GOVERNMENT OF MADHYA PRADESH,
URBAN ADMINISTRATION AND DEVELOPMENT DEPARTMENT

SPECIFICATIONS
(4 PARTS)

PART - 4

ELECTRICAL WORKS

ISSUED BY

COMMISSIONER
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CHAPTER -1
GENERAL

1.0 SCOPE

(i) These General Specifications indicate the requirements and precautions to be taken during the execution of Internal & External Electrical Installation works to ensure efficient, safe, economical and practical use of materials and equipments including prevention of risks and fire hazards.

(ii) These General Specifications are subject to revision from time to time.

(iii) This Chapter covers the general requirements applicable to works contracts for Internal/External Electrical Installation works.

1.1 RELATED DOCUMENTS

Each work has its own particular requirements. These General Specifications shall be read in conjunction with the standard conditions of contract contained in contract forms concerned, and their correction slips, the tender specifications, schedule of work, drawings and other documents in the tender papers connected with the particular work.

CHAPTER -2
GENERAL AND TECHNICAL

2.0 SCOPE

This chapter covers the general technical requirements and measurement of the various components in Internal Electrical Installation works.

2.1 TERMINOLOGY

2.1.1 The definition of terms shall be in accordance with IS:732-1989 (Indian Standard Code of Practice for Electrical Wiring), except for the definitions of point, circuit, and sub main wiring, which are defined in clauses 2.2, 2.3 and 2.4 hereunder. Some of the commonly used terms are indicated Table given below :-

Terminology

This appendix indicates same of the commonly used and important terms relevant and for the Internal EI works. For complete list of terms relevant ISS may be referred to :

(1) Exposed conductive part "A" conductive part of electrical equivalent which can be touched and which is not normally live, but which may become the earth potential.

(2) Extraneous conductive part-A conductive part not forming part of the electrical installation and liable to introduce a potential, generally the earth potential.

(3) Director contact - Contact of persons or livestock with live which may result in electrical shock.

(4) Indirect Contact - Contact of persons or livestock with exposed conductive parts made live by a fault and which may result in electrical shock.

(5) Live Part - A conductor or conductive part intended to be energized in normal use, including a neutral conductor but, by convention, not a PEN conductor.

(6) Touch Voltage - The potential difference between a grounded metallic structure and a point on the earth surface separated by a distance equal to the normal maximum horizontal reach of approximately 1 meter.

(7) Danger - Danger to health or danger to life or limb from shock, burn or injury from mechanical movement to persons (and livestock where present), or from fire attendant upon the use of electrical energy.

(8) Earth - The conductive mass of the earth, whose electric potential at any point is conventionally taken as zero.

(9) Earth Electrode - A conductor or group of conductors in intimate contact with and providing and electrical connection to earth.

(10) Earth fault loop impedance - The impedance of the earth fault current loop (phase to earth loop), starting and ending at the point of earth fault.

(11) Earth leakage current - A current which flows to earth, or to extraneous conductive parts, in a circuit which is electrically sound.

(12) Earth conductor - A protective conductor connecting the main earth terminal (or equipotential bonding conductor of an installation when there is no earth bus) to an earth electrode or to other means of earthing.

(13) Equipotential bonding - Electrical connections putting various exposed conductivity parts and extraneous conductive parts at a substantially equal potential.

Note: In a building installation, equipotential bonding conductors shall interconnect the following conductive parts:

(a) Protective conductor

(b) Earth continuity conductor, and

(c) Risers of air conditioning systems and heating system (if any).

(14) Main earthing terminal - The terminal or bar which is the equipotential bonding conductor or protective conductors, and conductors for functional earthing, if any, to the means of earthing.

(15) Protective conductor - A conductor used for some measures of protection against shock, and intended for connecting together any of the following parts:

(a) Exposed conductive parts,

(b) Extraneous conductive parts,

(c) The main earthing termianl, and

(d) The earthed point of the source, or an artificial neutral.

(16) Residual current - The algebraic sum of the instantaneous values of current flowing through all the live conductors of a circuit at a point of the electrical installation.

(17) Residual current device (RCD) - A mechanical switching device or an association of devices, intended to cause the opening of the contacts when the residual current attains a given value under the specified conditions.

(18) Residual operating current - Residual current which causes the residual current device to operate under specified conditions.

(19) Simultaneously accessible parts - Conductors or conductive parts which can be touched simultaneously by a person or, where applicable by livestock.

Note: In the context of protection against direct contact, a live part may be accessible with:

(a) Another live part, or

(b) An exposed conductive part, or

(c) An extraneous conductive part, or

(d) A protective conductor.

(20) Switch, linked - A switch, the contacts of which are so arranged as to make or break all the poles simultaneously, or in a definite sequence.

(21) Switch board - An assembly of switchgear with or without instruments, but the term does not apply to a group of local switches in a final circuit.

Note: This is a per ISS. In these specifications, this term is used for the mounting frame in particular with the mountings, it is termed as a switch board panel.

(22) Switchgear - An assembly of main and auxiliary switching apparatus for operation regulation, protection or other control of electrical installations.

Note : For more comprehensive definitions of the terms in 2.103 to 2.106 [See IS:1885 (Part-17)-1987].

2.1.2 The conventional signs and symbols for technical work shall be as show in Table given below :

CONDITIONAL SIGNS AND SYMBOLS FOR ELECTRICAL INSTALLATION

General Wiring

Wiring on the surface

Wiring under the surface

WIRING IN CONDUIT

Conduit on surface

Concealed conduit

Wiring swing upwards

Wiring swing downwards

Wiring passing vertically

FUSE BOARDS

Main fuse board without switches

Main fuse board with switches

Distribution fuse board without switches

Distribution fuse board without switches

SWITCHES AND SWITCH OUTLETS ONE WAY SWITCH

Single Pole

Two Pole

Three Pole

Single pole pull switch

Multiposition switch (for different degrees of lighting.

Two way switch

Pendant switch

Push button

SOCKET OUTLETS

Socket outlet, 6A

Socket outlet, 16A

Combined switch and socket outlet, 6A

Combined switch and socket outlet, 16A

Interlocking switch and socket outlet, 6A

Interlocking switch and socket outlet, 16A

LAMPS AND LIGHTING APPRATUS

Lamp or outlet for lamp

Group of three 40 W lamps

Lamp mounted on a ceiling

Counter weight lamp fixture

Chain lamp fixture

Rod lamp fixture

Lamp fixture with built-in-switch

Lamp fed from variable voltage supply

Emergency lamp

Panic lamp

Bulk head lamp

Water tight lighting fitting

Batten lamp holder

Projector

Lamp mounted on a wall

Spot light

Flood light

Fluorescent lamp

Group of three 40 W fluorescent lamps

ELECTRICAL APPLIANCES

General

BELLS, BUZZERS

Bell Push

Bell

Buzzer

FIRE ALARM

Fire alarm pus

Automatic control

Bell connected to fire alarm

Fire alarm indicator

(At 'N' insert number of ways)

PUBLIC ADDRESS SYSTEM

Amplifier

Control Board

Microphone outlet

Loudspeaker outlet

RAIDO RECEPTION OUTLETS

Receiver outlet

Aerial

FIXED APPARATUS OUTLETS

Exhaust fan

Ceiling fan

Bracket fan

Fan regulator

EARTHING

Earth point

2.2 POINT WIRING

2.2.1 Method and type of wiring shall be fully described and measured separately, it shall be classified according to the size and types of cables used.

2.2.2 Concealed conduit work and surface conduit work shall also be classified and described separately the former shall include embedding the conduit and allied fitting in walls, floors etc. during constructions or cutting chases, or both and making good as necessary.

2.2.3 Point wiring shall include all work necessary in complete wiring of a switch circuit of any length from the tapping point on the distribution circuit to the following via a switch:

(a) Ceiling rose or connector (in case of ceiling and exhaust fan points or stiff pendent).

(b) Ceiling rose (in case of pendent points except stiff pendent points).

(c) Lamp holder (in case of wall brackets, batten points bulk head fittings and similar other fittings).

(d) Call bell or Buzzer (in this case the words "Via the switch" shall be read as "Via the bell push or ceiling rose" as the case may be.

(e) Upto Electrical Clock outlet.

(f) Upto socket outlet.

2.2.4 When there is only one point on the distribution circuit (one way), the same shall be measured in two parts i.e. circuit wiring according to the definition of the circuit wiring and the other as "Points" according to the above definition for "Points".

2.2.5 The following shall be deemed to be included in the Point Wiring.

(a) Rigid steel conduit/rigid PVC non-metallic conduit/ casing and capping as the case may be, accessories for the same and wiring cables including earth wire controlling switch or any other type of switch to the point.

(b) Switch and ceiling rose or connector or batten holder with special and suitable round block for neatly housing the connector as required.

(c) In case of wall brackets, bulk head and similar fittings, wiring as required up the Lamp Holder.

(d) Bushed conduit or porcelain tubing when cables pass through wall etc.

(e) All PVC/Metal blocks switch boards and boxes sunk or surface type, with suitable covering, (Phenolic laminated sheet/modular plate with base frame) including those required for mounting fan regulator but excluding those under the distribution board

and main control switch, but as specified in schedule of item in this SOR, the boxes and covering plate shall be measured separately and shall be paid extra.

(f) All fixing accessories such as clips, nails, screws, phil plug, rawl plug, etc. as required.

(g) Joint for junction boxes and connecting the same as required. fan regulator etc.

(h) Socket outlets as specified.

(i) Inter connection wiring between points on the same circuits in same switch box or from another.

(j) Connector as required for looping of wiring for two or more wires wherever required.

(k) Pendants, if provided shall be paid extra.

2.2.6 The mechanical protection provided to the wiring coming within 1.5 Mtr. from floor level upto switch board shall be deemed to have been included in the item of work. Method of installation and making good the damages shall be described in the specification.

2.3.1 The terms length per point in point wiring in the case of fan points, light points and socket outlet shall mean the distance between the switch and ceiling rose, connector or back plate or lamp holder or socket outlet point depending upon the fitting measured along the run of wiring irrespective of the number of wires in the run, separate measurement may be made where the switches and socket outlet points are located on the same board.

2.3.2 In the case of boards with socket outlet point only, the length shall mean the distance between the socket outlet and the tapping point of live wire on the nearest switch board or junction box, as the case may be.

2.3.3 Any junction box provided for extending the wiring beyond the point referred to shall not be treated as the nearest tapping point.

2.3.4 A light point controlled by two, two way switches shall be measured as two points from fitting to switches on either side and classified according to the length.

2.3.5 In case of point with more than one light point controlled by the same switch such points shall be measured in parts, i.e. from the switch to the first light point classified as one point and for the subsequent point, the distance from the fitting to fitting shall be measured along the run of wiring, classified and treated as equivalent to half the point so derived.

2.3.6 In case of call bell/buzzer points, with single call bell/buzzer controlled by more than one push, the length of point shall be measured in parts, i.e. from the call bell/buzzer to one of the nearest push classified as one point and for the other pushes, the distance from each push to the call bell shall be measured along the run of wiring classified and treated as equivalent to half the point so derived.

2.3.7 Where more than one call bell/buzzer points are controlled by the same push, the length of the points shall be measured as in.

2.3.8 Same board socket outlet point means sockets and switches are provided on same board, if another sockets outlets in provided in adjacent switch board upto conduit length of 0.3 Mtr. away shall be considered on same board. If length of conduits is above 0.3Mtr. (i.e.

adjacent switch board is away above 0.3 Mtr.) the point shall be considered as separate socket point.

2.4 CIRCUIT WIRING

2.4.1 Length of two wire of same size as specified in the item from the distribution board/sub distribution board/ upto the tapping point inside switch board or switch board to switch board shall e considered as circuit wiring. The length of circuit wiring with two wires shall be measured from the distribution or sub distribution board to the first switch board in the circuit irrespective of whether the neutral conductor goes into the switch box or not. The earth continuity conductor as specified in item of circuit wiring shall run alongwith circuit wire inside conduit/casing etc. as the case may be.

2.4.2 In case of exclusive socket outlet points with switch and socket, the length of point shall be the distance between the socket outlet and the tapping point of live wire in the nearest distribution or sub distribution board and hence no separate measurement need be taken for circuit wiring or for earth continuity conductor.

2.4.3 Except as described above different types of wiring shall be measured separately and given in running meters. The length shall be the actual length of wiring installed and the number and size of cables shall be stated.

2.4.4 The length of sub mains, circuit wiring or any other type of wiring on linear basis shall include all lengths from end to end of casing and capping, wood batten or conduits as the case may be exclusive of inter connections inside the switch board etc. The increase on account of division or slackness shall not be included in the measurement.

2.5 SYSTEM OF DISTRIBUTION AND WIRING

2.5.1 Control at the point of entry of supply.

There shall be a linked switch with fuse or circuit breaker on each live conductor of the supply mains at the point of entry.

2.5.2 Distribution

(i) The wiring shall be done on a distribution system through main and/or branch distribution boards. The system design as well as the locations of boards shall be as specified by the Engineer-in-Charge.

(ii) Main distribution board shall be controlled by a circuit breaker or linked switch with fuse. Each outgoing circuit shall be controlled by a switch with fuse, circuit, breaker or only a fuse on the phase or live conductor (as in the case of a TPDB).

