of pipes if bend and circular boxes are used. The saddles are to be rigidly fixed on the wall with wooden/PVC 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 shall be drilled by motor drills using appropriate size bits to required depth. In case of conduits laid on a wooden surface, the screws of 25mm length shall be directly screwed and no sleeve is required.

(b) Concealed

Providing and fixing of PVC conduit pipes includes bends and circular boxes including painting. Providing and fixing of PVC conduit pipe 1.8 mm thick for size up to 25mm and 2mm thick for sizes from 32mm to 50mm. It can be run 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 shall be secured by binding wire tied on the nail to hold it until the plastering sets to its strength. In the case of the pipes laid in RCC works, it shall be tied securely by binding wire to the external reinforcement bars and should be flushed with the ceiling surface.

Laying of pipe diagonally can be permitted in the brick/stone masonry wall, provided there is no crossing with other pipes or change in direction.

PVC conduits pipe can be replaced by HDPE pipe wherever necessary.

(c) 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) PVC insulated/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. When bare conductor is used for earth continuity it should be provided outside the conduit.

(d) PVC conduit size

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

(i) 19 mm diameter

(ii) 25 mm diameter

(iii) 32 mm diameter

(iv) 40 mm diameter

(v) 50 mm diameter

8.2.4 MS Conduits

(a) 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 a spacing of not more than 100cm. Saddles shall 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/PVC 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 shall be drilled by motor drills using appropriate size bits. In case of conduits laid on a wooden surface, 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 MDB/DBs/SDBs where the wiring terminal ends from the pipe. Threading shall be provided at the pipe edge up to 20mm.

(b) Concealed

Providing and fixing of MS conduit pipe of specified gauge as indicated against the sizes mentioned hereunder, run in horizontal or vertical position as required. It should be embedded in the wall to a depth from 16mm to 25mm from the finished plaster level. Where applicable, the pipe shall be secured by binding wire tied on the nail to hold it until the plastering sets to its strength. In case of the pipes laid in RCC works, it shall be tied securely by binding wire to the external reinforcement bars and should be flushed with 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.

(c) 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) PVC insulated/bare copper wire for light and power circuits 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. When bare conductor is used for earth continuity it should be provided outside the conduit.

(d) Conduit size and Measurement

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

(i) 20mm diameter x 18SWG thick,

(ii) 25mm diameter x 16SWG thick,

(iii) 32mm diameter x 14SWG thick,

(iv) 40mm diameter x 14 SWG thick,

(v) 50mm diameter x 14 SWG thick

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

8.2.5 Steel Conduits

(a) 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 a spacing of not more than 30cm. The saddles shall be provided at the end of bends, circular boxes and tees. The saddles are to be rigidly fixed on the wall with wooden/PVC 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 shall be drilled by motor drills using appropriate size bits. In case of conduits laid on a wooden surface, screws of 25mm length shall be directly screwed and no sleeve is required.

(b) 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) PVC insulated/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. When bare conductor is used for earth continuity it should be provided outside the conduit.

(c) Conduit size and measurement

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

(i) 20 mm diameter

(ii) 25 mm diameter

(iii) 32 mm diameter

(iv) 40 mm diameter

(v) 50 mm diameter

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

Table 8.3: 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

Size of cable in mm^2		Size of Casing Capping mm				
Nominal Cross sectional area in mm^2	12/16x12 mm	20x12 mm	25x12 mm	32x20mm	40x20 mm	50x20 mm
1.0	3					
1.5	2	5	6	8	12	18
2.5	2	4	5	6	9	15
4.0		3	4	5	8	12
6.0		2	3	4	6	9
10		1	2	3	5	8
16			1	2	4	6
25				1	3	5
35					2	4
50					1	3

Table 8.4: 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**	
	Straight run (S)	**Bends (B)**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**
1.5	4	5	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

8.3. Point Wiring

Point wiring shall include all works necessary for complete wiring of length up to 10m, including switch and circuit up to the 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.

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 m shall be measured on linear basis.

8.4. Supplying and fixing of boxes (Surface/ recessed)

8.4.1 Wooden board, PVC and Steel boxes

Wooden boxes (hard wood), PVC boxes and steel boxes are normally available ready made 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 8.5 Sizes of wooden, PVC and steel boxes

Hard wooden boxes	PVC boxes		Steel boxes
	Without shutter	With shutter	
4” X 4” X 21/2 “	31x86x 20 mm	31x 86x20 mm	31x 86x 20 mm
6” X 4” X 21/2”	86x86x20 mm	86x86x20 mm	86x86x20 mm
8”x6”x21/2”	86x86x40 mm	86x86x40 mm	86x86x40 mm
10”x8”x21/2”	146x86x40 mm	146x86x40 mm	146x86x40 mm

8.4.2 MS boxes

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

(a) 60 x 60 x 60 mm

(b) 75 x 75 x 60 mm

(c) 150 x 150 x 60 mm

(d) 180 x 100 x 60 mm

(e) 200 x 125 x 60 mm

(f) 200 x 150 x 60 mm

(g) 200 x 150 x 100 mm

(h) 200 x 250 x 100 mm

(i) 200 x 300 x 100 mm

(j) 250 x 300 x 100 mm

(k) 300 x 380 x 100 mm

(l) 300 x 450 x 100 mm

8.5. Accessories

(a) Types of accessories to be used

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

(b) 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, 10-ampere rating switch shall be used for 10 A socket outlet and 16-ampere rating switch shall be used for 16 A socket outlet. Switch shall be so connected that the circuit is opened when button position is “UP” and the circuit is closed when the button position is “DOWN”.

(c) Lamp holders

Lamp holders for use on brackets and the like shall have not less than 1.3 cm nipple and 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.

(d) Ceiling Rose

A ceiling rose or any other similar attachment shall not be used on a circuit, the voltage of which normally exceeds 230 volts. Normally only one flexible cord shall be attached to a 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.

(e) Socket Outlets

A socket outlet shall not necessarily have a fuse terminal as an integral part of it. A fuse/MCB may be provided which shall be non-reversible and so arranged that the fuse/MCB is connected to the live conductor. A switch shall control every socket outlet. 10/16 amperes socket outlet point shall normally be fixed at 25 cm above the floor level. In the case of a toilet and kitchen, it shall be placed at 1.25 m above the floor level. 6 amperes sockets are normally placed at 1.25 m above the floor level. When 6 ampere rating is required at 25cm above floor level, a 6/16-ampere socket outlet shall replace the 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 an electrical appliance with a socket outlet shall be of the flexible twin core with an earthing cord that shall be secured by connecting between the earth terminal of the plug and the metallic body of the electrical appliance. The socket outlets used at 25cm above floor level shall be of the shutter or interlocking type.

(f) Telephone Socket outlet

Telephone Socket outlet shall be 2pin, RJ11 type. It is normally mounted at 25cm above the floor level. The socket and line shall be minimum 0.5m away from any electrical point or wiring of 230 volts.

(g) Internet socket outlet

Internet socket outlet shall be 2 pin, RJ 45 type. It is normally mounted at 25cm above the floor level. The socket and line shall be minimum 0.5m away from any electrical point or wiring of 230 volt.

(h) Industrial socket outlet

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

(i) Attachment of fittings and accessories

In casing capping and wooden batten wiring, accessories like ceiling roses, brackets, batten holders and stiff pendant holders shall be mounted to the 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 MS conduit wiring, all accessories like switches, socket outlets, call bell pushes and regulators shall be fixed in a flush pattern inside metal boxes conforming to relevant standards. Accessories like ceiling roses, brackets, stiff pendants etc. shall be fixed on metal outlet boxes, which shall be bonded to earth wires.

In case of HDPE /PVC conduit wiring, all accessories like switches, socket outlets, call bell pushes and regulators shall be fixed in a surface pattern inside PVC boxes conforming to relevant standards. Accessories like ceiling roses, brackets, stiff pendants etc. shall be fixed on PVC boxes.

8.6. Compound/Street Lighting Work

8.6.1 Steel tubular poles

Steel tubular poles shall conform to BTS/IEC/IS 2713(I-III)-1980.They shall be of seamless/swaged and welded type as specified and shall be in three stepped sections. Unless otherwise specified, $1/6^{th}$ 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 pole 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 $1/6^{th}$ of 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.

8.7. Painting

8.7.1 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.

8.7.2 Application

Paint shall be applied by spraying or by 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 smaller containers with a smooth stick while it is being applied.