(iii) The branch distribution board shall be controlled by a linked switch fuse or circuit breaker. Each outgoing circuit shall be provided with a fuse or miniature circuit breaker (MCB) of specified rating on the phase or live conductor.

(iv) Triple pole distribution boards shall not be used for final circuit distribution unless specified approval of the Engineer-in-Charge is obtained. In such special cases, the triple pole distribution boards shall be of HRC fuse type or MCB type only.

(v) The loads of the circuits shall be divided as far as possible evenly between the number of ways of the distribution boards, leaving atleast one spare cirucit for future extension.

(vi) The neutral conductors (incoming and outgoing) shall be connected to a common link (multiway conductor) in the distribution board and be capable of being disconnected individually for testing purposes.

(vii) 'Power' wiring shall be kept separate and distinct from 'Lighting' wiring, from the level of circuits i.e. beyond the branch distribution boards.

(viii) Wiring shall be separate for essential loads (i.e. those fed through standby supply) and non essential loads throughout.

2.5.4 Wiring System

(i) Unless and otherwise specified in the tender documents, wiring shall be done only by the 'Looping system'. Phase or live conductors shall be looped at the switch boxes and neutral conductors at the point outlets.

(ii) Where joint box system is specified in the tender documents, all joints in the conductors shall be made by means of approved mechanical connectors in suitable and approved junction boxes.

(iii) Lights, fans and call bells and 5A/6A socket outlets shall be wired in the 'lighting' circuit 15A/16A socket outlets and other power outlets shall be wired in the 'Power circuits'. 5A/6A socket outlets may be wired in the power circuit in residential/non residential buildings.

(iv) The wiring throughout the installation shall be such that there is no break in the neutral wire except in the form of a linked switch gear.

2.5.5 Run of Wiring

(i) The type of wiring shall be as specified in tender documents namely conduit.

(ii) Surface wiring shall run, as far as possible, along the walls and ceiling so as to be easily accessible for inspection.

(iii) In no case, the open wiring shall be run above the false ceiling without the approval of Engineer-in-Charge.

(iv) In all types of wiring due consideration shall be given for neatness, good appearance and safety.

2.5.6 Passing through walls or floors

(i) When wiring cables are to pass through a wall, these shall be taken through a protection (Steel/PVC) pipe or porcelain tube of suitable size such that they pass through in a straight line without twist or cross in them on either end of such holes. The ends of metallic pipe shall be neatly bushed with porcelain, PVC or other approved material.

(ii) Where a wall pipe passed outside a building so as to be exposed to weather, the outer end shall be bell mouthed and turned downwards and properly bushed on the open end.

(iii) All floor openings for carrying any wiring shall be suitably sealed after installation.

2.5.7 Joints in wiring

(i) No bare conductor in phase and/or neutral or twisted joints in phase, neutral, and/or protective conductors in wiring shall be permitted.

(ii) There shall be no joints in the through runs of cables, if the length of final circuit or sub main is more than the length of a standard coil, thus necessitating a through joint, such joints shall be made by means of approved mechanical connectors in suitable junction boxes.

(iii) Termination of multi stranded conductors shall be done using suitable crimping type thimbles.

2.7 CAPACITY OF CIRCUITS

(i) 'Lighting' circuit shall not have more than a total of 8 points of light, fan and socket outlets or a total connected load of 1000 watt whichever is less.

(ii) 'Power' circuit shall be designed with only one outlet per circuit in non residential buildings. The circuit shall be designed based on the load. Where not specified, the load shall be taken as 1 KW per outlet.

(iii) Power circuit in residential buildings shall be designed for not more than two outlets (15A/16A) and/or 5A/6A per circuit. The ratings for load calculation purposes shall however be taken as per the type of outlets (See clause 2.101(i/ii) for their wiring.

(iv) Load more than 1 kW shall be controlled by an isolator or miniature circuit breaker.

2.8 CONFORMITY TO I.E ACT, I.E. RULES, AND STANDARDS

(i) All electrical works shall be carried out in accordance with the provisions of Indian Electricity Act, 1910 and Indian Electricity Rules, 1956 amended upto date. List of Rules of particular importance to building installations is given in below.

IMPORTANT CLAUSES OF INDIAN ELECTRICITY RULES, 1956

The following clauses of Indian Electricity Rules, 1956 shall in particular be taken care of in the execution of Internal EI works.

Clause No	Subject
3	Authorization
29	Construction, installation, protection, operation and maintenance of electric supply lines and apparatus.
31	Cutout on consumer's premises.
32.	Identification of earthed and earthed neutral conductors and position of switches and cutouts therein.
33	Earthed terminal on consumer's premises.
36	Handling of electric supply lines and apparatus.
41	Distinction of circuits of different voltages.
42	Accidental charge.
43	Provision applicable to protective equipment.
44	Instructions for restoration of persons suffering from electric shock.
44A.	Intimation of Accident.
45	Precautions to be adopted by consumers, owners, occupiers electrical contractors, electrical workmen and suppliers.
46	Periodical inspection and testing of consumer's installation.
48	Precaution against leakage before connection.
50	Supply and use of energy.
50A	Additional provisions for supply and use of energy in multistoried building (more than 15 meters in height).
51	Provisions applicable to medium, high or extra high voltage installations.
54	Declared voltage of supply of consumer.
55	Declared frequency of supply to consumer.
56.	Sealing of meters and cutouts.
58	Point of commencement of supply.
59	Precautions against failures of supply : Notice of failures.
61	Connection with earth.
61A	Earth leakage protective device
64	Use of energy at high and extra high voltage.
64A	Additional provisions for use of energy at high and extra high voltage.
67	Connection with earth.
68	General conditions as to transformation and control of energy.
137	Mode of entry
138	Penalty for breaking seal.

138A	Penalty for breach of rule 44A
139	Penalty for break of rule 45.
140	Penalty for break of rule 82.
140A	Penalty for breach of rules 77, 79 or 80.
141	Penalty for breach of rules.

(ii) The works shall also conform to relevant Indian Standard Codes of Practice (COP) for the type of work involved given in below.

IMPORTANT INDIAN STANDARDS

S.No.	Standards	Title Codes of Practice/ Guide
1.	IS:732-1989	Code of practice for electrical wiring installation
2.	IS:4648-1968	Guide for electrical layout in residential buildings.
3.	IS:8061-1976	Code of practice for design, installation and maintenance of service lines upto and including 650 V.
4.	IS:8884-1978	Code of practice for installation of electric bells and call system.
5.	IS:5578-1985	Guide for marking of insulated conductor.
6.	IS:11353-1985	Guide for uniform system of marking and identification of conductors and apparatus terminals.
7.	IS:5728-1970	Guide for short circuit calculations.
8.	IS:7752 (Part-1)-1975	Guide for improvement of power factor in consumer installation Low and medium supply voltage.
9.	IS:3646 (Part-1)- 1966	Code of practice for interior illumination Principles for good lighting and aspects of design.
10.	IS:3646 (Part-2)-1966	Code of practice for interior illumination: Schedule of illumination and glare index.
11.	IS:3646 (Part-3)-1968	Code of practice for interior illumination : Calculation of coefficients of utilization by the BZ method.
12.	IS:4347-1967	Code of practice for hospital lighting.
13.	IS:6665-1972	Code of Practice for industrial lighting.
14.	IS:2672-1966	Code of Practice for library lighting.
15.	IS:10118(Part-1)-1982	Code of practice for selection, installation and maintenance of switch gear and control gear General.
16.	IS:10118(Part-2)-1982	Code of practice for selection, installation and maintenance of switch gear and control gear selection.
17.	IS:10118(Part-3)-1982	Code of practice for selection, installation and maintenance of switch gear and control gear installation.
18.	IS:10118(Part-4)-1982	Code of practice for selection, installation and maintenance of switch gear and control gear maintenance.
19.	IS:4146-1983	Application guide for voltage transformers.
20.	IS:1201-1983	Application guide for current transformers.
21.	IS:5547-1983	Application guide for capacitor voltage transformers.
22.	IS:2309-1989	Code of practice for the protection and allied structures against lighting.
23.	IS:3043-1987	Code of practice for earth.
24.	IS:5216(Part-1)-1982	Guide for safety procedures and practices in electrical work General.
25.	IS:5216(Part-2)-1982	Guide for safety procedures and practices in electrical work life saving techniques.
26.	IS:3696(Part-2)-1966	Safety code for scaffolds and ladders: Ladders.
		ELECTRIC FANS
1.	IS:555-1979	Electric table type fans and regulators.
2.	IS:1169-1967	Electric pedestal type fans and regulators.
3.	IS:374-1979	Electric ceiling type fans and regulators.

S.No.	Standards	Title Codes of Practice/ Guide
4.	IS:2997-1961	Air circulator type electric fans and regulators.
5.	IS:2312-1967	Propeller type AC ventilating fans.
6.	IS:3588-1987	Electrical axial flow fans.
7.	IS:3963-1987	Roof Extractor units.
8.	IS:1283-1981	Hor air fan.
9.	IS:6272-1987	Industrial cooling fans (man coolers)
10.	IS:4894-1987	Centrifugal fans
11	IS:11037-1984	Electronic type fan regulators.
12	IS:12155-1987	General and Safety requirements for fans and regulators for household and similar purposes.

LOW VOLTAGE SWITCH GEAR AND CONTROL GEAR

1.	IS:4237-1983	General requirements for switch gear and control gear for voltages not exceeding 1000 V AC or 1200 V DC.
2.	IS:6875(Part-1)-1973	Control switches (switching devices control and auxiliary circuits including contractor relays) for voltages upto and including 100 VAC and 1200 V DC : General requirements and tests.
3.	IS:6875(Part-2)-1973	Control switches (switching devices for control and auxiliary circuits including contactor relays) for voltages upto and including 1000 V AC and 1200 V DC : Part 2 Push button and related control switches (Amendment 2).
4.	IS:6875(Part-3)-1983	Control switches (switching devices for control and auxiliary circuits including contactor relays) for voltages upto and including 1000 V AC and 1200 V DC: Rotary control switches.
5.	IS:10027-1981	Composite units of air break switches and rewireable type fuses for voltages not exceeding 650 V AC.
6.	IS:4064(Part-1)-1978	Air break switches, air break disconnectors, air break switch disconnectors and fuse combination units for voltages not exceeding 1000 V AC or 1200 V DC: General requirements.
7.	IS:2675-1983	Enclosed distribution fuse boards and cutouts for voltages not exceeding 1000V.
8.	IS:8828-1978	Miniature air break circuit breakers for voltages not exceeding 1000 volt.
9.	IS:13032-1991	Miniature circuit breaker boards for voltages upto and including 1000 volts AC.
10.	IS:12610-1988	Residual current operated circuit breakers.
11.	IS:2959-1985	Contactors for voltage not exceeding 1000 V AC or 1200 VDC.
12.	IS:2516(Part-1/Sec.1 1985)	Circuit breakers: Requirements and test voltages not exceeding 1000 V AC or 1200 V DC.
13.	IS:12021-1987	Specifications for control transformers for switchgear and control gear for voltages not exceeding 1000 volts AC.
14.	IS:5039-1983	Distribution pillars for voltages not exceeding 1000 V
15.	IS:8623(Part1)-1977	Factory built assemblies of switch gear and control gear for voltages upto and including 1000 V AC and 1200 V DC: General requirements.
16.	IS:8623(Part-2)-1980	Factory built assemblies of switch-gear and control gear for voltages upto and including 100 V AC and 1200 V DC: Particular requirements for bus bar trunking system (bus ways).
17.	IS:8544(Part-1)-1977	Motor starters for voltages not exceeding 1000 V: Direct on line AC starters.
18.	IS:8544(Part-2)-1977	Motor starters for voltages not exceeding 1000 V: Start delta starters.
19.	IS:8544(Part-4)-1979	Motor starters for voltages not exceeding 1000 V: Reduced voltage AC starters, two step auto – transformer starters.

S.No.	Standards	Title Codes of Practice/ Guide
		POWER CABLE
1.	IS:694-1990	PVC insulated cables for working voltages upto and including 1100 V/
2.	IS:1554(Part-1)1988	PVC insulated and sheathed (heavy duty) electric cables: For working voltages upto and including 1100V.
3.	IS:3964(Part-2)-1968	Recommended current ratings for cables PVC insulated light duty cables.
4.	IS:1288-1988	PVC insulated (heavy duty) electric cables with solid alluminium.
5.	IS:1289(Part-1)-1984	Flexible cables for lifts and other flexible connections : Elastomer insulated cables.
		ELECTRIC WIRING ACCESSORIES
1.	IS:9537(Part-1)-1980	Conduits for electrical installations: General requirements.
2.	IS:9537(Part-2)-1981	Conduits for electrical installations: Rigid steel conduits
3.	IS:3480-1966	Flexible steel conduits for electrical wiring.
4.	IS:2667-1988	Fittings for rigid steel conduits for electrical wiring.
5.	IS:3837-1976	Accessories for rigid steel conduits for electrical wiring.
6.	IS:9537(Part-4)-1983	Conduits for electrical installation : Pliable self recovering conduits for insulating materials.
7.	IS:6946-1973	Flexible (pliable) non-metallic conduits for electrical installations.
8.	IS:3419-1989	Fittings for rigid non-metallic conduits.
9.	IS:5133(Part-1)-1969	Boxes for enclosure of electrical accessories: Steel and cast iron boxex.
10.	IS:5133(Part-2)-1969	Boxes for enclosure of electrical accessories : Boxes made of insulating materials.
11.	IS:2412-1975	Like clips for electrical wiring.
12.	IS:371-1979	Ceiling roses.
13.	IS:3854-1988	Switches for domestic and similar purposes.
14.	IS:4615-1968	Switch socket outlets (non-interlocking type).
15.	IS:4160-1967	Interlocking switch socket outlet.
16.	IS:1293-1988	Plugs and socket outlets of rated voltage upto and including 250 volts and rated current upto and including 16 Amperes.
		ELECTRICAL LAMPS AND THEIR AUXILIARIES
1.	IS:118-1978	Tungsten filament general service electric lamps.
2.	IS:2118(Part-1)-1977	Tubular fluorescent lamps for general lighting service: Requirements and tests.
3.	IS:9900(Part-1)-1981	High pressure mercury vapor lamps: Requirements and test.
4.	IS:9974(Part-1)-1981	High pressure sodium vapor lamps: General requirements and tests.
5.	IS:1258-1987	Bayonet lamp holders.
6.	IS:3323-1980	B1-pin lamp holders for tubular fluorescent lamps.
7.	IS:3324-1982	Holders for starters for tubular fluorescent lamps.
8.	IS:2215-1984	Starters for fluorescent lamps.
9.	IS:1534(Part-1)-1977	Ballast for fluorescent lamps: For switch start circuits.
10.	IS:1569-1976	Capacitors for use in tubular fluorescent high pressure mercury and low pressure sodium vapor discharge lamp circuits.
11.	IS:6616-1982	Ballasts for high pressure mercury vapor lamps.
		LIGHT FITTINGS AND LUMINARIES
1.	IS:1913(Part-1)-1978	General and safety requirements for luminaries: Tubular flu (2)
2.	IS:10322(Part-1)-1982	Luminaries : General requirements
3.	IS:10322(Part-2)-1982	Luminaries : Constructional requirements
4.	IS:10322(Part-5/Sec-1) 1987	Luminaries: Particular requirements : Recessed luminaries.
5.	IS: 10322(Part-5/Sec-3) 1987	Luminaries: Particulars requirements: Luminaries for road and

S.No.	Standards	Title Codes of Practice/ Guide
		street lighting.
6.	IS:10322 (Part-5/Sec-5) 1987	Luminaries: Particulars requirements: Portable general purpose luminaries
7.	IS:10322(Part-5/Sec-5) 1987	Luminaries: Particulars requirements : Floodlight
8.	IS: 3287-1965	Industrial lighting fittings with plastic reflectors.
9.	IS: 1777-1978	Industrial luminaries with metal
10.	IS:2206(Part-1)-1984	Flame proof electric lighting fittings : Well glass and bulk head types.
11.	IS:3528-1966	Water proof electric lighting fittings.
12.	IS:3553-1966	Water tight electric lighting fittings.
13	IS:8030-1976	Luminaries for hospitals.
14.	IS:7537-1974	Road traffic signals.
15.	IS:9583-1981	Emergency lighting units.
		ELECTRICAL APPLIANCES
1.	IS:302-1979	General and safety requirements for household and similar electrical appliances.
2.	IS:2268-1988	Electric call bells and buzzers for indoor use.
3.	IS:3412-1985	Electric water boilers.
		ELECTRICAL INSTRUMENTS
1.	IS:6236-1971	Direct recording electrical measuring instruments.
2.	IS:1248(Part-1)-1983	Direct acting indicating analogue electrical measuring instruments and their accessories: General requirements.
3.	IS:1248(Part-2)-1983	Direct acting indicating analogue electrical measuring instruments and their accessories. Ammeters and voltmeters.
4.	IS:1248(Part-3)-1983	Direct acting indicating analogue electrical measuring instruments and their accessories: Wattmeters and Varmeters.
5.	IS:1248(Part-4)-1983	Direct acting indicating analogue electrical measuring instruments and their accessories : Frequency meters.
6.	IS:1248(Part-5)-1983	Direct acting indicating analogue electrical measuring instruments and their accessories: Phase meters, power factor meters and synchroscope.
7.	IS:722(Part-1)-1988	AC electricity meters: General requirements and tests.
8.	IS:722(Part-1)-1977	AC electricity meters: Single phase whole current watthour meters class-2
9.	IS:722(Part-3)-1977	AC electricity meters: Three phase whole current and transformer operated and single phase transformer operated watthour meters class-2.
10.	IS:722(Part-5)-1980	AC electricity meters: Volt-ampere hour meter for restricted power factor range, class 3.5
11.	IS:722(Part-7/sec-1) 1987	AC electricity meters: Volt ampere hour meter for full power factor range: General requirements.
12	IS:722(Part-9)-1972	Single phase 2 wire whole current watthour meter (class 1.0).
13	IS:722(Part-9)-1972	AC electricity meters : Three phase whole current and transformer operated Watthour meters, and single phase two wire transformer operated watthour meters (Class 1.0).
14.	IS:8530-1977	Maximum demand indicators.
15.	IS:2992-1987	Insulation resistance testers hand operated, (Magneto-generator type).
		INSTRUMENT TRANSFORMERS
1	IS:2705 (Part-1)-1981	Current Transformer : General requirements.
2.	IS:2705 (Part-2)- 1981	Current Transformer: Measuring current transformers.
3.	IS:2705 (Part-3) 1981	Current Transformer : Protective current transformers.
4.	IS:2705 (Part-4) 1981	Current Transformer : Protective current transformer for specific

S.No.	Standards	Title Codes of Practice/ Guide
		purpose applications.
5.	IS: 6949-1973	Summation current transformers.
		FUSES
1.	IS:9224 (Part-1)-1979	Low Voltage fuses : General requirements
2.	IS:9224 (Part-2)-1979	Low Voltage fuses : Supplementary requirements for fuses for industrial applications.
3.	IS: 2086-1982	Carriers and bases used in rewireable type electrical fuses upto 650 volts.
4.	IS:9926-1981	Fuse wire used in rewireable type electric fuses upto 650 volts.
5.	IS:8187-1976	D-Type fuses.
		MISCELLANEOUS
1.	IS:2551-1982	Danger notice plates.
2.	IS:2448 (Part-1)-1963	Adhesive insulating tapes for electric purposes: Tapes with cotton textile subtraction.
		ELECTROTECHNICAL VOCABULARY
1.	IS:1885(Part-1)-1961	Electrotechnical Vocabulary : Fundamental definitions.
2.	IS:1885 (Part-9)- 1980	Electrotechnical Vocabulary : Electric Relays.
3.	IS: 1885 (Part-11)-1966	Electrotechnical Vocabulary : Electric measurements.
4.	IS:1885 (Part-16/Sec-1)-1968	Electrotechnical vocabulary : Lighting General aspects.
5.	IS:1885 (Part-16/Sec-2)-1968	Electrotechnical vocabulary : Lighting : General illumination, lighting fittings and lighting for traffic and signaling.
6.	IS: 1885 (Part-16/Sec-3)-1967	Electrotechnical vocabulary : Lighting : Lamp and auxiliary apparatus.
7.	IS: 1885 (Part-17)- 1979	Electrotechnical vocabulary : Switch gear and control gear.
8.	IS: 1885 (Part-32)-1971	Electrotechnical vocabulary : Cables conductors and accessories for electricity supply.
		SAFETY
1.	IS:4770-1991	Rubber gloves for electrical purposes.
2.	IS:5424-1969	Rubber mats for electrical purposes. (xv)

Note:- The above IS Codes shall be applicable with latest amendments if any.

(iii) In all electrical installation works, relevant safety codes of practice shall be followed Guidelines on safety procedure outlined in given below.

SAFETY PROCEEDURE

1. While the Indian Electricity Rules 1956, as amended upto date, and to be followed in their entirely, particular attention is drawn to the various clauses indicated in Appendix 'A' Any installation or portion of installation which does not comply with these rules should be got rectified.
2. The detailed instructions on safety procedures given in B.I.S. Code No. 5216-1969-Code of Safety Procedures and Practices in Electrical Works shall be strictly followed.
3. It shall be the responsibility of the Junior Engineer (E) and the Assistant Engineer (E) to see that the control switches and distribution boards are duly marked, the distribution diagrams of sub station are prominently displayed, and the sub station

premises, main switch rooms and D.B. enclosure are kept clean. Particularly care should be taken to prevent the sub station being used as store for inflammable materials, broken furniture, waste materials etc.

4. No inflammable materials shall be stored in places other than the rooms specially constructed for this purpose in accordance with the provisions of Indian Explosives Act. If such storage is unavoidable, it should be allowed only for a short period and in addition, special precautions, such as cutting off the supply to such places at normal times, storing materials away from wiring and switch boards, giving electric supply for a temporary period with the permission of Junior Engineer (E) shall be taken.
5. Rubber or insulating mats should be provided infront of the main switch boards or any other control equipments of medium voltage and above.
6. Protective and safety equipments such as rubber gauntlets or gloves earthing roads, line men's belt, protable artificial respiration apparatus etc. should be provided in each sub station, service centre/enquiry office and important installations. Where electric welding or such other nature of work in undertaken, goggles shall also be provided.
7. Necessary number of caution boards such as "Man on Line", "Don't switch on" should be readily available in each sub station, enquiry office and important installations.
8. Standard first aid boxes containing materials as prescribed by the St. John Ambulance Brigade or Indian Red Cross should be provided in each sub station, enquiry officer and important installations and should be readily available.
9. Periodical examination of the first aid facilities and protective and safety equipments provided at the various installations shall be undertaken for their adequacy and effectiveness and a proper record shall be maintained.
10. Charts (one in English and another in the regional language) displaying methods of giving artificial respiration to a recipient of electrical shock should be prominently displayed at appropriate places.
11. A chart containing the names, address and telephone numbers of nearest authorized medical practitioners, hospitals, Fire Brigade and also of the officers in executive charge shall be displayed prominently alongwith the First Aid Box.
12. Executive Engineers should take immediate steps to train supervisory and authorized persons of the Engineering staff viz. AEs, JEs, Head Electricians, Foreman, Electricians and Wiremen in the First Aid Practices, including various methods of artificial respiration with the help of local authorities such as Fire Brigade, St. John Ambulance Brigade. Indian Red Cross or other recognized institutions equipped to impart such training, as prompt rendering of artificial respiration can save life at times of electric shock.

13. All new recruits should be given such First Aid Training immediately after appointment.

14. All Supervisory and authorized persons of the Engineering staff should be deputed for refresher course in First Aid Training after every two years.

15. Details of preventive maintenance to be undertaken shall be in accordance with the schedule given in Appendix 'F'. All preventive maintenance works shall be preplanned as far as possible and names of persons who are assigned to this work should be entered in a log book.

16. Electrical wiring and control switches should be periodically inspected and any defective wiring, broken parts of switches which will expose live parts, should be replaced immediately to make the installations safe for the user.

17. Reports indicating details of preventive maintenance works done should be kept in a register by each Junior Engineer (E) and should bear signatures of Asstt. Engineer and Executive Engineer by way of checks.

18. No work shall be undertaken on live installations, or on installations which could be energized unless one another person is present to immediately isolate the electric supply in case of any accident and to render first aid, if necessary.

19. No work of live LT bus bar or pedestal switch board in the sub-stations should be handled by a person below the rank of a Wireman and such a work should preferably be done in the presence of the Junior Engineer (E) incharge of the work.

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

22. Before starting any work on the existing installation, it should be ensured that the electric supply to that portion in which the work is undertaken is preferably cut off. Precautions like displaying. "Men at Work" caution boards on the controlling switches, removing fuse carrier from these switches, and these fuse carriers being kept with the person working on the installation, etc. should be taken against accidental energisation, "Permit to Work" should be obtained from the Junior Engineer-in-Charge. No work on HT main should be undertaken unless it is made dead and discharged to earth with an earthing lead of appropriate size. The discharge operation shall be repeated severaltimes and the installation connected to earth positively before any work is started.

23. 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 switch board etc. any earthing connection made for doing the work has been removed. "Permit to Work" is received back duly signed by the person to whom it was issued in token of having completed the work and the installation being ready for re-energizing and "Men at Work" caution boards removed.

24. In case of electrical accidents and shock, the electrical installation on which the accident occurred should be switched off immediately and the affected person should be immediately removed from the live installation by pulling him with the help of his coat, shirt, wooden rod, broom handle or with any other dry cloth or paper. He should be removed from the place of accident to a nearby safe place and artificial respiration continuously given as contained in B.I.S. Code and Standard prescribed by St. John Ambulance Brigade or Fire Brigade.

25. While artificial respiration on the affected person is started immediately, help of Fire Brigade and Medical Practitioner should be called for an artificial respiration should be continued uninterrupted until such help arrives.

26. These instructions should be explained in Hindi/Local language to those staff who do not understand English.

27. Executive Engineers should take particular care to ensure that these instructions are imparted to the existing staff and as well as to the new entrants.

28. **PREVENTIVE MAINTENANCE**

For proper maintenance of Electrical Installations, the following items of work shall be carried out regularly as per periodically stated below and a proper record of such work shall be maintained.