8.7.3 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.

8.7.4 Painting of conduit and accessories

After installation, all accessible surfaces 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.

9. Lighting and Miscellaneous Appliances

9.1. Types of lamps

9.1.1 Incandescent lamps

Incandescent light bulbs 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 screw-in base 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:

(a) GLS Clear/Pearl/Argenta

These lamps shall be of tungsten filament for general lighting services with advantages of instantaneous light, low installation costs and warm colour tone for a wide variety of interior/exterior lighting applications. Wattage (W): 25, 40, 60, 100, 150, 200, 300 and 500. These shall be of good colour appearance, instantaneous operation and suitable for dimming.

(b) Argenta Superlux Lamps

These type of 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. Wattage (W): 40 and 60

(c) Special Incandescent Lamps

(Pygmy, Candle, Night/Decoration and Clear): These 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, etc Wattage (W): Clear – 15, Night – 0, Coloured – 15, Decoration Candle – 25, and Pygmy – 15

(d) Miniature Lamps

shall be of such a design to give a long, trouble free service. When used in a properly designed parabolic reflector, shall produce a sharp beam of light. These shall be suitable for operation on a low voltage D.C source like dry cells or battery, e.g. Flash lamps used in Torches and Miner's bulbs used in Miner's cap lamps.

9.1.2 Reflector Lamps

Reflector Lamps are intended to give directional light with substantially higher level of luminance as against normal incandescent lamps of comparable wattage. These shall have a satin frosted front finish and high efficacy internal mirror reflector to achieve high intensity homogenous beam. Reflectors shall be of wattage 75, 100 and 150 W. Spotlighting colour lamps shall have silicon lacquer coating in different colours and shall provide a wealth of possibilities for creating distinctive lighting effects. These shall be of the wattage 40, 50 and 60W. 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. It shall be of wattage 250W.

9.1.3 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 a 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. It shall be normally of wattage 20 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. Single ended shall be of 12W and double ended shall be of 100, 150, 200, 300, 500, 750 and 1000W depending of types like compact, small or large.

9.1.4 Compact Fluorescent Lamps (CFLs)

These 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, shall often be integrated with a ballast, and many shall have a screw base identical to conventional incandescent lamps. It shall be in two categories:

Retrofit – which can directly replace ordinary bulbs like GLS 25W, 40W, 60W, 100W, etc. and

Non-Retrofit – which requires special luminaires with built-in ballast.

The CFLs shall have features like high lamp efficacy, low wattage and Tri band Phosphors. It shall be compact, light in weight and consist of narrow fluorescent tubes. The Non-Retrofit shall have a standardized base with two or four pins depending of the design. The geometry of CFLs available shall range from twin tubes to quad tubes to “F-lamps” to circlines to “double-D” lamps. They shall have a lifetime of about 10,000 hours and shall be dimmable only with dimmable ballast.

9.1.5 Fluorescent Lamps

These are basically low-pressure mercury vapour lamps and have the advantages of low wattage consumption and higher efficiency. In addition to the tube with its electrodes, gas fill, and phosphors, fluorescent lighting systems shall require ballast to condition electric power from the utility in order to produce the voltage and current characteristics required by the fluorescent lamps. It shall have triple coil construction for long trouble-free service life, high luminous efficacy and shall be aesthetically appealing. It shall not have black ends over life due to Anode Ring. It shall be of 18, 36 and 58W with Operating Lamp current of 0.37, 0.44 and 0.68A respectively. Fluorescent lamps for operation in switch start circuits on A.C mains shall be of 20, 40 and 65W with Operating Lamp current of 0.38, 0.44 and 0.67A respectively. 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 and shall be dimmable but only with proper control and ballast.

9.1.6 High Intensity Discharge Lamps (HID Lamps)

High intensity discharge light sources shall include Mercury vapour lamps, Metal Halide lamps and Sodium Lamps. They shall require ballasts similar to fluorescent lighting. HID lamps shall be available in wide range of wattage from 35 to 2000. They shall have a lifetime of 10,000 to 24,000 hours and shall not normally be dimmable.

(a) Mercury vapour lamps

Shall have a quartz discharge tube enclosed in an internally phosphor coated outer shell and have a universal burning position. They shall have high luminous efficacy, short run-up time and light output shall not be effected by temperature variations.

(b) 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.

(c) Sodium Lamps

High-pressure sodium vapour lamps shall have 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 electro-statically. The discharge tube shall contain an amalgam of mercury and sodium along with Xenon gas as starting aid. They shall have a very short run-up time and rapid re-strike time, excellent lumen-maintenance, and high efficacy.

Low-pressure sodium vapour lamps shall have a discharge tube enclosed in a clear tubular bulb. They shall attain the highest luminous efficacy of any light source. 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 do not require any control gear. They shall have outer envelope coated with phosphor to give good colour rendition, shall have high luminous efficacy, and internal tungsten filament shall act as ballast.

9.1.7 Light Emitting Diode (LED) lamps

LED lamps are Energy Efficient. LED lamps are available in the form of bulbs and tubes.LED Lamps comprise of built-in or independent module type and must comply with BTS IEC 62031/BTS IEC 62560/62612/62717/62776. Built-in self-ballasted LED modules are generally designed to form a replaceable part built into a luminaire, a box, an enclosure or the like and not intended to be mounted outside a luminaire, etc., without special precautions. Independent LED modules are so designed that it can be mounted or placed separately from a luminaire, an additional box or enclosure or the like. The independent LED module provides all the necessary protection with regard to safety according to its classification and marking. In addition to one or more LEDs it may contain further components like optical, mechanical, electrical and electronic but excluding the control gears.

9.2. Luminaires (Indoors)

9.2.1 Home lighting Luminaires and Professional battens

The luminaire 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, specially designed lamp holder and starter holder with starter, all pre-wired up to 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 shall be provided with a specifically designed connector, which has a provision for the main input.

-The luminaire shall be suitable for fixing on the wall/ceiling or suspension mounting with a conduit.

The surface mounted and recessed luminaire 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 luminaire 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 to prevent the luminaire from tripping. The lamp unit shall house the lamp holder and a reflector. Each luminaire shall be provided with an on-off switch.

9.2.2 Luminaries for Commercial areas

The objective of lighting in commercial indoor areas is to create an optimum ambience combined with high efficiency; good glare protection and maximum comfort.
The luminaire 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 up to 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 luminaire shall be suitable for pendent or ceiling mounting. The decorative recess mounted luminaires 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 the connector block and a louver/diffuser with a metal frame which shall be provided with mechanisms for fixing onto the housing. The luminaire shall be suitable for surface/conduit mounting.

9.2.3 Luminaries for decorative and accent lighting

Recessed/Semi-recessed downlighter suitable for use with reflector lamps and incandescent lamps shall be provided with a pair of mounting clips for easy installation at site. The luminaire shall consist of a ceiling ring made of suitable material, painted white. A connector system made of glass-filled nylon shall be provided for cable termination. The luminaire shall also be provided with an adjustable swivelling unit for adjusting lamp direction in the vertical plane.

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

Surface mounted luminaire suitable for use with CFLs shall consist of a housing made of mild steel, painted suitably. 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.

9.2.4 Luminaries for Industries uses

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

- mounting channel made of CRCA sheet steel stove enameled 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 enameled white, fixed by means of two knurl head screws. Stove enameled 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 steelpainted 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.

9.2.5 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.

9.2.6 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:

(e) a housing made from die-cast aluminium with low copper content offering excellent corrosion resistance painted black

(f) an eyebolt of 30mm inside diameter for suspension

(g) anodized aluminium reflector

(h) toughened glass cover assembly with safety chain

9.2.7 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^{o}C. Such fittings are normally used in ammunition go-down, chemical laboratories, painting workshop, POL de-pot, gas go-down etc.

9.3. Luminaires (Outdoor)

9.3.1 Road lighting luminaires

Road 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 luminaire which shall determine the spacing of the luminaries on a given road. They shall ensure complete immunity of the housing from insects and rainwater. The luminaire suitable for the fluorescent lamps shall comprise of a sheet aluminium canopy finished in stove grey, detachable CRCA sheet stove enamel white reflector-cum-control gear tray with pre-wired ballast(s), capacitor, starter(s), and other accessories up to the connector block. 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 luminaire shall be suitable for side entry mounting and shall also be supplied with top suspension arrangement if required.

Street lighting luminaries suitable for use with 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 performance without the ingress of water and insects.