(a)	Earth testing	..	..	Once in a year
(b)	Insulation test	..	..	Once in a year
(c)	Cleaning of E.I.			
(i)	Residential Buildings	..	..	Once in a year
(ii)	Non-residential Buildings	..	..	Once in a year
(d)	Painting of E.I.			
(i)	Residential Buildings	..	..	Once in 3 year
(ii)	Office Buildings	..	..	Once in 2 year
(iii)	Important Public Buildings	..	..	Once in a year
(iv)	Spray painting of ceiling fans	..	..	Once in 5 year
(e)	Oiling and greasing of fans	..	..	As and when required
(f)	Checking of regulators, replacement of carbon brushes etc. when required	..	..	Once in a year
(g)	Polarity test	..	..	Once in 5 years

2.9 GENERAL REQUIREMENTS OF COMPONENTS

2.9.1 Quality of materials

All materials and equipments supplied by the contractor shall be new. They shall be of such design, size and material as to satisfactorily function under the rated conditions of operation and to withstand the environmental conditions at site.

2.9.2 Ratings of components

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

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

2.9.3 Conformity to Standards

(a) All components shall conform to relevant Indian Standard Specification wherever existing Materials with ISI certification mark shall be preferred. However, for conduits, wiring cables. Piano/tumbler switches and sockets outlets, ISI marked materials shall only be permitted.

2.9.4 Interctrangeability

Similar parts of all switches, lamp holders, distribution fuse boards, switchgears, ceiling roses, brackets, pendants, fans and all other fittings of the same type shall be interchangeable in each installation.

2.9.5 Categorization of components

(a) Makes of certain items of materials are categorized from time to time by the Department and included in Schedule of rates only those makes of items under the category indicated in tender documents shall be used in the work.

(b) For items of materials for which makes are approved by the Department, only such approved makes shall be permitted in the work.

2.9.6 Special risks

Special forms of construction such as flame proof enclosures, shall be adopted where there is risk of fire, or explosion and wherever indicated in the tender documents.

2.10 CABLES

2.10.1 Conductors of wiring cables (other than flexible cables) shall be of copper, as specified.

The smallest size of conductor for 'lighting' circuits shall have a nominal cross sectional area of not less than 1.5 Sqmm. The minimum size of conductor for 'power' wiring shall be 4 Sqmm.

2.10.2 Flexible cables

(i) Conductor of flexible cables shall be of copper. The minimum cross sectional area of conductor for flexible cable shall be 0.0006 Sq.inch (14/0.0076 or 14/0.193mm).

(ii) Only 3 core flexible cables are mechanically protected by armour or tough rubber, or PVC sheath these shall not be used in workshops and other places where they are liable to mechanical damage.

(iv) Flexible cable connection to bell push from ceiling rose shall be taken through steel conduit/metallic casing and capping.

2.11 WIRING ACCESSORIES

2.11.1 Control switches for points

(i) Control switches (single pole switches) carrying not more than 16A may be modular or piano type, as specified, and the switch shall be 'ON' when the knob is down.

(ii) The type and current rating of switch controlling a group of points, or discharge lamps, or a single large load shall be suitable for the respective loads and as specified in the tender documents.

(iii) Power (15A/16A) outlets shall be controlled by single pole modular or piano type switches or by MCB's where specified. Only MCB's shall be used for controlling industrial type socket outlets, and power outlets above 1KW.

(iv) Control switch shall be placed only in the live conductor of the circuit. No single pole switch or fuse shall be inserted in the protective (earth) conductor, or earthed neutral conductor of the circuit.

2.11.2 Socket outlets

(i) Socket outlets shall be of the type namely, piano type or modular type as their control switches. These shall be rated either for 5A/6A or 15A/16A. Combined 5A/15A or 6A/16A six pin socket outlet may be provided in 'power' circuits only where specified.

(ii) (a) In an earthed system of supply, socket outlets and plugs shall only be of 3 pin type, the third pin shall be connected to earth through protective (loop earthing) conductor.

(b) Conductor connecting electrical appliances with socket outlets shall be of flexible twin cord with an earthing cord, which shall be secured by connecting between the earth terminal of plug and the metallic body of the electrical appliances.

(iii) Sockets for the power outlets of rating above 1 KW shall be of industrial type with associated plug top and controlling MCB.

(iv) Where specified, shutter type (interlocking type) of sockets shall be used.

(v) A socket outlet shall not embody fuse terminal as integral part of it. But the fuse main be embodies in plug in which case the plug shall be non-reversible and shall so arranged and connected that the fuse is connected to phase or live conduct or the non earthed conductor of the circuit.

(vi) Every socket outlet shall be controlled by a switch or MCB as specified. The control switch/MCB shall be connected on the live side of the line.

(vii) 5A/6A and 15A/16A socket outlets shall be installed at the following position unless otherwise specified.

(a) Non residential buildings - 30cm above floor level.

(b) Kitchen- 30cm above working platform and away from the likely positions of stove and sink.

(c) Bathroom - No socket outlet is permitted for connecting a portable appliance thereto, MCB/IC switch may be provided above 2.00 Mtr. for fixing appliances, and atleast 1 Mtr. away from shower.

(d) Rooms in residences - 30cm above floor level, or any other level in special cases desired by the Engineer-in-Charge.

(viii) Unless and otherwise specified, the control switches for the 5A/6A and 15A/16A socket outlets shall be kept alongwith the socket outlets.

2.11.3 Switch box covers

Phenolic laminated sheets/modular plate with base frame of approved shade shall be used for switch box covers. Laminated sheet shall be of 3mm thick synthetic phenolic resin bonded laminated sheet as base material and conforming to grade P-1 of IS : 2036-1974.

2.11.4 Ceiling rose

(i) A ceiling rose shall not be used on a circuit, the voltage of which normally exceeds 250V.

(ii) Only one flexible cord shall be connected to a ceiling rose. Specially designed rose shall be used for multiple pendants.

(iii) A ceiling rose shall not embody fuse terminal as an integral part of it.

2.11.5 Lamp holders

(i) Lamp holders may be of batten, angle, pendant or bracket holder type as required. The holder shall be made of brass or and shall be rigid enough to maintain shape on application of a nominal external pressure. There should be sufficient threading for fixing the base to the lamp holder part, so that they do not open out during attention to the lamp or shade.

(ii) Lamp holders for use on brackets and the like shall have not less than 1.5cm nipple, and all those for use with flexible pendant shall be provided with cord grips.

(iii) All lamp holders shall be provided with shade carriers.

(iv) Where center contact Edison Screw lamp holders are used, the outer or screw contact shall be connected to the 'middle wire', or the neutral conductor of the circuit.

2.12 FITTINGS

2.12.1 Types

The type of fittings shall be as specified in tender documents.

2.12.2 Indoor type fittings

(i) Where conductors are required to be drawn through tube or channel loading to the fittings, the tube or channel must be free from sharp angles or projecting edge, and of such size as will enable them to be wired with the conductors used for the final circuit without removing the braiding or sheathing. As far as possible all such tubes or channels should be of sufficient size to permit looping back.

(ii) Pendants in verandahs and similar situations exposed to wind shall be of fixed rod type.

(iii) Vitreous enamelled iron shade be of size 250mm x 90mm (nominal) size with a tolerance of 5mm. Plastic shade should not be generally used in fittings suitable for incandescent lamps.

(iv) Wires used within prewired fittings shall be flexible with PVC insulation and 14/0.193mm (minimum) copper conductors. The leads shall be terminated on built in terminal block, ceiling rose or connector as required.

(v) Fittings using discharge lamps shall be complete with power factor correction capacitors, either integrally or externally. An earth terminal with suitable marking shall be provided for each fitting for discharge lamps.

(vi) Fittings shall be installed such that the lamp is at a height of 2.5m above floor level, unless otherwise directed by the Engineer-in-Charge.

2.12.3 Bulk head fittings

Bulk head fittings shall be of cast iron/cast alluminium body, suitably painted white inside and gray outside, complete with heat resistant glass cover, gasket, BC lamp holder for 100W incandescent lamp, and wire guard & CFL.

2.12.4 Fittings for outdoor use shall be of appropriate (weather proof) design so as to effectively prevent the entry of moisture. Flexible cord conductors and cord grip lamp holders must not be used where exposed to weather.

2.14 MCB TYPE DISTRIBUTION BOARDS (MCBDB)

(i) MCBDB's may be of single phase, 3 phase (horizontal type) suitable for feeding single phase loads, or 3 phase (vertical type) suitable for feeding single phase as well as 3 phase loads as specified. These shall be complete with accessories, but without MCBs which shall be specified as a separate item in the tender documents.

(ii) The current ratings and the number of ways shall be as specified. Blanking plates shall be provided to close unused ways.

(iii) DB with integral incomer

Where it is proposed to install the controlling MCB/MCB type isolator/both, the total number of outgoing MCBs will be reduced by one or two numbers corresponding to SP or SP&N at the incoming, since the total number of ways are fixed in MCBDBs. Bus bars in such units shall also be correspondingly shorter. The inter connections shall be done between the incomer and outgoings as part of the DB in the works.

(iv) MCBDBs shall be of surface/flush mounting pattern according to the requirement of their location and shall be suitable to accommodate MCB's and MCB type isolators and RCD (ELCB) at incoming in single pole or multiple configuration as required.

(v) MCBDBs shall be dust and vermin proof conforming to IP 22, 42 and 54 as specified.

(vi) MCBDBs shall have removable type and plates with knock outs at the bottom and top and shall have hinged covers with locking arrangement.

(vii) Only the knobs of the MCBs shall protrude out of the front covers through openings neatly machine made for the purpose.

(viii) The bus bars used shall be solid electrolytic copper of appropriate sections.

(ix) DIN bar (s) shall be provided for mounting the MCBs.

2.15 PRE-WIRED MCB DISTRIBUTION BOARDS

(i) Prewired MCBDBs shall be provided only where specified.

(ii) The complete board shall be factory fabricated and shall be duly prewired in the works, ready for installation at site.

(iii) The board shall be of wall mounted cubical type construction, fabricated out of 1.6mm thick sheet steel with stove enamelled paint finish.

(iv) The board shall also be provided with a loose wire box as a compartment for the complete width and, depth of the board and of minimum height of 125mm in case of TPN DB's and 100mm in case of SPN BD's.

(v) The board shall be provided with a hinged cover of 1.6mm thick sheet steel in the front. only the knobs of the MCBs shall protrude out of the front covers through openings neatly machine made for the purpose.

(vi) Knock out holes at the bottom and detachable plate with knock out holes at the top of the board shall be provided.

(vii) The board shall be complete with the following accessories.

(a) 200A copper bus bar (s) (b) Neutral link

(c) Common earth bar

(d) Din bar for mounting MCBs

(e) Elemex type terminal connectors suitable for incoming and outgoing cables.

(f) A set of indication lamps with HRC cartridge fuses for each phase of the incoming supply.

(g) Earthing stud (s).

(viii) The board shall be fully prewired with single core PVC insulated copper conductors/insulated solid copper links and terminated on to extended type terminal connectors, suitable for connections to the sizes of the respective conductors.

(ix) All incoming and outgoing wiring to the prewired MCBDBs shall be terminated only in the Elemex type extended terminal connectors to be provided within the DB. The terminal connectors shall therefore be so provided as to facilitate easy cable connections and subsequent maintenance.

(x) A common copper earth bar shall be provided within the loose wire box. The common neutral bar as well as the terminal connectors shall however be provided within the main compartment just below the loose wire box.

2.16 MINIATURE CIRCUIT BREAKERS (MCB's)

(i) C Characteristics MCB's shall be used only for normal 'lighting' circuits.

(ii) D characteristics MCB's shall be invariably used for motor loads halogen lamp fittings sodium/mercury discharge lamps and all 'power' circuits.

(iii) Ratings (A as well as KA), No. of poles, type of MCB etc: shall be as specified in the SOR items.

2.18 SWITCH BOARD LOCATIONS

2.18.1 General Aspects

(i) Switch boards shall be located as per drawings.

(ii) As far as practicable, the boards should be accessible from common areas like corridors, lobby areas, etc.

(iii) Switch boards shall be located only in dry situations and in well ventilated spaces. They shall not be placed in the vicinity of storage batteries and exposed to chemical fumes.

(iv) Switch boards shall not be erected above gas stoves, or sinks or within 2.5m of any washing unit in the washing rooms of laundries or in the bath rooms.

2.18.2 Main Switch Boards

(i) Main switch boards shall be situated as near as practicable to the termination of service line, and shall be easily accessible without the use of any external aid, to quickly disconnect the supply in case of emergencies.

(ii) Main switch boards shall be installed in rooms, or cup boards or suitable enclosed space having provisions for locking arrangement so as tosafeguard against operation by unauthorized personnel.

2.18.3 Distribution Switch Boards

(i) The distribution boards shall be located as near as possible to the center of the load they are intended to control. These board shall be fixed on suitable stanchion or wall, and shall be accessible for attention to fuses/MCBs.

(ii) Where two or more distribution boards feeding low pressure circuits are fed from a supply al medium voltage, these distribution boards shall be -

(a) Fixed not less than 2m apart, or

(b) Arranged so that two cannot be opened at a time, namely, they are interlocked, and the metal case is marked Danger 400V, or

(c) Installed in a room or enclosure accessible to only authorized persons.

2.19 SWITCH BOARD CONSTRUCTION

2.19.1 Hinged Type Board

(i) Hinged type boards shall be suitable for mounting of energy meter.

(ii) The board shall consist of a box made of sheet metal not less than 18 SWG thick and shall be provided with a hinged cover to enable the board to be swung open for the examination of the wiring at the back. The joints shall be substantially welded. The front sheet shall be provided with locking arrangement and suitable hinges to enable the board to swing open for examination of the wiring. The joints shall be substantially welded.

(iii) There shall be a clear distance of 3cm between the front and back sheets. More space shall be allowed wherever necessary.

(iv) The board shall be provided with an earthing stud. the earth stud should be commensurate with the size of eart lead.

(v) Suitable hole shall be drilled to take the wiring as well as for fixing the mounting. No hole shall be drilled closer than 1cm from any edge of the board.

2.19.2 cubicle Type Switch Boards

Cubicle type switch boards shall be wall/floor mounted or wall floor mounted as specified.

2.19.3 Common requirements for all Types of Switch Boards

(i) Switch boards, if unavoidably fixed in places likely to be exposed to weather, to drip, or to dampness, their outer casing shall be weather proof, and shall be provided with glands or bushing or adopted to receive screwed conduits according to the manner in which the cables are run. PVC and double flanged bushes shall be fitted in the holes of the switches for entry and exist of wires.

(ii) When it is unavoidable to install in a situation where inflammable, or explosive dust, varpour or gas is likely to be present, the switch boards shall be totally enclosed, or made flame proof as may be necessitated by the particular circumstances.

(iii) The various live parts, unless they are effectively screened by substantial barriers of non hygroscopic, non-inflammable, insulating material, shall be so spaced that an are cannot be maintained between such parts and with earth.

(iv) In every case in which switches and fuses are fitted on the same pole, these fuses shall be as arranged that the fuses are not alive when their respective switches are in the 'off' position.

(v) No fuses, other than fuses in instrument circuit shall be fixed on the back of, behind a switch board panel, or frame.

(vi) Equipments which are on the front of a switch board shall be so arranged that inadvertent personal contact with live parts (direct contact) is unlikely during the manipulation of switchgears changing of fuses, or like operations.

(vii) The arrangement of the gear shall be such that they shall be readily accessible and their connections to all instruments and apparatus shall be easily traceable.

(viii) Interconnections of the various mounting on the boards shall be done using PVC insulated copper conductors, or solid strips with PVC taping/sleeving, of appropriate sizes. Terminations shall be made such that local heating is avoided.

(ix) No holes, other than the holes by means of which the panel is fixed, shall be drilled closer than 1cm from any edge of the panel.

(x) All the metal work of switch boards shall be painted prior to erection with one coat of anti-rust.

(xi) All switch boards shall be provided with Danger Notice Plate conforming to relevant Indian Standards. If required in the tender specifications, a pilot lamp shall be fixed and connected through an independent single pole switch and fuse to the bus bars of the board.

2.20 SWITCH BOARD INSTALLATION

(i) Unless and otherwise specified in the tender documents, a switch board shall not be installed, so that its bottom is within 1.25m above the floor unless the front of the switch board is completely enclosed by a door, or the switch board is located in a position to which only authorized persons have access.

(ii) The switch board inside a residence shall be installed such that the operating knob/handle of the incomer is at a height of about 2m for case of operation at times or emergency.

(iii) There shall be a clear distance of 1 Mtr. in front of the switch boards. The space behind the switch boards shall be either less than 20cm or more than 75cm. If there are any attachments or bare connections at the back of the switch board. Rule 51(c) of the Indian Electricity Rules shall apply.

(iv) Hinged type boards shall be securely fixed on wall by means of rag bolts. Fixed type boards shall be installed by suitably grouting the frame work on the wall and/or floor as required. Cubicle type boards shall be installed by suitable foundation bolts grouted in the floor, or alternatively over masonry cable trenches on necessary channel sections, duly grouted as required.

(v) Cubicle type switch boards shall be recessed in the wall if so specified in the tender documents. The front shall then be fitted with hinged panel with locking arrangement the outer surface of door being flush with the wall. Ample room shall be provided for the wiring/cable connections at the side and at the front between the switch gear mounting and the door.

(vi) (a) The connections between the switch gear mounting and the outgoing cable upto the wall shall be enclosed in a protection pipe.

(b) Where it is required to terminate a number of conduits on a board, it may be convenient to provide a suitable MS adopter box for the purpose. Such boxes shall be provided with the prior approval of the Engineer-in-Charge and this will be paid for separately.

(vii) All wires to the boards shall be bushed at the entries to avoid damage to insulation.

(viii) No apparatus shall project beyond any edge of the panel. No fuse body shall be mounted within 2.5cm of any edge of the panel.

(ix) Bus bars and interconnecting strips in fabricated boards shall be PVC taped or sleeved in Red, Yellow and Blue for phases, Black for neutral and green for earthing. The inter connecting cables shall also follow this colour coding.

(x) All unused holes in the boards and in the mounting shall be plugged suitably to avoid entry of insects.

2.21 WIRING OF SWITCH BOARDS AND DISTRIBUTION BOARDS

(i) All connections between pieces of apparatus or between apparatus and terminals on a board shall be neatly arranged in a definite sequence, following the arrangement of the apparatus thereon avoiding unnecessary crossings.

(ii) Cables shall be connected to terminals either by crimped or soldered lugs, unless the terminals are of such a form that they can be securely clamped without cutting away of cable strands.

(iii) All bare conductors shall be rigidly fixed in such a manner that a clearance of atleast 2.5cm is maintained between conductors of opposite polarity or phase, and between the conductors and any material other than insulating material.

(iv) In a hinged type board, the incoming and outgoing cables shall be neatly bunched and shall be fixed in such a way that the door shall be capable of swining through an angle of not less than 90 degrees.

2.22 MARKING OF APPRATUS

(i) Marking of earthed neutral conductor

On the main switch gear, where the conductors include an earthed conductor of a two wire system, or an earthed neutral conductor of a multi wire system, or a conductor which is to be connected thereto, an indication of a permanent nature shall be provided to identify the earthed neutral conductor. In this connection Rule 32(i) of Indian Electricity Rules (See Appendix-C) shall be referred to the neutral conductor shall be black in colour.

2.23 ATTACHMENT OF FITTINGS AND ACCESSORIES

2.23.1 Conduit wiring system

(i) All accessories like switches, socket outlets, call bell pushes and regulators shall be fixed in flush pattern inside the switch/regulator boxes. Accessories like ceiling roses, brackets, batten holders, stiff pendants etc. shall be fixed on metal outlet boxes. The fan regulators may also be fixed on metal outlet boxes, if so directed by the Engineer-in-Charge.

(ii) Alluminium alloy or cadmium plated iron screws shall be used to fix the accessories to their bases.

(iii) The switch box/regulator box shall normally be mounted with their bottom 1.25m from floor level, unless otherwise directed by the Engineer-in-Charge.

2.24 FIXING TO WALLS AND CEILING

(i) Wooden plugs for ordinary walls or ceiling shall not be used in view of the ban on use of timber in Government works. However, where so specified, these shall be of well seasoned teak or other approved hard wood not less than 5cm long by 2.5cm square on the inner end, and 2cm square on the outer end. They shall be cemented into walls within 8.5mm of the surface, the remainder being finished according to the nature of the surface with plaster or lime punning.

(ii) PVC sleeves, dash fasteners should normally be used for fixing to walls or ceiling.

(iii) Plugging of walls or ceiling can be done in a between way where neatness in the first consideration. In all such cases, an approved type of asbestos or fibre fixing plug (rawl or phil plug) with correct size of tools shall be used and done in a workmanlike manner.

2.25 FANS, REGULATORS AND CLAMPS

2.25.1 Ceiling Fans

(i) Ceiling fans including their suspensiors shall conform to relevant Indian Standards.

(ii) All ceiling fans shall be wired to ceiling roses or to special connector boxes and suspended from hooks or shackles with insulators between hooks and suspension rods. There shall be no joint in the suspension road.

(iii) For wooden steel joists and beams, the suspension shall consist of MS flat of size not less than 40mm x 6mm secured on the sides of the joists or beams by means above the beam, a through bolt of size not less than 1.5cm dia shall be placed above the beam from which the flats are suspended. In the latter case, the flats shall be secured from movements by means of another bolt and nut at the bottom of the beam. A hook consisting of MS rod of size not less than 1.5cm dia shall be inserted between the MS flat through oval holes on their sides. Alternatively, the flats may be bend inwards to hold tightly between them by means of a bolt and nut, a hook of 'S' form.

(iv) In the case of 'I' beams, flats shall be shaped suitably to catch the flanges and shall be held together by means of a long bolt and nut.

(v) For concrete roofs, a 12mm dia MS rod in the shape of 'U' with their vertical legs bent horizontally at the top at least 19cm on either side, and bound to the top reinforcement of the roof shall be used as per IS code.

(vi) In buildings with concrete roofs having a low ceiling height, where the fan clamp mentioned under sub clause (v) above cannot be used, or wherever specified, recessed type fan clamp inside a metallic box as per IS code.

(vii) Canopies on top of suspension rod shall effectively hide the suspension.

(viii) The leading in wire shall be of nominal cross sectional area not less than 1.5 Sqmm and shall be protected from abrasion.

(ix) Unless otherwise specified, all ceiling fans shall be hung 2.75m above the floor.

(x) In the case of measurement of extra down rod for ceiling fan including wiring, the same - shall be measured in units of 10cm. Any length less than 5cm shall be ignored.

(xi) The wiring of extra down rod shall be paid as supplying and drawing cable in existing conduit.

2.25.2 Exhaust Fans

(i) Exhaust fans shall conform to relevant Indian Standards.

(ii) Exhaust fans shall be erected at the places indicated by the Engineer-in-Charge. For fixing and exhaust fan, a circular hole shall be provided in the wall to suit the size of the frame, which shall be fixed by means of rag bolts embedded in the wall. The hole shall be neatly plastered to the original finish of the wall. The exhaust fan shall be connected to the exhaust fan point, which shall be wired as near to the

hole as possible, by means of a flexible cord, care being taken to see that the blades rolate in the proper direction.

(iii) Exhaust fans for installation in corrosive atmosphere shall be painted with special PVC paint of chlorinated rubber paint.

(iv) Installation of exhaust fans in kitchens, dark rooms and such other special locations need careful consideration, any special provisions needed shall be specified.

2.25.3 Regulators

The metallic body of regulator or ceiling fans/exhaust fans shall be connected to earth by protective conductor.

2.26 WORKMANSHIP

(i) Good workmanship is an essential requirement to be compiled with. The entire work of manufacture/ fabrication, assembly and installation shall conform to sound engineering practice.

(ii) The work shall be carried out under the direct supervision of a first class licensed foreman, or of a person holding a certificate of competency issued by the State Govt. for the type of work involved, employed by contractor, who shall rectify then and there the defects pointed out by the Engineer-in-Charge during the progress of work.

2.27 COMMISSIONING OF COMPLETION

Before the workman leaves the work finally, he must make sure that the installation is in commission, after due testing.

2.28 COMPLETION PLAN AND COMPLETION CERTIFICATE

(i) For all works costing more than Rs. 20000/- completion certificate after completion of work as given in Appendix-F shall be submitted to the Engineer-in-Charge.

(ii) Completion plan drawn to a suitable scale in tracing cloth with ink indicating the following alongwith three blue print copies of the same shall also be submitted.

(a) General layout of the building.

(b) Locations of main switch board and distribution boards, indicating the circuit numbers controlled by them.

(c) Position of all points and their controls.

(d) Types of fittings, viz. fluorescent, pendants, brackets, bulk head, etc. fans and exhaust fans.

(e) Name of work, job number, accepted tender reference actual date of completion, names of Division/Sub Division and name of the firm who executed the work with their signature.

(iii) In the case of works costing less than Rs. 20000/- the completion plan shall be prepared by the Department and signed by the contractor before final payment is made.

2.29 ADDITION TO AN INSTALLATION

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

2.30 CONNECTION TO ANCILLARY BUILDINGS

(i) Unless otherwise specified, electrical connections to ancillary buildings such as out houses, garages etc. adjacent to the main building at a distance not greater than 3m and when no road intervenes, shall be taken in an earthed GI pipe of suitable size in the exposed portion at a height of not less than 2.5m. This applies to both runs of mains or sub mains or circuit wiring between the buildings.

(ii) When the distance between the buildings exceed 3m or a road was intervenes, separate mains, or sub mains shall be run from the main building to ancillary building and the portion of the same exposed to weather shall be carried in weather proof cable on GI bearer wire at a height not less than 4m above the ground level. Alternatively, PVC wire in GI pipe or underground cable may be used below ground level.

2.31 DRAWINGS

(i) The work shall be carried out in accordance with the approved drawings of UADD as directed by engineer-in-charge.

(ii) All wiring diagrams shall be deemed to be 'Drawings' within the meaning of the term as used. They shall indicate the main switch board, the distribution boards (with circuit numbers controlled by them), the runs of various mains and sub mains and the position of all points with their controls.

(iii) All circuits shall be indicated and numbered in the wiring diagram and all points shall be given the same number as the circuit to which they are electrically connected.