Compact Post-Top lanterns suitable for use with sodium vapour and other HID lamps shall have a cast aluminium spigot for mounting and an opal acrylic diffuser to provide soft, diffused light.

9.3.2 Luminaires for Environment lighting

Post-Top luminaire suitable for use with high pressure sodium vapour lamps, high pressure mercury vapour lamps and blended light lamps shall have 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 performance outdoors without the ingress of water.

The housing shall be made of coloured Fiberglass Reinforced Plastic (FRP). A clear acrylic cover shall protect the housing from the immediate environment.

9.3.3 Floodlighting Luminaries

Floodlighting luminaries 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 without the ingress of water.

9.4. Calculation of lighting

Lighting in special areas should be based on lux level requirement. Improper lighting reduces work efficiency and makes the environment dull. The following points are important and should be given due consideration at the time of deciding the lighting.

(a) Working time – Lighting requirement may be less if working time is day only. It will increase with night working.

(b) Day lighting – If the building is planned to have good day lighting then lighting requirement during day can be substantially lower.

(c) Object oriented lighting – Lighting should be designed to have it on the required place only.

(d) Colour rendering – Lamps should be selected to suit the requirement. In art gallery fluorescent lamps should not be used.

(e) Working plane – In offices the working plane is top of the tables. Lighting should be suitable for maximum illumination at the tables.

The number of fixtures required in an area can be calculated as under:

$$N = L \times d \times w / (L_m \times COU \times f_m)$$

where

N =Number of fixtures
L =Lux level required
d =Length of the room
w =Width of the room

L_m = Lumen output of the selected fixture when the fixture is new
COU = Coefficient of utilisation
f_m = Maintenance factor

Appendix B gives figures of lux level requirement in some important areas.

Coefficient of utilisation is worked out from the table given by the lighting fixture manufacturers. It depends on the reflection factor of the surroundings and room index of the area to be illuminated.

$$\text{Room index} = d \times w/((d + w) \times h)$$

Where h is the height of the lighting fixture from working plane.

The light output of the fixture will be always higher when it is new. Withaging and settlement of dirt on the fixture lumen output reduces. After cleaning the output increases but it does not reach the original value. Lighting should be designed to average output of the fixture during its lifetime. This factor is called the maintenance factor of the fixture. In commercial complexes the frequency of cleaning is more hence the maintenance factor should be considered between 0.7 and 0.8. Maintenance factor for offices should be taken between 0.65 and 0.7. For industrial installations it should be 0.6. For specific details refer manufacturer data.

The Coefficient of utilization factor is defined as “the ratio of the total lumens received on the working plane to the total lumens emitted by the light source. It shall be considered as 0.8. For specific details refer manufacturer data.

9.5. Miscellaneous Appliances

Ceiling fan, Exhaust fan, fan regulator, immersion water heater, geyser, electric stove, room heater, electric iron, induction cooktop, air conditioner, refrigerator,rice cooker,curry cooker, water boiler, vacuumcleaner,drier,mixture,microwaveoven,washing,machine,dishwasheretc. are important appliances used in buildings. Some of the appliances commonly used are described here below:

9.5.1 Ceiling fans

Ceiling fans including their suspension shall conform to **BTS IEC 60335**. All ceiling fans shall be wired, ready for connection to ceiling roses and to suspend on hooks. There shall be no joint in the suspension rod. For wooden joists and beams, the suspension shall consist of MS 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 bent 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 MS 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 nut & bolt. 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 a building with a concrete roof having a low ceiling height i.e. less than 2.5m, ceiling fans 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. A minimum clearance between the blade of fan and the ceiling of not less than 23cm shall be provided. Alternatively, wall fan, cabin fan and pedestal fan may 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/yellow/blue, 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.

9.5.2 Exhaust fan

Exhaust fan shall conform to **BTS IEC 60335**. The purpose of an 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 as possible to the hole for fixing the fan. The connection shall be made with 3 core, coloured red/yellow/blue, 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 the 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.

9.5.3 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.

9.5.4 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 than 40 ohms and a power rating of not more than 2000 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 the case of a geyser, the power rating shall not exceed more than 2000Watts. Wherever possible, the geyser shall be placed outside the bathroom. If erected inside the bathroom, care shall be taken to locate it 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.

9.5.5 Electric stove

The power rating of electric stoves shall not exceed more than 2000 watts. Should the rating required exceed 2000 watts but not exceed 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 a 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 PVC insulated/bare copper conductor. Both phase and neutral wire shall have insulation resistance of not less than 1 mega-ohm.

9.5.6 Room heater/Electric iron/ induction cooktop

Power rating of room heater/electric iron/induction cooktop shall not exceed more than 2000 watts. A switch of rating not less than 16 ampere shall be provided as an integral part of the appliance. The connection shall be made with 3 core, steel and cotton breaded 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.

9.5.7 Air conditioner and refrigerator

Power rating of air conditioner and refrigerators shall not exceed more than 2000 watts and 100 watts respectively. A switch of rating not less than 16 ampere, thermostat and indicating lamp shall be provided as an integral part of the appliances. 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.

9.5.8 Rice/curry cooker and water boiler vacuum cleaner, drier, , mixture, microwave oven,washing machine,dishwasher

Power rating of rice/curry cooker, water boiler, vacuum cleaner, drier, mixture, microwave oven ,washing machine,dishwasher shall not exceed 1000W. A separate switch of 10 ampere or 6/16 ampere rating and indicating lamp shall be provided as an integral part of the appliance. In case of cooker and boiler, bimetallic operated auto off switch with cook/warm or boil warm indicating lamps 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 10 ampere or 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.

10. Earthing

10.1. General

Earthing shall conform to the following Specifications. For further details not covered in this Specification relevant Standards shall be referred to.

10.2. Earthing requirement

It is considered that the conductor to be used for earthing is galvanized steel/copper conductor.All building shall be connected to at least one earthing. For every 50 kW load, an additional earthing shall be provided.

10.3.Types & selection 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.

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.

10.4. Arrangement for Earth Electrode

10.4.1 Pipe Earth Electrode

G.I. pipe shall be of medium class, 40 mm diameter and 4.5 m in length. Galvanizing of the pipe shall conform to the relevant 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 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.

10.4.2 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.