CHAPTER 3

METALLIC CONDUIT WIRING SYSTEM

3.0 SCOPE

This chapter covers the detailed requirements for wiring work in metallic conduits. This chapter covers both surface and recessed types of works.

3.1 APPLICATION

(i) Recessed conduit is suitable generally for all applications. Surface conduit work may be adopted in places like workshops, plant rooms, pump rooms, wiring above false ceiling/below false flooring and at locations where recessed work may not be possible to be done. The type of work viz. surface or recessed shall be as specified in the respective works.

(ii) Flexible conduits may only be permitted for inter connections between switch gear, DB's and conduit terminations in wall.

3.2 MATERIALS

3.2.1 Conduits

(i) All rigid conduit pipes shall be of steel be ISI marked. The wall thickness shall be not less than 1.6mm (16 SWG) for conduits upto 32mm dia and not less than 2mm (14 SWG) for conduits above 32mm dia. These shall be solid drawn or reamed by welding and finished with galvanized or stove enamelled surface.

(ii) The maximum number of PVC insulated cables conforming to IS : 694-1990 that can be drawn in one conduit is given sizewise in Table -1 and the number of cables per conduit shall not be exceeded. Conduit sizes shall be selected accordingly in each run. The table given below.

TABLE -1

Maximum number of PVC insulated 650/1110 V grade
alluminium/copper conductor cable conforming to IS:694-1990
(Clause - 3.2.1 (ii))

Nominal Cross section area of	20mm		25mm		32mm		38mm		50mm		64mm	
conductor in Sqm	S	B	S	B	S	B	S	B	S	B	S	B
1.5	5	4	10	8	18	12	-	-	-	-	-	-
2.5	5	3	8	6	12	10	-	-	-	-	-	-
4.0	3	2	6	5	10	8	-	-	-	-	-	-
6.0	2	-	5	4	8	7	-	-	-	-	-	-
10.0	2	-	4	3	6	5	8	6	-	-	-	-
16.0	-	-	2	2	3	3	6	5	10	7	12	8
25.0	-	-	-	-	3	2	5	3	8	6	9	7

Nominal Cross section area of conductor in Sqm	20mm		25mm		32mm		38mm		50mm		64mm	
	S	B	S	B	S	B	S	B	S	B	S	B
35.0	-	-	-	-	-	-	3	2	6	5	8	6
50.0	-	-	-	-	-	-	-	-	5	3	6	5
70.0	-	-	-	-	-	-	-	-	4	3	5	4

Note:-

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

(iii) No steel conduit less than 20mm in diameter shall be used.

3.2.2 Conduit accessories

(i) The conduit wiring system shall be complete in all respects including their accessories.

(ii) All conduit accessories shall be of threaded type and under no circumstances pin grip type of clamp grip type accessories shall be used.

(iii) Bends couplers etc. shall be solid type in recessed type of works and may be solid or inspection type as required, in surface type of works.

(iv) (a) Saddles for surface conduit work on wall shall not be less than 0.55mm (24 gauge) for conduits upto 25mm dia and not less than 0.9mm (20 gauge) for largest diameter. The corresponding widths shall be 19mm and 25mm.

(b) The minimum width and the thickness of girder clips used for fixing conduits to steel joists, and clamps shall be given below.

TABLE - II
Girder Clips or clamps
(Clause 3.2.2(iv)

Size of conduit	Width	Thickness
20mm	19mm	0.9mm (20 SWG)
25mm	19mm	0.9mm (20 SWG)
32mm and above	25mm	1.2mm (18 SWG)

3.2.3 Outlets

(i) The switch box or regulator box shall be made of metal on all sides, except on the front. In the case of cast boxes, the wall thickness shall be at least 3mm and in case of welded mild steel sheet boxes, the wall thickness shall not be less than 1.2mm (18 gauge) for boxes upto a size of 20cm x 30cm and above this size

1.6mm (16 gauge) thick MS boxes shall be used. The metallic boxes shall be duly painted with anticorrosive paint before erection as per chapter 9 of these Specifications.

(ii) (a) Outlet boxes shall be of one of the size, covered in the Schedule of Rates.

(b) Where a large number of control switches control switches and/or fan regulators are required to be installed at one place, these shall be installed is more than one outlet box adjacent to each other for case of maintenance.

(iii) An earth terminal with stud and 2 metal washers shall be provided in each Metal/box for termination of protective conductors and for connection to socket outlet/ metallic body of fan regulator etc.

(iv) A metal strip shall be welded/screwed, to the metal box as support if tumbler type of control switches, sockets and/or fan regulators are to be fixed therein.

(v) Clear depth of the box shall not be less than 60mm and this shall be increased suitably to accommodate mounting of fan regulators in flush pattern.

(vi) The fan regulators can also be mounted on the switch box covers, if so stipulated in the tender specifications, or if so directed by the Engineer-in-Charge.

(vii) Except where otherwise stated, 3mm thick phenolic terminated sheets as per clause 2.11.3 shall be fixed on the front with brass screws, or alluminium alloy/ cadmium plated iron screws is approved by the Engineer-in-Charge.

3.3 INSTALLATION

3.3.1 Common aspects for recessed and surface conduit works

(i) Conduit Joints

(a) The conduit work of each circuit or section shall be completed before the cables are drawn in.

(b) Conduit pipes shall be jointed by means of screwed couplers and screwed accessories only. Threads on conduit pipes in all cases shall be between 13mm to 19mm long sufficient to accommodate pipes to full threaded portion of couplers or accessories.

(c) Cut ends of conduit pipes shall have no sharp edges, nor any burrs left to avoid damage to the insulation of the conductors while pulling them through such pipes.

(d) The Engineer-in-Charge, with a view to ensuring that the above provision has been carried out, may require that the separate lengths of conduit etc. after they have been prepared, shall be submitted for inspection before being fixed.

(e) No bare threads portion of conduit pipe shall be allowed unless such bare threaded portion is treated with anticorrosive pipe derivative or covered with approved plastic compound.

(ii) Bends in conduit

(a) All necessary bends in the system, including diversion, shall be done either by neatly bending the pipes without cracking with a bending radius of not less than

7.5cm or alternatively, by inserting suitable solid or inspection type normal bends, elbows or similar fittings, or by fixing cast iron inspection boxes, whichever is most suitable.

(b) No length of conduit shall have more than the equivalent of four quarter bends from outlet to outlet.

(c) Conduit fittings shall be avoided as far as possible on conduit system exposed to weather. Where necessary, solid type fittings shall be used.

(iii) outlets

(a) All outlets such as switches, wall sockets etc. may be either flush mounting type, or of surface mounting type, as specified in the Additional Specification.

(b) All modular switches socket outlets, fan regulator etc. shall be fixed on click fit pattern. Paino type switches and accessories shall be fixed on the phenolic laminated sheet covers in flush pattern.

(iv) Painting after erection

After installation, all accessories of conduit pipes, fittings, switch and regulator boxes etc. shall be painted as per IS code.

3.3.2 Additional requirements for surface conduit work

(i) Painting before erection

The outer surface of conduit including all bends, unions, tees, junction boxes, etc. forming part of the conduit system, shall be adequately protected against rust when such system is exposed to weather, by being painted with 2 coats of red oxide paint applied before they are fixed.

(ii) Fixing conduit on surface

(a) Conduit pipes shall be fixed by addles, secured to suitable approved plugs with screws in an approved manner at an interval of not more than one metre, but on either side of the couplers or bends of similar fittings, saddles shall be fixed at a distance of 30cm from the centre of such fittings.

(b) Where conduit pipes are to be laid along the trusses, steel joists etc. the same shall be secured by means of saddles or girder clips or clamps as required by the Engineer-in-Charge.

(c) In long distance straight run of conduit, inspection type couplers at reasonable intervals shall be provided, or running threads with couplers and jamnuts shall be provided.

(iii) Fixing outlet boxes

Only a portion of the switch box shall be sunk in the wall, the other portion being projected out for suitable entry of conduit pipes into the box.

3.3.3 Additional requirements for recessed conduit work

(i) Making chase

(a) The chase in the wall shall be neatly made, and of ample dimensions to permit the conduit to be fixed in the manner desired.

(b) In the case of buildings under construction, the conduits shall be burried in the wall before plastering, and shall be finished neatly after erection of conduit.

(c) In case of exposed brick/rubble masonry work, special care shall be taken to fix the conduit and accessories in position alongwith the building work.

(ii) Fixing conduits in chase

(a) The conduit pipe shall be fixed by means of stapples, J. hooks or by means of saddles, not more than 60cm apart, or by any other approved means of fixing.

(b) All threaded joints and conduit pipes shall be treated with some approved preservative compound to secure protection against rust.

(iii) Fixing conduits in 'RCC work'

(a) The conduit pipes shall be laid in position and fixed to the steel reinforcement bars by steel binding wires before the concreting is done. The conduit pipes shall be fixed firmly to the steel reinforcement bars to avoid their dislocation during pouring of cement concrete and subsequent tamping of the same.

(b) Fixing of standard bends or elbows shall be avoided as far as practicable, and all curves shall be maintained by bending the conduit pipe itself with a long radius which will permit easy drawing in of conductors.

(c) Location of inspection/junction boxes in RCC work should be identified by suitable means to avoid unnecessary chipping of the RCC slab subsequently to locate these boxes.

(iv) Fixing inspection boxes

(a) Suitable inspection boxes to the minimum requirement shall be provided to permit inspection and to facilitate replacement of wires, if necessary.

(b) These shall be mounted flush with the wall or ceiling concrete. Minimum 65mm depth junction boxes shall be used in roof slab and the depth of the boxes in other places shall be as per IS : 2667-1977.

(c) Suitable ventilating holes shall be provided in the inspection box covers.

(v) Fixing switch boxes and accessories

Switch boxes shall be mounted flush with the wall. All outlets such as switches, socket outlets etc. shall be flush mounting type, unless otherwise specified in the Additional Specifications.

(vi) Fish wire

To facilitate subsequent drawing of wires in the conduit. GI fish wire of 1.6mm/ 1.2mm (16/18 SWG) shall be provided alongwith the laying of the recessed conduits.

(vii) Bunching of cables

(a) 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 the same conduit.

(b) Where the distribution is for single phase loads only, conductors for these phases shall be drawn in one conduit.

(c) In case of three phase loads, separate conduits shall be run from the distribution boards to the load points, or outlets as the case may be.

3.3.4 Earthing requirements

(i) The entire system of metallic conduit work, including the outlet boxes and other metallic accessories, shall be mechanically and electrically continuous by proper screwed joints, or by double checknuts at terminations. The conduit shall be continuous when passing through walls or floors.

(ii) Protective (loop earthing) conductor (s) shall be laid along the runs of the conduit between the metallic switch boxes and the distribution boards/switch boards, terminated thereto. These conductors shall be of such size and material as specified. Depending upon their size and material, the protective earth conductors shall be either drawn inside the conduits alongwith the cables, or shall be laid external to the conduits. When laid external to the conduits, this shall be properly clamped with the conduit at regular intervals.

(iii) The protective conductors shall be terminated properly using earth studs, earth terminal block etc. as the case may be.

(iv) Gas or water pipe shall not be used as protective conductor (earth medium).

TABLE -1

Maximum number of PVC insulated 650/1110 V grade
alluminium/copper conductor cable conforming to IS:694-1990
(Clause - 3.2.1 (ii))

Nominal Cross section area of conductor in Sqm	20mm		25mm		32mm		38mm		50mm		64mm	
	S	B	S	B	S	B	S	B	S	B	S	B
1.5	5	4	10	8	18	12	-	-	-	-	-	-
2.5	5	3	8	6	12	10	-	-	-	-	-	-
4.0	3	2	6	5	10	8	-	-	-	-	-	-
6.0	2	-	5	4	8	7	-	-	-	-	-	-
10.0	2	-	4	3	6	5	8	6	-	-	-	-
16.0	-	-	2	2	3	3	6	5	10	7	12	8
25.0	-	-	-	-	3	2	5	3	8	6	9	7
35.0	-	-	-	-	-	-	3	2	6	5	8	6
50.0	-	-	-	-	-	-	-	-	5	3	6	5
70.0	-	-	-	-	-	-	-	-	4	3	5	4

Note:-

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

TABLE - II
Girder Clips or clamps
(Clause 3.2.2(iv)

Size of conduit	Width	Thickness
20mm	19mm	0.9mm (20 SWG)
25mm	19mm	0.9mm (20 SWG)
32mm and above	25mm	1.2mm (18 SWG)

CHAPTER -4

NON METALLIC CONDUIT WIRING SYSTEM

4.0 SCOPE

This chapter covers the detailed requirements for the wiring works in non-metallic conduits. This chapter covers both surface and recessed types of wiring work.

4.1 APPLICATION

4.1.1 Recessed conduit work is generally suitable for all applications. Surface conduit work may be adopted in places like workshops etc. and where recessed work may not be possible to be done. The type of work shall be as specified in individual works.

4.1.2 Flexible non metallic conduits shall be used only at terminations, wherever specified.

4.1.3 Special precautions

(i) If the pipes are liable to mechanical damages, they should be adequately protected.
(ii) Non metallic conduit shall not be used for the following applications:
(a) In concealed/inaccessible places of combustible construction where ambient.
(b) In places where ambient temperature is less than 5 degrees C.
(c) For suspension of fluorescent fittings and other than 5 degrees C.
(d) In areas exposed to sunlight.