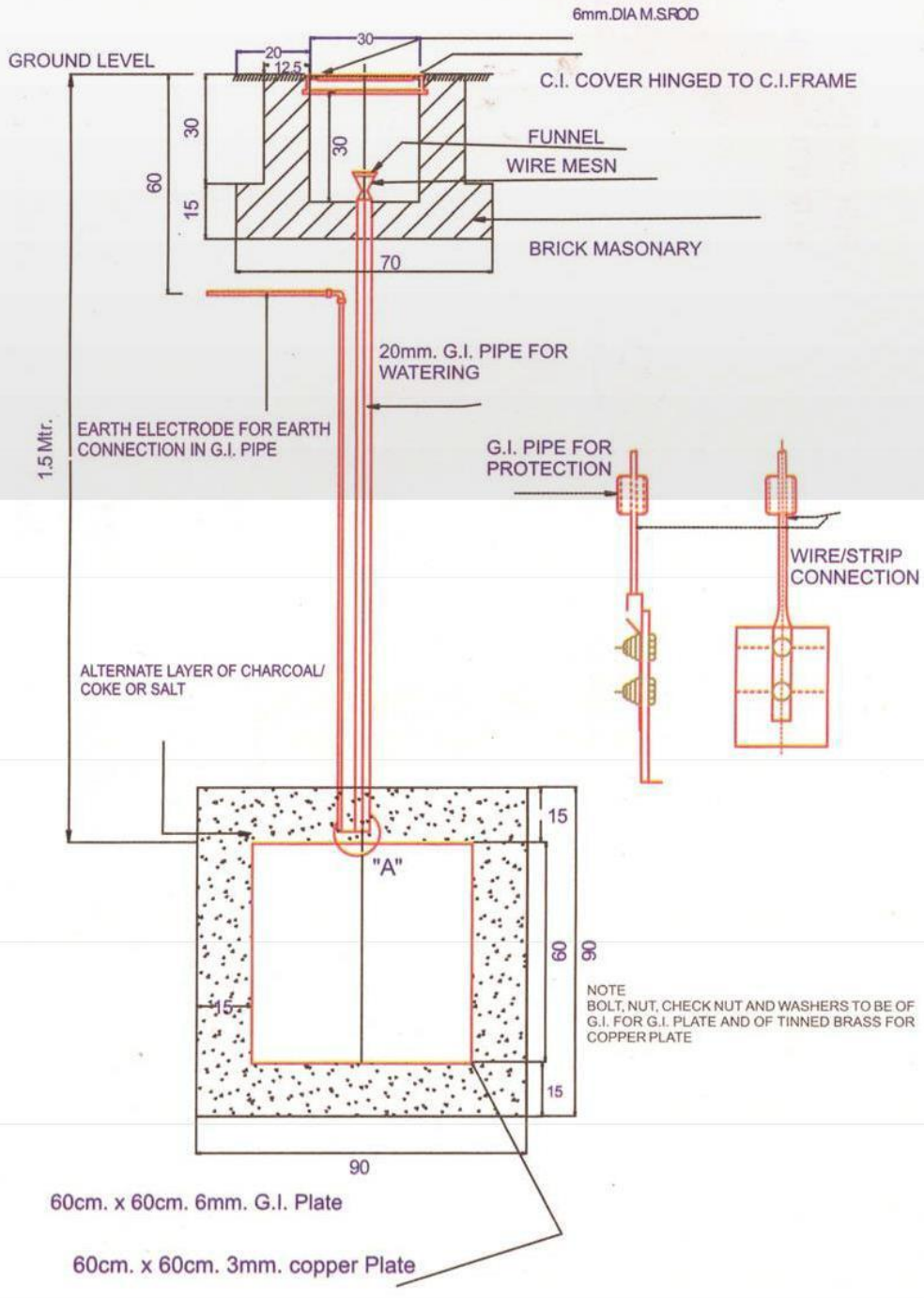
10.4.3 Strip or Conductor Electrode

Strip electrodes shall not be less than 25 mm x 4 mm of galvanized iron and 25 x 1.6 mm 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.

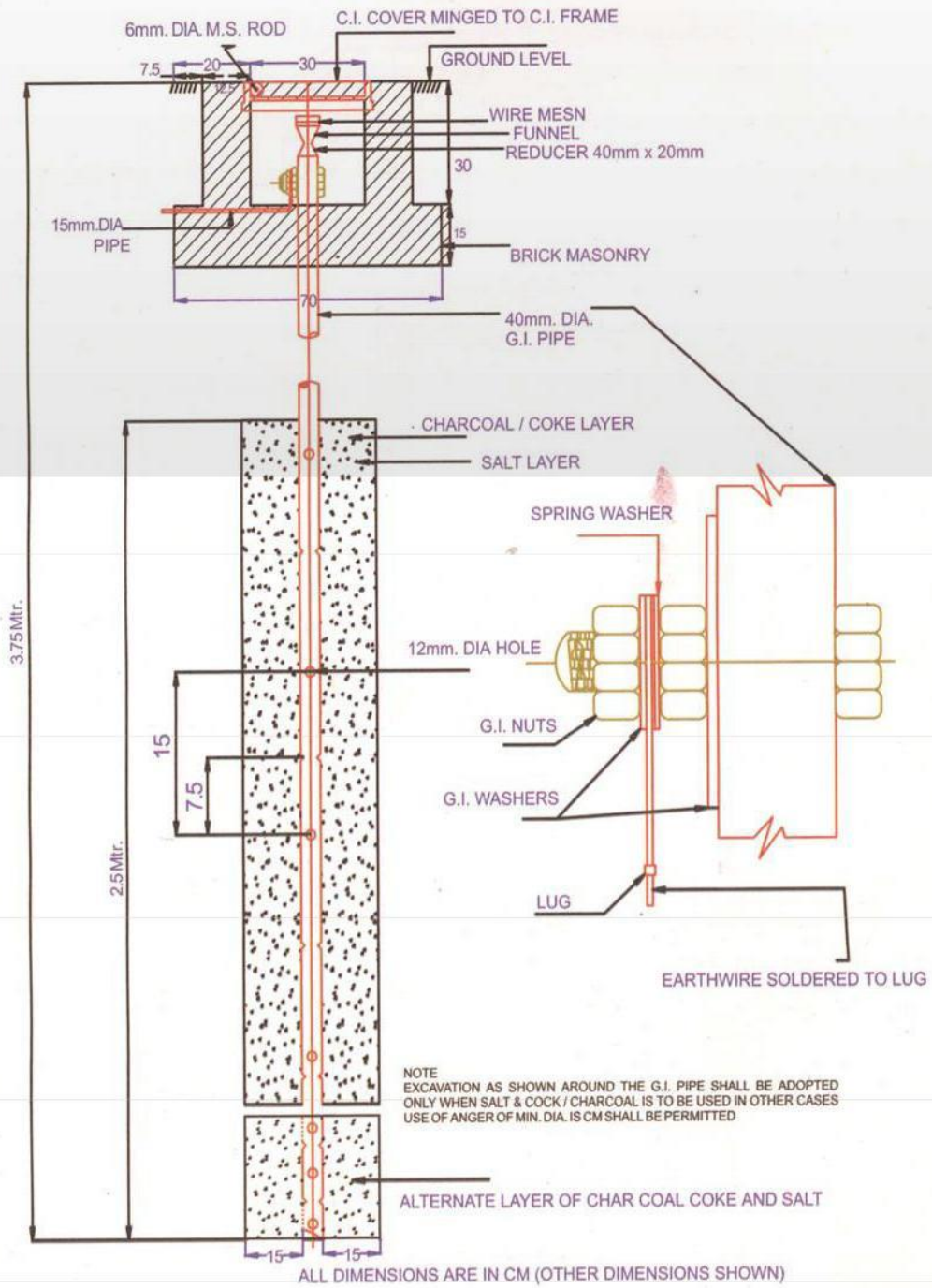
The Electrode shall be buried in a trench not less than 0.5 m deep. If conditions necessitate use of more than one strip or conductor electrode, they shall be laid as widely distributed as possible preferably in an single straight or circular trench or in a number of trenches radiating from one point.

METHOD OF PLATE EARTHING



ALL DIMENSION ARE IN CM. (OTHER DIMENSION SHOWN)

METHOD OF PIPE EARTHING



10.5.Method of Installing Watering Arrangement

In the case of plate earth electrode, a watering pipe of 20 mm diameter of 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 locking arrangement shall be suitably embedded in the masonry enclosure.

10.6.Location for Earth Electrode

Normally an earth electrode shall not be situated less than 1.5 m from any building. Care shall be taken that the excavations for the earth electrode do 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 that the soil has reasonable chance of remaining moist, as far as possible. Entrances, pavements and road ways, are to be avoided for locating the earth electrode.

10.7.Artificial Treatment of Soil

Where there is no option of site and 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. 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 specified in the Schedule of work and in such cases, excavation for earth electrode shall be as per dimensions.

10.8.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 lightning arresters/ lightning conductor.

10.9.Resistance of Earth

No earth electrode shall have a greater ohmic resistance than 5 ohms as measured by an approved earth testing apparatus. In rocky soil the resistance may be up to 8 ohms.

10.10. Size of Earthing Lead

10.10.1 Main earthing Lead

The main earthing lead shall be of G.I. wire or copper strip, in the case of G.I. pipe earth electrode, G.I. wire or 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 one half of sectional area that of the largest conductor to be protected but that a conductor larger than 100 sq. mm in case of G.I. conductor need not be used. The minimum size of main earthing lead shall not be less than 8 SWG of copper or G.I. wire and 20 mm x 3 mm in case of copper strip or 25 mm x 4 mm in case of G.I. strip.

10.10.2 Size of Earth Lead for Sub-stations/ Generating Stations

The Following table gives the recommended size of Cu earth bus in case of generating stations and sub-stations.

Capacity of transformer/generating set	Size of copper strip in mm
Up to 300 KVA	20 X 4
Above 300 KVA but not exceeding 500 KVA	32 X 5 or 40 X 4
Above 500 KVA but not exceeding 800 KVA	49 X 6.3 or 50 X 5
Above 800 KVA but not exceeding 1000KVA	50 X 6.3

10.10.3 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 14 SWG copper or 12 SWG of G.I. or 4 mm aluminium wire.

10.11. Method of Connecting Earth Lead to Earth Electrode

In the case of plate earth electrode the earthing lead shall be securely bolted to the plate with two bolts, nuts, checknuts and washers. In the case of pipe earth electrode, it shall be connected by means of 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 in case of copper plate electrode. Earth pits in 3-phase system should be connected in parallel only.