4.2 MATERIALS

4.2.1 Conduits

(i) All non-metallic conduit pipes and accessories shall be of suitable material complying with IS : 2509-1973 for rigid conduits and IS: 6946-1973 for flexible conduits. The rigid non metallic conduits shall be ISI marked. The interior of the condiuits shall be free from obstruction.

(ii) The conduits shall be circular in cross section. The conduits shall be designated by their nominal outside diameter. The dimensional details of rigid non-metallic conduits are given in Table below.

TABLE -III
Dimensional details of rigid non-metallic conduits
[(Clause 4.2.1 (ii)]

(All dimensions in mm)

Sl.No.	Nominal outside diameter (in mm)	Maximum Outside diameter (in mm)	Minimum Inside diameter (in mm)	Maximum permissible eccentricity (in mm)	Maximum permissible ovality (in mm)
1.	20	$20^{+0.3}$	17.2	0.2	0.5
2.	25	$25^{+0.3}$	21.6	0.2	0.5
3.	32	$32^{+0.3}$	28.2	0.2	0.5
4.	40	$40^{+0.3}$	35.8	0.2	0.5
5.	50	$50^{+0.3}$	45.0	0.4	0.6

(iii) No non-metallic conduit less than 20mm in diameter shall be used. Tolerance on nominal outside diameter shall be + 0.3mm and - 0mm. The mechanical strength of non-metallic conduits used should not be less than medium grade (M.M.S.)

(iv) Wiring Capacity

The maximum number of PVC insulated alluminium/copper conductor cables of 650/1100V grade conforming to IS : 694-1990 that can be drawn in one conduit of various sizes is given in Table under clause 3.2.1 (ii). Conduit sizes shall be selected accordingly.

4.2.2 Conduit accessories

(i) The conduit wiring system shall be complete in all respect including accessories.

(ii) Rigid conduit accessories shall be normally of grip type.

(iii) Flexible conduit accessories shall be of threaded type.

(iv) Bends, couplers etc. shall be solid type in recessed type of works, and may be solid or inspection type as required, in surface type of works.

(v) Saddles for fixing conduits shall be heavy guage non-metallic type with base.

(vi) The minimum width and the thickness of the ordinary clips or girder clips shall be as per given below.

TABLE - IV
Ordinary clips or girder clips
[(Clause 4.2.2 (vi)]

	Size of conduit	Width	Thickness
1.	20mm and 25mm	19mm	20 SWG (0.9144mm)
2.	32mm and above	25mm	18 SWG (1.219mm)

(vii) For all sizes of conduit, the size of clamping rod shall be 4.5mm (7 SWG) diameter.

4.2.3 Outlets

(i) The switch box shall be made of either rigid PVC moulding, or mild steel, or cast iron on all sides except at the front. The regulator boxes shall however be made only of mild steel or cast iron.

(ii) PVC boxes shall comply with the requirements laid down in IS: 5133 (Part-II)-1969. These boxes shall be free from burrs, fins and internal roughness. The thickness of the walls and base of PVC boxes shall not be less than 2mm. The clear depth of PVC boxes shall not be less than 60mm.

(iii) The specification for metallic boxes shall be as per requirements of clause 3.2.3

(iv) 3mm thick phenolic laminated sheet covers for all types of boxes shall be as per requirements of clause 2.11.3

4.3 INSTALLATION

4.3.1 Common aspects for both recessed and surface conduit works

(i) The erection of conduits of each circuit shall be completed before the cables are drawn in.

(ii) Conduit Joints

(a) All joints shall be sealed/cemented with an approved cement. Damaged conduit pipes/fittings shall not be used in the work. Cut ends of conduit pipes shall have no sharp edges nor any burrs left to avoid damage to the insulation of conductors while pulling them through such pipes.

(b) The Engineer-in-Charge with a view to ensuring that the above provision has been carried out, may, require that the separate lengths of conduit etc. after they have been prepared, shall be submitted for inspection before being fixed.

(iii) Bends in conduit

(a) All bends in the system may be formed either by bending the pipes by an approved method of heating, or by inserting suitable accessories such as bends, elbows or similar fittings, or by fixing non-metallic inspection boxes, whichever is most suitable. Where necessary, solid type fittings shall be used.

(b) Radius of bends in conduit pipes shall not be less than 7.5cm. No length of conduit shall have more than the equivalent of four quarter bends from outlet to outlet.

(c) Care shall be taken while bending the pipes to ensure that the conduit pipe is not injured, and the internal diameter is not effectively reduced.

(iv) Outlets

All switches, plugs, fan regulators etc. shall be fitted in flush pattern. The fan regulators can be mounted on the switch box covers, if so stipulated in the tender specifications, or if so directed by the Engineer-in-Charge.

(v) Painting

After installation, al accessible surface of metallic accessories shall be painted.

4.3.2 Additional requirements for surface conduit work

(i) Conduit pipes shall be fixed by heavy gauge non-metallic saddles with base, secured to suitable approved plugs with screws in an approved manner, at an interval of not more than 60cm, but on either side of couplers or bends or similar fittings, saddles shall be fixed at a closer distance from the centre of such fittings. Slotted PVC saddles may also be used where the PVC pipe can be pushed in through the slots.

(ii) Where the conduit pipes are to be laid along the trusses steel joists etc. the same shall be secured by means of saddles or girder clips as required by the Engineer-in-charge. Where it is not possible to use those for fixing suitable lamps with bolts and nuts shall be used.

(iii) If the conduit pipes are liable to mechanical damage, they shall be adequately protected.

4.3.4 Earthing requirements

(i) A protective (earth) conductor shall e drawn inside the conduit in all distribution circuits to provide for earthing of non current carrying metallic parts of the installation. These shall be terminated on the earth terminal in the switch boxes, and/or earth terminal blocks at the DBs.

(ii) Protection conductors of large size which may not be possible to be carried inside the conduits (as in the case of some sub mains etc.) may be laid external to the conduits and clamped thereof suitably.

(iii) Gas of water pipes shall not be used as protective conductors (earth medium).

TABLE -III
Dimensional details of rigid non-metallic conduits
[(Clause 4.2.1 (ii)]

(All dimensions in mm)

Sl.No.	Nominal outside diameter (in mm)	Maximum Outside diameter (in mm)	Minimum Inside diameter (in mm)	Maximum permissible eccentricity (in mm)	Maximum permissible ovality (in mm)
1.	20	$20^{+0.3}$	17.2	0.2	0.5
2.	25	$25^{+0.3}$	21.6	0.2	0.5
3.	32	$32^{+0.3}$	28.2	0.2	0.5
4.	40	$40^{+0.3}$	35.8	0.2	0.5
5.	50	$50^{+0.3}$	45.0	0.4	0.6

TABLE - IV
Ordinary clips or girder clips
[(Clause 4.2.2 (vi)]

	Size of conduit	Width	Thickness
1.	20mm and 25mm	19mm	20 SWG (0.9144mm)
2.	32mm and above	25mm	18 SWG (1.219mm)

CHAPTER - 5
CASING WIRING SYSTEM

5.0 SCOPE

This chapter covers the requirements of casing wiring system using metallic or PVC casing and capping (otherwise also called 'wireways').

5.1 APPLICATION

5.1.1 Casing and capping wiring is suitable for surface wiring work indoors where necessitated, either due to aesthetics or technical requirements, such as case of extension of existing wiring, avoidance of recessed wiring in RCC columns etc. PVC insulated cables and/or other approved insulated cables to IS : 694-1990 shall be used in this type of work.

5.1.2 (i) This system using PVC wireways shall not be adopted in residential buildings, or such other locations where there is a risk of tampering.

(ii) Restrictions of applications on the sue of non-metallic conduit as indicated in clause 4.1.3 are applicable for PVC casing wiring system as well.

(ii) Where casing wiring system has to be necessarily adopted in situations under (i) and/or (ii) above, only metallic wireways shall be used.

5.2 MATERIALS

5.2.1 The casing and capping shall be of the same material, viz. either PVC or anlayzed alluminium, in extruded sections.

5.2.2 The casing shall have a square or rectangular body. The capping shall be slide in type with double grooving in the case of PVC wireways, and plain type for metallic wireways. All surfaces shall have smooth finish inside and outside. The top of the side walls of the casing body wshall be suitable for the above types of fixing arrangement of capping thereof.

5.2.3 PVC casing and capping shall be of good quality PVC, free from defects like deformation, unevenness, blisters, cavities etc.

5.2.4 Dimensions

(ii) the sizes of casing and capping for the various sizes of cables and the maximum number of 650/1100 V. grade PVC insulated alluminium/copper conductor cables that can be carried in one casing are given sizewise in TableV below.

TABLE - V
Maximum number of PVC insulated 650/1100 Volts grade alluminium/cooper conductor cable conforming to IS:694-1990
[Clause 5.2.4(i)]

Nominal cross Sectional area of conductor in Sqmm	10/15mm x10mm	20mm x10mm	25mm x10mm	30mm x10mm	10mm x20mm	50mm x20mm
1.5	3	5	6	8	12	18
2.5	2	4	5	6	9	15
4.0	2	3	4	5	8	12
6.0	-	2	3	4	5	9
10.0	-	1	2	3	5	8
16.0	-	-	1	2	4	6
25.0	-	-	-	1	3	5
35.0	-	-	-	-	2	4
50.0	-	-	-	-	1	3
70.0	-	-	-	-	1	2

Note : Dimensions shown above are outer dimensions of casing

(ii) The thickness of the casing and capping shall be 1.2mm +/- 0.1mm.

5.2.5 Outlet boxes

The outlet boxes such as switch boxes, regulator boxes and their phenolic laminated sheet covers shall be as per requirements under clause 3.2.3

5.3 INSTALLATION

5.3.1 Attachment to wall and ceiling

(i) The casing shall be fixed by means of suitable flat head screws to approved type of asbestos or fibre fixing plugs, at intervals not exceeding 60cm for all sizes. One either side of the joints, the distance of the fixing arrangement shall not exceed 15cm from the joint. Screw head shall be counter sunk within the centre of the casing. Alternatively, round headed screws may be used.

(ii) All casing shall be fixed directly on wall or ceiling as above.

(iii) Casing shall be used only on dry walls and ceiling, avoiding outside walls as far as possible and shall not be burried in walls, nor fixed in proximity to gas, steam or water pipes, or immediately below the latter.

(iv) Casing under steel joists shall be secured by MS clips of not less than 1.2mm (18 SWG) thickness width not less than 19mm or by approved clamps.

5.3.2 Passing through floors or walls

When conductors pass through floors, the same shall be carried in an approved PVC conduit, or heavy gauage steel conduit properly bushed at both ends. The conduit shall be carried 20cm above floor level and 2.5cm below ceiling level and neatly terminated into the casing. Steel conduit pipes wherever accessible shall be securely earthed.

5.3.3 Joints in casing and capping

(i) The wireways in straight runs should be in single piece as far as possible so as to avoid joints.

(ii) All joints shall be scared or cut diagonally in longitudinal section and shall be smoothed down by filling to make the joints a very close fit as far as possible and without burrs. They shall be screwed at joints with two or more screws as would be necessary.

(iii) Joints in capping shall not overlap those in casing.

(iv) Joints arising out of bends or diversions shall be done using standard accessories like elbows, tees, 3 way/4 way junctions etc. of high graded PVC/alluminium alloy (as the case may be) or by suitably cutting the wireways and filling them to have a reasonably gapless butt joints. In no case, the radius of curvature of the cables inside a bend shall be less than 6 times their overall diameter.

5.3.4 Casing to harmonize with decor.

(i) When the wiring is to be done over an ornamental work with which it is required to harmonize, the design of any special accessories which may be necessary shall be submitted to the Engineer-in-Charge for approval before use on the work.

(ii) Casing attached to ceiling shall be carried completely across the ceiling/wall whenever required by the Engineer-in-Charge, instead of being stopped at an outlet location, and in all such cases, dummy casing must be provided.

5.3.5 Attachment of capping

(i) Wherever required by the Engineer-in-Charge, capping shall not be fixed until the work has been inspected with the wires in position and approved. The inspection will be done from time to time as the work progresses.

(ii) Capping shall be attached to casing in individual sections only after all the insulated wires are laid inside.

(iii) No screws or nails shall be used for fixing PVC capping to the casing.

(iv) Metallic capping shall be fixed by using cadmium plated flat head/round head screws in a staggered manner with an axial spacing not exceeding 30cm.

5.3.6 Installation of cables

(i) For ease of maintenance, cables carrying direct current or alternating current shall always be bunched so that the outgoing and return cables are drawn in the same casing.

(ii) Necessary clamps shall be provided to hold the wires inside the casing at suitable intervals, so that at the time of opening of the capping, the wires may remain in position in the casing and do fall out.

5.4 EARTH CONTINUITY

(i) A protective (earth continuity) conductor shall be drawn in the casing and capping for earthing of all metallic boxes of installations as well as for connections to the earth pin of socket outlets.

(ii) In the case of metallic casing and capping there shall a metallic link between adjacent casings with screw connections, also connections from the end casing to

the earth terminal of metallic boxes/outlets/switch board as the case may be for complete earthing of the system.