The earthing lead shall be securely connected at the other end to the MDB.

Loop earthing shall be provided for all mountings of MDB and other metal clad switches and distribution boards with not less than 14 SWG copper or 12 SWG G.I. or 4 sq. mm Aluminium wire.

10.12. 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 by 40 mm diameter medium class G.I. pipe in case of strip. Portion of this protection pipe within the ground shall be buried at least 30 cm deep (to be increased to 60 cm in case of road crossing and pavements). The portion within the building shall be recessed in walls and floors to adequate depth.

11. Protection of Buildings against lightning

11.1. Introduction

Protection of buildings against lightning shall generally be done in accordance with BTS/IEC/IS 2309: 1989. A brief of the same is given below for guidance. Protection of special structures like trees, live stock in fields, structures supporting overhead lines, structures with highly combustible roof etc. shall be strictly done. . Lightning protection in high rise(3 storey and above)to buildings shall be carried out in accordance with this standard. For buildings up to 2 storey the lightning protection may be done if directed by the Engineer.

11.2. 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.

11.3. Zone of Protection

The zone of protection of a lightning conductors 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 45º. 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 60º to the vertical, while the protective angle away from the conductors is still taken as 45º to the verticals.

11.4. 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 standard 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 11.1 and Table 11.2 respectively.

11.5.Design Considerations

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

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

(b)The lightning protective system should be so installed that it does not spoil the architectural or aesthetic beauty of the building.

(c)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.

(d) A vertical air termination where provided need not have more than one point and shall project at least 30 cm above the project, salient point or network on which it is fixed.

(e)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.

(f)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.

(g)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.

(h)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.

11.6.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.

(a) 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 at least two down conductors except for very small buildings.

(b) For structures having a base area exceeding 100 sq. m the number of down conductors required should be worked out as follows

(i) One for first 100 sq. m plus one more for every additional 300 sq. m or part thereof or,

(ii) 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.

11.7.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.

11.8.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.

11.9.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’.

11.10. 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 10 ohms before any bonding has been affected to metal in or on a structure or to surface below ground.

Table 11.1 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 diameter
3	Copper strip	20 mm X 3 m
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

Table 11.2 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

12. Inspection and Testing

Every installation shall on completion and before being energised, be inspected and tested in accordance with the requirements of this standard to verify that the requirements of these clauses have been met as far as practicable. The method of test shall be such that no danger to persons or property or damage to equipment can occur even if the circuit tested is defective.

12.1. Visual Inspection

The first part of visual inspection is to ensure that the system is safe to test and that enough information is available to carry out the test safely.

On completion of wiring a general inspection shall be carried out by competent personnel in order to verify that the provisions of this standard have been complied with. This shall include checking whether all equipment, fittings, accessories, wires, cables used in the installation are of adequate rating and quality to meet the requirement of the load.

12.1.1 Main Distribution Board

(a) The Main Distribution Board(control Panel) shall be accessible for operation and maintenance

(b) All connections to earthing system are feasible for periodic inspection.

(c) Sharp cable bends are avoided and cables are laid in smooth manner.

(d) Suitable circuit breaker is provided near the apparatus for controlling the apparatus in an easily accessible location.

(e) Cables are not taken through areas where they are likely to be damaged.

(f) The screens and armours of the cables are earthed properly.

(g) Adequate precautions are taken to ensure that no live part is exposed to cause danger.

(h) All cables are terminated using suitable size lugs only. Glands are used at the panel entry. Armouring is properly fixed in the gland.

(i) Proper cable tag marker is provided on the cable.

(j) All buried underground cables are provided with underground cable marker.

(k) Danger sign is provided on each panel/ switch board.All switchgears and distribution board are firmly fixed.

12.1.2 Lighting Circuits

(a) The plug points in lighting circuit are of 3 pin type and the third pin of the point is earthed properly.

(b) A separate earth wire is run in the lighting installation to provide earthing for plug points, fixtures and equipment.

(c) MCBs are fitted with suitable rating only.

(d) Clear and permanent identification marks are painted or labels are provided on all Sub distribution boards.

(e) All spare knockouts provided in Sub distribution boards are blocked.

(f) All switchboard, fittings, conduits etc are firmly fixed.

12.1.3 Power Circuits

(a) The third pin of the power socket is earthed properly.

(b) MCBs are fitted with suitable rating only.

(c) Clear and permanent identification marks are painted or labels are provided on all Sub distribution boards.

(d) All spare knockouts provided in Sub distribution boards are blocked.

(e) All power sockets,conduits etc are firmly fixed.

12.2.Testing

After visual inspection of installation the following test shall be carried out:

(a) Sample measurement
(b) Continuity of circuit conductor
(c) Protection by phase barriers and enclosures
(d) Insulation Resistance Test
(e) Cable testing
(f) Routine test certificate for factory made panels
(g) Testing of site manufactured panels
(h) Polarity Test of Switch
(i) Earth Continuity Test
(j) Earth Electrode Resistance Test

12.2.2 Sample measurements

Sample pieces of wires, cables, earthing conductor used from each lot should be kept separate for testing. Using wire gauge, micrometer, vernier caliper,etc, following specifications shall be checked.

(a) Diameter of conductor,
(b) Thickness of insulation,
(c) Over all diameter of cable
(d) Armour size
(e) Earth conductor size

12.2.3 Continuity of circuit conductor

Continuity should be checked for each conductor with DC lamp tester or with a multi meter.

12.2.4 Protection by phase barriers and enclosures

Where protection against direct contact is intended to be afforded by phabarriers or enclosures provided during erection, it shall be verified by test that the enclosure or phase barriers afford a degree of protection not less than IP 2X or IP 4X as appropriate.

12.2.5 Insulation Resistance

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 AC 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 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.

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 framework, and all live parts of each rheostat, appliance and sign, shall be not less than half a Megaohm.

12.2.6 Cable testing

Cable manufacturers give the routine and type test certificates for each drum. Cable test certificate includes thickness of each material used, diameter of conductor and cable, high voltage testing results, resistance of the cable per km., insulation resistance details.

HV testing should also be carried out on the cable at site if HV tester is available, apart from Megger test. Continuity test shall be conducted before energising the cable.

12.2.7 Routine test certificate for factory made panels

Bigger panels (rating more than 400 A) should not be allowed to be manufactured at site. They should be procured from panel manufacturers. It should be checked that they are made as per the approved General Arrangement(GA) drawing and single line diagram. Manufacturer should provide routine test certificate with following details:

(a) Physical inspection details,

(b) Megger test – LV megger test should be conducted among the phases, earth and neutral

(c) HV test – all power circuits should be tested for 2.5 kV voltage for one minute and all control circuit at 1.5 kV for 1 minute.

The manufacture should have type test certificate for short circuit withstand test from a recognised institute.

12.2.8 Testing of site manufactured panels

Except HV test all above-mentioned tests are possible at site. If HV tester can be arranged, than this test should also be carried out. With this test switchgear, hardware with little defects can be identified.

12.2.9 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 conductor 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.

12.2.10 Testing of earth continuity path

The earth continuity conductor including metal conduits and metallic envelopes of cables in all cases shall be tested for electric continuity. 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.

12.2.11 Measurement of earth electrode resistance

This measurement is elaborated in Annex C for measurement of soil resistivity.

13. Quality Assurance Plan & Safety Measures

13.1. Safety Measures

Safety measures have been elaborated in respective sections. Some general safety aspects are covered below.

(a) The switchgear rooms and other suitable places can be provided with fire extinguishers.

(b) Rubber mat of 1.1 kV grade shall be placed in front of floor-mounted panel.

(c) All equipment to be used for maintenance of the system should be of electrical grade only. The pliers, screw drivers etc should have insulation suitable for 1.1 kV grade.

(d) Shock treatment chart duly framed should be affixed in switchgear room. This chart should be in English and Dzongkha languages.

(e) The single line diagram should be displayed on wall near the main distribution board.

(f) Danger board sign with voltage level should be fixed on main distribution board.

(g) The electrical switchgears and distribution boards shall be clearly marked to indicate the areas being controlled.

(h) Electrical supply shall be cut off before carrying out any repair and maintenance work.

(i) 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.

(j) In case of electrical accidents and shock, the electrical installation on which the accident occurred should be switched off immediately. The person should be removed from the place of accident to a nearby safe place and artificial respiration continuously given.

13.2.General

This must be followed strictly for each electrical installation. The installation may be new or an extension to the old. The format given here must be filled completely by licensed supervisor only and should be given to the approving authority whenever demanded. This information demanded should be up to date. If the approving authority visits the site and demands the information, it should be given immediately, failing this will lead to cancellation of the license of the supervisor. If the information filled in the format is found to be wrong, this will lead to cancellation of the license of the supervisor.

13.3.Checklists for inspection and testing

1	Name of site	
2	Name of Owner	
3	Address of the site	
4	Phone number at the site	
5	Connection details a) Supply voltage b) Substation to which load will be connected	
6	Particulars of the work	
7	Document submission(Lists and Document number)	
7.1	Legends	
7.2	Conduit layout	
7.3	Single line diagram	
7.4	Earthing drawings	
7.5	Electrical equipment layout	
7.6	Lists of brand	
7.7	Soil resistivity measurement report *	
7.8	Other documents(if any)	

Note * If specifically asked

13.4. Internal point details

Sl/No.	Description	No. of point	Total load	Type & system of wiring
1	Light point			
2	Fan point			
3	Power point 6/16 A			
4	Power point 6 A			
5	Power point 10 A			

13.5. Earthing details

1	Type of earthing	
2	No. of earth pits	
3	Size of main earth conductor	

13.6. Test results

a) High voltage test of the site fabricated panel on power and control circuits

Power circuit 2.5 KV	
Control circuit 1.5 KV	

b) Insulation resistance of each drum or roll of cables received at site before cutting and laying. The values are in M-ohms.

1	Between phases R & Y Y & B B & R	
2	Between phase and neutral R & N Y & N B & N	
3	Between phase and earth R & E Y & E B & E	
4	Between neutral and earth	

c) Insulation resistance of the whole system after completion of the work and before energizing. The values are in M-ohms.

1	Between phases R & Y Y & B B & R	
2	Between phase and neutral R & N Y & N B & N	
3	Between phase and earth R & E Y & E B & E	
4	Between neutral and earth	

d) Polarity test

Polarity of non-linked single pole branch switches

e) Earth continuity test

Maximum resistance between various earth joints i.e conduit and earth conductor ……..ohms.

Name & seal of the supervisor	Name and seal of the contractor
License No.	Address
Address	Phone No.
Phone No.	

ANNEX A: ABBREVIATIONS

A.1 Abbreviations

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

A	:	Ampere
AC	:	Alternating Current
C.I	:	Cast Iron
CFLs	:	Compact Fluorescent Lamps
DB	:	Distribution Board
DC	:	Direct Current
ELCB	:	Earth Leakage Circuit Breaker
G.I	:	Galvanized Iron
GLS	:	General Lighting Service
HF	:	High Frequency
HID	:	High Intensity Discharge
HRC	:	High Rupturing Capacity
HRPVC	:	High Rupturing Polyvinyl Chloride
HT	:	High Tension
I	:	Current
ICDB	:	Iron Clad Distribution Board
kV	:	Kilo Volt
kW	:	Kilo Watt
LT	:	Low Tension
MCB	:	Miniature Circuit Breaker
MS	:	Mild Steel
PF	:	Power Factor
PVC	:	Polyvinyl Chloride
R	:	Resistance
RCCB	:	Residual Current Circuit Breaker
SDB	:	Sub Distribution Board
SPMCB	:	Single Pole Miniature Circuit Breaker
SPN	:	Single Pole & Neutral
TPN	:	Triple Pole & Neutral
V	:	Volt
W	:	Watt
XLPE	:	Cross-linked polyethylene
LED	:	Light Emitting Diode

ANNEX B

RECOMMENDED VALUES OF ILLUMINATION IN LUX

Sl. No.	Area	Illumination Lux
B.1	**Offices**	
1.	Entrance hall & reception areas	150
2.	Conference room & executive office	300
3.	General offices	300
4.	Business place	450
5.	Drawing office & computer room	300
6.	Corridors & lift areas	70
7.	Stairs	100
8.	Lift landing	150
9.	Electrical distribution room	150
B.2	**Education Centers**	
1.	Assembly hall	150
2.	Examination hall	300
3.	Class room – Desks	300
4.	Class room - Black board	300
5.	Library – shelves	100
6.	Library – reading tables	300
7.	Drawing, art, painting room	450
8.	Laboratories & practical rooms	300
9.	Workshops in colleges	200
10.	Office	300
11.	Teachers common room	150
12.	Corridors & lift areas	70
13.	Stairs	100
14.	Embroidery and sewing teaching rooms	700
B.3	**Public buildings**	
B.3.1	**Banks**	
1.	Public areas	150
2.	Counters, offices and others areas	300
B.3.2	**Libraries**	
1.	Shelves	100
2.	Reading tables	300
B.3.3	**Museums & art galleries**	
1.	General	150
2.	Displays	200-300
B.3.4	**Cinemas & theatres**	
1.	Foyers	150
2.	Auditoria	50
3.	Stairs	100
4.	Corridors	70

Sl. No.		Area	Illumination Lux
B.3.5		**Hospitals & Clinic**	
	1.	Waiting rooms and consulting rooms	150
	2.	Operation theatre general	300
	3.	Operation theatre tables	Special lighting
	5.	Stairs	100
	6.	Corridors	70
	4.	Laboratory	300
	5.	Ward – general	100
	6.	Ward – table	150
B.4		**Hotels, restaurants and commercial complexes**	
B.4.1		**Hotels**	
	1.	Entrance hall	150
	2.	Reception and accounts	300
	3.	Dining rooms	100
	4.	Lounges	150
	5.	Bedrooms – general	100
	6.	Bedrooms – dressing rooms	200
	7.	Stairs	100
	8.	Corridors	70
	7.	Laundries	200
	8.	Kitchen	200
	9.	Bathrooms	100
B.4.2		**Restaurants**	
	1.	Dining rooms	100
	2.	Cash counter	200
	3.	Kitchen	200
B.4.3		**Commercial Complexes**	
	1.	Sale counters	300
	2.	Stock room	200
	3.	Cash Counters	200
	4.	Stairs	100
	5.	Corridors	70
B.5		**Home**	
	1.	Kitchen	300
	2.	Bathrooms	100
	3.	Garages	70
	4.	Bed room & Reading room	150
	5.	Drawing (Living)room	150
	6.	Study room	300
	7.	Sewing area	700
	8.	Stairs	100
	9.	Special Areas	Special lighting
	10.	Corridors	70
	11.	Store room	150

Sl. No.		Area	Illumination Lux
B.6		**Industrial Building**	
B.6.1		**General Areas**	
	1.	Canteen	150
	2.	Cloak room	100
	3.	Entrance, corridors, stairs	100
	4.	Outdoor areas	20
B.6.2		**Assembly shops**	
	1.	Rough work	150
	2.	Medium work	300
	3.	Fine work	700
	4.	Very fine work	1500
B.6.3		**Bakeries**	
	1.	Mixing and making up rooms, oven and wrapping rooms	150
	2.	Decorating and icing room	200
B.6.4		**Boot & shoe factory**	
	1.	Sorting and grading	1000
	2.	Preparatory operations	700
	3.	Cutting table and press	1000
	4.	Bottom preparation and finishing	700
	5.	Shoe room	700
B.6.5		**Breweries & distilleries**	
	1.	General	150
	2.	Brew house, canning, bottling	200
	3.	Inspection	Special lighting
B.6.6		**Food processing plant**	
	1.	Inspection of raw products	450
	2.	Preparation	300
	3.	Processing areas	200
	4.	High speed labeling lines	300
	5.	Inspection of finished products	450
B.6.7		**Carpet factory**	
	1.	Winding and beaming	200
	2.	Designing and cutting, setting patters	300
	3.	Weaving, mending and inspection	450
B.6.8		**Clothing works**	
	1.	Matching up	450
	2.	Cutting and sewing	
		a) Light	300
		b) Medium	450
		c) Dark	700
		d) Pressing	300
	1.	Inspection & hand tailoring	
		a) Light	450
		b) Medium	1000
		c) Dark	1500

Sl. No.	Area	Illumination Lux
B.6.9	**Dairies**	
1.	General working	200
2.	Inspection	Special lighting
3.	Filling	450
B.6.10	**Flour mills**	
1.	General	150
2.	Weighting bridge/table	300
B.6.11	**Garages**	
1.	Parking	70
2.	Washing, polishing, general service, greasing	150
3.	Repairs	300
B.6.12	**Tool room**	700
B.6.13	**Laundries and Dry cleaning works**	
1.	Receiving, sorting, washing, drying, ironing and dispatch	200
2.	Dry cleaning and bulk machine work	200
3.	Fine hand ironing, pressing, inspection	300
B.6.14	**Jewellery making**	
1.	Fine process	700
2.	Minute process	3000
3.	Gem cutting, polishing and cutting	1500
B.6.15	**Paint shop**	
1.	General and automatic process	200
2.	Special batch mixing	450
3.	Colour matching	700
B.6.15	**Printing press**	
1.	Presses	300
2.	Composition room	450
3.	Proof reading	300
4.	Computer room	300
5.	Finishing	300

ANNEX C

SOIL RESISTIVITY MEASUREMENT

Wenner's 4-electrode method is used for measurement of soil resistivity. In this method, four electrodes are driven into the earth along a straight line at equal intervals. A current is passed through the outer two electrodes and the earth and a voltage difference is observed between the inner two electrodes. The current flowing through the earth produces an electric field proportional to its density and to the resistivity of the soil. The voltage developed between the inner electrodes is also proportional to the field. Consequently, the soil resistivity will be proportional to the ratio of voltage and current. Soil resistivity can be indicated by following equation:

$$\rho = \frac{\frac{4\,d\,\pi\,V}{I}}{1 + \frac{2d}{\sqrt{(d^2 + 4e^2)}} - \frac{2d}{\sqrt{(4d^2 + 4e^2)}}}$$

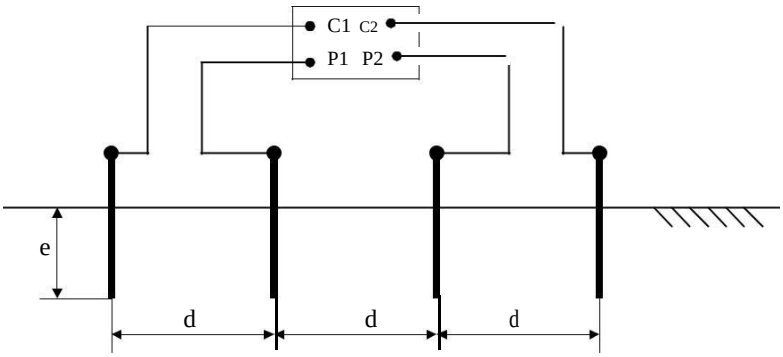
Where

ρ =Resistivity of soil in ohm-metre
d =distance between adjacent earth electrodes
V =voltage difference between the inner 2 electrodes in volts
I =current flowing through the outer 2 electrodes in amps
e =depth of burial of the earth electrode

The depth of burial of the electrodes is normally small as compared to the distance between the adjacent electrodes. In this case the denominator becomes 2. The soil resistivity can be indicated by following equation:

$$P = 2\,d\,\pi\,R$$

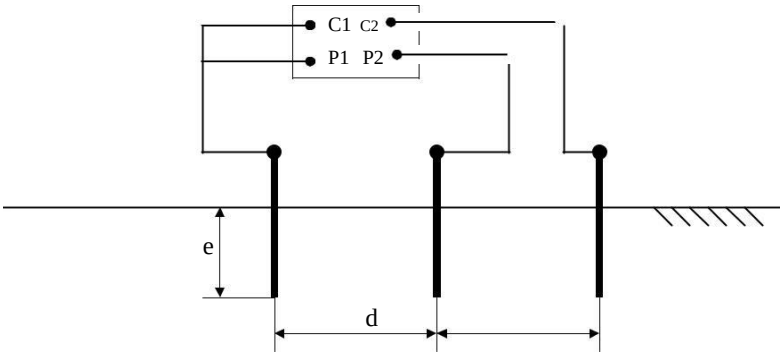
Where R is the earth tester reading in ohms. The depth of the test pegs should be nearly 15 cm in the ground. Only copper wires should be used as the resistance of these leads will be negligible. Following figure shows the method of inserting the pegs in the ground.



It is recommended that the readings should be taken in all the 8 directions by rotating 3 electrodes at 45^0 to understand the uniformity of the soil. Also one set of readings
should be obtained by changing the distance between the test pegs in one direction only. This distance could be increased by 1 m. If the earth tester has facility of range selection then proper range should be selected. If the soil resistivity is below 25 ohm metre then it should be considered as highly corrosive soil and proper care should be taken. Only hot dip galvanized strip or copper strip should be used in this case. If the value of soil resistivity is more then 100 ohm metre then the soil is not corrosive and 10 % safety for corrosion of steel is not required to be taken.

At each installation at least one earth pit should have testing facility. In future if resistance of the earth pit is required to be measured, it should be possible by removing the test links. The drawing of earth pit with test facility is given in Annex E. In this Annex the earth pit is shown with parallel connection facility.

For finding out the resistance of the earth pit, only two pegs are required. Test electrode works as combined potential and current peg and should be treated as third peg. The reading of the earth tester directly gives the reading of the earth pit resistance. Following diagram shows the arrangement for fixing the pegs in the ground for measurement of the resistance. In this case the connections to the grid should be removed. For finding out overall resistance the grid should be connected with the earth electrode and one reading should be taken this will be the overall resistance of the earthing system.



ANNEX D

ELECTRICAL SYMBOLS

SWITCHES AND SOCKET

	Single Pole/1 or 2 Module, 1 Way Switch
	Single Pole/1 or 2 Module, 2 Way Switch Bell Push Button
	6A Socket with 6A Switch
	10A Socket with 10A Switch
	16A Socket with 16A Switch

LAMPS AND LIGHTING FIXTURES

	Wall Mounted Fixture
	Ceiling Mounted Fixture
	Pendent Mounted Fixture
	Bulk Head Fixture
	Spot Light Fixture
	Single Tube Light Fixture
	Double Tube Light Fixture
	Call Bell

ELECTRICAL APPLIANCE

	Ceiling Fan
	Exhaust Fan
	Bracket Fan
	Lightning Arrester
	Fan Regulator
	Single Phase Energy Meter
	Three Phase Energy Meter
	Earthing Point
	Loud Speaker Outlet

TELEPHONE AND TELEVISION

 Telephone Socket

 Television Socket

 Television Splitter

 Telephone Terminal Cabinet (TTC)

FIRE ALARM

 Fire Alarm Push Button

 Heat Detector

 Smoke Detector

 Fire Alarm Indicator

 Fire Alarm Control Board

DISTRIBUTION BOARD

 Main Distribution Board (MDB)

Sub Main Distribution Board (SMDB)

Bibliography

Wires and cables

1. *BTS IEC 60227-1: Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V –Part 1:General requirements*
2. *BTS IEC 60227-2 Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V –Part 2:Test methods*
3. *BTS IEC 60227-4: Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V –Part 4:Sheathed cables for fixed wiring*
4. *BTS IEC 60245-2 Rubber insulated cables - Rated voltages up to and including 450/750 V –Part 2:Test methods*
5. *BTS IEC 60502-1 Power cables with extruded insulation and their accessories for rated voltages from 1kV (Um = 1,2 kV) up to 30 kV (Um = 36 kV) - Part 1: Cables for rated voltages of 1 kV (Um = 1,2 kV) and 3 kV (Um = 3,6 kV)*
6. *BTS IEC 60502-2 Power cables with extruded insulation and their accessories for rated voltages from 1 kV (Um = 1,2 kV) up to 30 kV (Um = 36 kV) - Part 2: Cables for rated voltages from 6 kV (Um = 7,2 kV) up to 30 kV (Um = 36 kV)*
7. *BTS IEC 60502-4 Power cables with extruded insulation and their accessories for rated voltages from 1 kV (Um = 1,2 kV) up to 30 kV (Um = 36 kV) - Part 4: Test requirements on accessories for cables with rated voltages from 6 kV (Um = 7,2 kV) up to 30 kV (Um = 36 kV)*

Lamps and luminaires

8. *BTS IEC 60064 Tungsten filament lamps for domestic and similar general lighting purposes- Performance requirements*
9. *BTS IEC 60432-1 Incandescent lamps- Safety specifications-Part-1:Tungsten filament lamps for domestic and similar general lighting purposes*
10. *BTS IEC 60432-2 Incandescent lamps- Safety specifications-Part-2:Tungsten halogens lamps for domestic and similar general lighting purposes*
11. *BTS IEC 60968 Self ballasted fluorescent lamps for general lighting services- Safety requirements*
12. *BTS IEC 61199 Single capped fluorescent lamps-Safety specifications*
13. *BTS IEC 60901 Single-capped fluorescent lamps –Performance specifications*

    BTS IEC 60901-amd3(edition2.0,2004-05-17)
    BTS IEC 60901-amd4(edition2.0,2007-12-07)
    BTS IEC 60901-amd5(edition2.0,2011-11-23)
    BTS IEC 60901-amd6(edition2.0,2014-12)

14. *BTS IEC 60081 Double-capped fluorescent lamps-Performance requirements*
15. *BTS IEC 60081-amd2(edition 5.0,2003-03-04) Double-capped fluorescent lamps-Performance requirements*
16. *BTS IEC 60081-amd3 (edition 5.0,2005-09-27) Double-capped fluorescent lamps-Performance requirements*
17. *BTS IEC 60081-amd4(edition 5.0,2010-02-18) Double-capped fluorescent lamps-Performance requirements*

18. *BTS IEC 60081-amd5(edition 5.0 ,2013-07-19) Double-capped fluorescent lamps-Performance requirements*
19. *BTS IEC 61195 Double capped fluorescent lamps-Safety specifications*
20. *BTS IEC 60662 High pressure sodium vapours lamps-Performance specifications*
21. *BTS IEC 60188 High-pressure mercury vapours lamps- Performance Specifications*
22. *BTS IEC 61167 Metal halide lamps-Performance specifications*
23. *BTS IEC 62031 LED modules for general lighting-Safety specifications*
24. *BTS IEC 62560 Self-ballasted LED lamps for general lighting services by voltage 50 V – Safety specifications*
25. *BTS IEC 62612 Self-ballasted LED lamps for general lighting services by voltage 50 V – Performance specifications*
26. *BTS IEC 62717 LED modules for general lighting-Performance requirements*
27. *BTS IEC 62776 Double-capped LED lamps designed to retrofit linear fluorescent lamps –Safety specifications*
28. *BTS IEC 60598-2-1 Luminaries. Part 2: Particular requirements. Section One: Fixed general purpose luminaries*
29. *BTS IEC 60598-2-5 Luminaries. Part 2: Particular requirements. Section Five: Floodlights*

Switches and sockets

30. *BTS IEC 60669-1 Switches for household and similar fixed-electrical installations - Part 1: General requirements*
31. *BTS IEC 60669-2-4 Switches for household and similar fixed electrical installations - Part 2-4: Particular requirements - Isolating switches*
32. *BTS IEC 60884-2-2 Plugs and socket-outlets for household and similar purposes. Part 2: Particular requirements for socket-outlets for appliances*
33. *BTS IEC 60884-1 Plugs and sockets-outlets for household and similar purposes- Part-1 General Requirements*

Low voltage switchgear and controlgear

34. *BTS IEC 60898-1 Electrical Accessories-Circuit-breakers for over current protection for household and similar installations-Part 1:Circuit breakers for a.c operation*
35. *BTS IEC 60898-2 Circuit breakers for over current protection for household and similar installations-Part-2:Circuit breakers for a.c and d.c operation*
36. *BTS IEC 61008-1 Residual current operated circuit breakers without integral over current protection for household and similar uses(RCCBs)-Part 1:General rules*
37. *BTS IEC 61008-2-1 Residual current operated circuit – breakers without integral over current protection for household and similar uses(RCCB's) Part-2-1:Applicability of the general rules to RCCB's functionality independent of line voltage*
38. *BTS IEC 61008-2-2 Residual current operated circuit – breakers without integral over current protection for household and similar uses(RCCB's) Part-2-2:Applicability of the general rules to RCCB's functionality independent of line voltage*
39. *BTS IEC TR 60755 General requirements for residual current operated protective devices*
40. *BTS IEC 61009-1 Residual current operated circuit breakers with integral over current protection for household and similar uses(RCBOs)-Part 1:General rules*
41. *BTS IEC 61009-2-1 Residual current operated circuit breakers with integral over current protection for household and similar uses(RCBOs)-Part 2-1:Applicability of general rules to RCBOs functionality independent of line voltage*
42. *BTS IEC 61009-2-2 Residual current operated circuit breakers with integral over current protection for household and similar uses(RCBOs)-Part 2-2:Applicability of general rules to RCBOs functionality independent of line voltage*

43. *BTS IEC 60947-1 Low voltage switchgear and controlgear-Part-1:General rules*
44. *BTS IEC 60947-2 Low voltage switchgear and controlgear-Part-2:Circuit breakers*
45. *BTS IEC 61439-1 Low voltage switchgear and control gear assemblies- Part-1: General rules*
46. *BTS IEC 61439-3 Low voltage switchgear and control gear assemblies – Part-1:Distribution boards intended to be operated by ordinary persons*
47. *BTS IEC 62271-100+AMD 1 CSV High –voltage switchgear and controlgear – Part 100: Alternating current circuit-breakers*
48. *BTS IEC 62271-102:+AMD 1+AMD 2 CSV High voltage switchgear ans controlgear – Part -102 : Alternating current disconnectors and earthing switches*

Appliances (Geysers, water heaters and fans)

49. *BTS IEC 60335-1 Household and similar electrical appliances-Safety-Part-1: General requirements*
50. *BTS IEC 60335-2-21 Household and similar electrical appliances-Safety-Part2-21: Particular requirements for storage water heaters*
51. *BTS IEC 60335-2-30 Household and similar electrical appliances-Safety-Part2-30: Particular requirements for room heaters*
52. *BTS IEC 60335-2-35 Household and similar electrical appliances-Safety-Part2-35: Particular requirements for instantaneous water heaters*
53. *BTS IEC 60335-2-61 Household and similar electrical appliances-Safety-Part2-61: Particular requirements for thermal storage room heaters*
54. *BTS IEC 60335-2-73 Household and similar electrical appliances-Safety-Part2-73: Particular requirements for fixed immersion heaters*
55. *BTS IEC 60335-2-74 Household and similar electrical appliances-Safety-Part2-74: Particular requirements for portable immersion heaters*
56. *BTS IEC 60335-2-80 Household and similar electrical appliances-Safety-Part2-80: Particular requirements for fans*

UPS

57. *BTS IEC 62040-1 Uninterruptible Power Systems (UPS)-Part-1: General and Safety requirements for UPS*

58. *Building code of Bhutan 2003 (Part 2: Building Services)*

59. *Specification for Electrical works 2017,DES,MoWHS*

BHUTAN STANDARDS
Internal House Wiring Standard – Safety Specifications

ELECTRICAL AND ELECTRONICS ENGINEERING TECHNICAL COMMITTEE (TC-03)

Working Group

Organization	Convener
College of Science and Technology,RUB	Mr. Roshan Chhetri
	Members
Bhutan Power Corporation Ltd.	Mr. Nilesh Thapa
Bhutan Electricity Authority	Mr. Sangay Dorji Tshering
Department of Engineering Services,MoWHS	Mr. Namgay Wangchuk
Thimphu Thromde ,MoWHS	Mr. Namgay Wangchuk

ཞྭེམ་ནང་སྒོག་ཐག་བཅུག་ནས་ནིའི་གནས་ཚད། ཉེན་སྐྱོང་དབྱེ་ཁག།

BHUTAN STANDARDS
Internal House Wiring Standard – Safety Specifications

ELECTRICAL AND ELECTRONICS ENGINEERING TECHNICAL COMMITTEE (TC-03)

Organization	**Chairman**
College of Science and Technology,RUB	Mr. Roshan Chhetri
	Members
Bhutan Power Corporation Ltd.	Mr. Nilesh Thapa
Bhutan Electricity Authority	Mr. Sangay Dorji Tshering
Druk Green Power Corporation Ltd.	Mr. Langa Tshering
Department of Renewable Energy,MoEA	Ms. Dechen Dema
Department of Engineering Services,MoWHS	Mr. Namgay Wangchuk
National Housing Development Corporation Ltd.	Mr. LB Tamang
Thimphu Thromde	Ms. Nidup Zangmo
Reliable Electrical Engineering Services	Mr. Thonga Tenzin
Director General, Bhutan Standards Bureau (Ex-officio member)	Mr. Sonam Phuntsho

Member Secretary
Tek Bahadur Chhetri
Standardization Division
Bhutan Standards Bureau