TABLE - V
Maximum number of PVC insulated 650/1100 Volts grade alluminium/cooper conductor cable conforming to IS:694-1990
[Clause 5.2.4(i)]

Nominal cross Sectional area of conductor in Sqmm	10/15mm x10mm	20mm x10mm	25mm x10mm	30mm x10mm	10mm x20mm	50mm x20mm
1.5	3	5	6	8	12	18
2.5	2	4	5	6	9	15
4.0	2	3	4	5	8	12
6.0	-	2	3	4	5	9
10.0	-	1	2	3	5	8
16.0	-	-	1	2	4	6
25.0	-	-	-	1	3	5
35.0	-	-	-	-	2	4
50.0	-	-	-	-	1	3
70.0	-	-	-	-	1	2

Note : Dimensions shown above are outer dimensions of casing

CHAPTER -7
EARTHING

7.0 SCOPE

This chapter covers the essential requirements of earthing system components and their installation. For details not covered in these Specifications. IS:code of Practice on Earthing (IS:3043-1987) shall be referred to.

7.1 APPLICATION

(i) The electrical distribution system in the Department is with earthed neutral (i.e. neutral earthed at the transformer/generator end). In addition to the neutral earthing, provision is made for earthing the metallic body of equipments and non current carrying metallic components in the sub station, as well as in the internal/ external electrical installations.

(ii) Earthing system is also required for lighting protection, computer installations and hospital operation theatres, etc. for functional reasons.

(iii) Earthing requirements are laid down in the Indian Electricity Rules, 1956, as amended from time to time, and in the Regulations of the Electricity Supply Authority concerned. These shall be complied with.

(iv) Though this chapter form part of the Specifications for Internal EI works, these requirements shall be complied with in works of earthing for other applications also.

7.2 EARTHING REQUIREMENTS

1. Statutory requirement

(i) All medium voltage equipments shall be earthed by two separate and distinct connections with earth. In the case of high and extra high voltages, the neutral points shall be earthed by not less than two separate and distinct connections with earth, each having its own electrode at the generating station or substation, and may be earthed at any other point, provided no interference is caused by such earthing. If necessary, the neutral may be earthed through a suitable impedance.

(ii) Necessary protective device shall be provided against earth leakage.

2. Supply system requirement

'System Earthing' is provided to preserve the security of the supply system. This is done by limiting the potential of live conductors with reference to earth, to such values as consistent with the level of insulation applied. Earthing the neutral point of the transformer ensures reasonable potential to earth, including at the time when the HV supply is impressed on the transformer. Earthing also ensures efficient operation of protective gear in the case of earth faults. Earthing may not give protection against faults that are not essentially earth faults. For example, if a

phase conductor on an overhead spur line breaks, and the part remote from the supply falls to the ground, it is unlikely that any protective gear relying on earthing, other than current balance protection at the substation, will operate, since the earth fault current circuit includes the impedance of the load that would be high relative to the rest of the circuit.

3. Installation protection requirement

"Equipment Earthing" is provided to ensure that the exposed conductive parts in the installation do not become dangerous by a attaining a high touch potential under conditions of faults. It should also carry the earth fault currents, till clearance by protective devices, without creating a fire hazard.

4. Special requirements

(i) "Static Earthing" is provided to prevent building up of station charges, by connections to earth at appropriate. Example, operation theaters in hospitals. (For details, please refer to IS:7689-1974 and the National Electrical Code).

(ii) 'Clean Earth" may be needed from some of the data processing equipments. These are to be independent of any other earthing in the building. (For details, please refer to IS:10422-1982 and IS:3043-1987).

(iii) Earthing is essentially required in protection of buildings against lightning. (For details, please refer to chapter 9 and Appendix-G of these specifications).

5. TYPES OF SYSTEM EARTHING

(a) The various types of System Earthing in practice are indicated below, out of which TN-S and T-TN-S system are generally applicable to installations in the Department.

(i) TN-S system

Neutral is earthed at source. In addition to the phase and neutral conductors, an independent protective earth (PE) conductor connected to the source earth is also run with the supply line. All the exposed conductive parts of an installation are connected to this PE conductor via the main earthing terminal of the installation. Independent earth electrode is also necessary with in the consumer premises at the main earthing terminal.

(ii) TN-C system

Neutral is earthed at source. No separate PE conductor is run with the supply line, nor in the internal installations, since neutral and PE are on a common conductor. All exposed conductive parts of an installation as well as the neutral line are connected to this PE&N conductor. (A CNE cable is used for wiring such installations). Additional earth electrode has to be provided for this conductor locally for 3 phase consumers.

(iii) TN-C-S- system (Also called Protective Multiple Earth system)

Supply is as per TN-C system. The arrangement in the installations is as per TN-S system, i.e. The PE and N are combined in one conductor at supply line. This is

earthened at source as well as at frequent intervals. There will be independent protective conductor in the installation. Consumer also normally provides earth electrode terminating on to main earth electrode in his installation, and this is in turn 'linked' to the PE&N conductor from supply line. All the exposed conductive parts in the installation are connected to the PE&N conductive, through protective conductors and this main earthing terminal link.

(iv) T-TN-S System (for 6, 606 or 11 KV bulk supply)

No earth is provided with HV supply line, which is terminated in delta connected transformer primary. Neutral of the transformer (star connected) secondary is earthed. Independent earth electrodes and bus are provided for the body earthing. Protective conductors are run through out the LT distribution from the same for equipotential bonding.

(v) TT system

Neutral is earthed only at source and no PE conductor is given with supply line. All the exposed conductive parts of the installation are connected to an earth electrode at consumer end, which is independent of the source earth, electrically.

(vi) IT system

The source has either no earth or is earthed through a high impendence. All the exposed conductive parts of the installation are connected to an earth electrode, which is independent of the source earth, electrically.

6. Concept of protection against indirect contact

(i) The most commonly and successfully used method of protection against indirect contact is by "Earthed Equipotential bonding and automatic disconnection of supply", details of which are elaborated in IS:732-1989 and IS:3040-1987. All the exposed conductive parts are connected through protective (loop earthing) conductors to the main earthing terminal. All the extraneous conductive parts which are simultaneously accessible with the exposed conductive parts are also bonded to the main earthing terminal through main bonding conductor so that there is no dangerous potential between the exposed and theoxtraneous conductive parts. The earth fault loop impedance (EFLI) and the characteristics of the tripping devices are co-ordinated such that the faulty circuit is automatically disconnected before there is a persistent touch voltage at the exposed conductive part over it period of time, causing a shock hazard. If the disconnecting time is not satisfactory due to large EFLI supplementary bonding between the exposed and the extraneous conductive parts is provided. Alternatively, use of RCD's becomes very relevant in most such situations. (See Appendix-H for information on selection of RCD's). For more details IS:3043-1987 may be referred to.

Note: Decision regarding the providing of RCD (RCCB) shall be taken in individual cases keeping in view the type, use, importance, system of earthing and nature of

electrical installations to be protected by the RCD, requirements of the local Electric Supply Companies etc.

(ii) Earthing (comprising the electrode, earthing conductor, main earthing terminal etc.) and protective conductors in an installation area thus vital components in this system of protective against shock hazards. The concept is indicated diagrammatically in Fig. 3 indicates the method of ensuring the same, as envisaged in these Specifications.

(iii) Rule 61A of I.E. Rules, 1958 calls for protective devices against earth leakages for certain loads. This should be complied with.

(iv) The following exposed conductive parts are excepted from bonding to earth.

(a) Overhead line insulator wall brackets or another metal connected to them, provided they are out of arm's reach.

(b) Inaccessible steel reinforcement in RCC poles.

(c) Exposed conductive parts that cannot be gripped or contacted by a major surface of the human body, provided a protective conductor connection cannot be readily made, or reliably maintained.

(d) Fixing screws of non-metallic parts, provided there is no risk of them contacting live parts.

(e) Short lengths of conduits or similar items which are not accessible.

(f) Metal enclosure for mechanical protection of double insulated equipments.

7. Selection of type of Electrodes

Following are general guidelines for the selection of the type electrodes

S.No.	Type of Electrode	Application
(i)	GI pipe	Internal electrical installation, with incoming switch gear upto 200A.
(ii)	GI plate	(i) For internal electrical installation with incoming switch gear larger than 200A.
		(ii) Neutral earthing of transformers, generating sets upto 500 KVA.
		(iii) Lightning conductors.
(iii)	Copper plate	Neutral earthing of transformer /generating sets above 500 KVA.
(iv)	Strip/Conductor	Locations where it is not possible to use other types.

8. Number of Earth Electrodes

(i) In all cases, relevant provisions of Rules 33, 61 and 67 of Indian Electricity Rules, 1956 as amended shall be complied with.

(ii) Non current carrying metal parts of all apparatus utilizing power supply at voltage exceeding 250 volts shall be earthed by two separate as and distinct connections to the earth bus, or to two separate distinct earthing sets.

(iii) The number of earthing electrodes for substations and generation sets shall be as under :-

For neutral earthing of each transformer	- 2 sets
For body earthing of all the transformer HT/LT panels and other electrical equipments in the substation/power house	- 2 sets
For neutral earthing of each generating set	- 2 sets
For body earthing of all the generating sets, LT panels and other electrical equipments in the generator room	- 2 sets

Where the generator and substation equipments are located together with the same building, the body earthing can be common for all the electrical equipments in the building.

8. Size of protective conductor

(i) The cross section of a protective conductor may be calculated by either of the following 2 methods, the second one being used for designs in general, and the first one for checking purposes.

(i) $S > I\ t/K$

Where S = Cross sectional area of protective conductor is Sq.mm.

I = Earth fault (Leakage) current in Amp.

t = Total tripping time of the device in sec. (not exceeding 5 sec)

k = Factor dependent on the material of the protective conductor insulation if any thereon, and initial and final temperatures.

I = U, where U = Nominal phase voltage to earth

Z = Earth fault loop impendance (considering its 5 seconds value)

Note:1 Values of Z are available in Tables in IEE wiring Regulations, UK, dependent on tripping devices. Alternatively, this can be calculated.

Note:2 Values of K for different materials are given in IS: 3043 for various parameters.

(ii) The minimum shall as per the following:

(iii)

Size of phase conductor	Size of protective conductor of the same material as phase conductor
S upto 16 sqmm	S sqmm
S = 16 to 35 sqmm	16 sqmm
S > 35 sqmm	S/2 sqmm

Note: If the material of the protective conductor is different from that of the phase conductor, the size as per the above should be multiplied by K1/K2 where K1 is the K factor for phase conductor material, and K2 for the protective conductor material. As a rough guide, the following values can be taken.

K1/K2 for copper

_____ = 1.20 to 1.24

Alluminium (Insulated)

Copper

_____ = 2.17 to 2.25

Steel wire (Insulated)

Copper

_____ = 2.31 to 2.45

Steel (conduits/trunking)

(ii) The minimum acceptable size of a protective conductor shall be 2.5 Sqmm if protected mechanically, and 5 Sqmm if otherwise.

9. Size of earthing conductor

(i) The earthing conductors shall comply with the provisions of clause 3.5 above, except that the minimum cross sectional area shall be 16 Sqmm (copper or steel) when protected against corrosion, and 25 Sqmm copper, or 50 Sqmm steel when not protected against corrosion.

(ii) For determining the size of earthing conductor for substations and generating sets, IS:3043-1987 may be referred to.

10. Size of bonding conductor

The main bonding conductor should be half the size of the earthing conductor, subject to a minimum of 6 Sqmm and maximum of 25 Sqmm copper, or equivalent sizes for other materials. This is applicable for TNS and TNC-s system only.

11. Details for contract purposes

While this Appendix provides information on design considerations, the sizes of the conductors, types of electrodes etc. shall be as laid down in the tender documents of individual works, and as directed by the Engineer-in-Charge.

7.2 MATERIALS

7.2.1 Earth Electrodes

7.2.1.1 Types

The type of earth electrode shall be any of the following as specified (For selection criteria in designs.

(a) Pipe earth electrode

(b) Plate earth electrode

(c) Rod earth electrode

7.2.1.2 Electrode materials and dimensions

(i) The materials and minimum sizes of earth electrode table given below:

MATERIALS AND SIZES OF EARTH ELECTRODES
[Clause 7.2.1.2(i)]

Type of Electrode	Material	Size
Pipe	GI Medium Class	40mm dia, 2.5m to 4.5m long as specified (without joint)
Plate	GI	60cm x 60cm x 6.3mm thick
Rod	GI	16mm dia, 3.0long (without joint)
Conductor	(i) GI	6.68mm dia (2 SWG) 5.89mm dia (4 SWG)
	(ii) Copper	4.00mm dia (8 SWG)

Note: Galvanization of GI items shall conform to class IV of IS: 4736-1986.

(ii) GI pipe electrode shall be cut tapered at the bottom and provided with holes of 12mm dia drilled not less than 7.5cm from each other upto 2m of length from the bottom.

(iii) The length of the buried strip or conductor earth electrode shall be not less than 15m. This length shall suitably be increase if necessary, on the basis of the information available about solid resistance of the Engineer-in-Charge shall be taken for any such increase in length.

7.2.2 Earthing Conductor

(i) The earthing conductor (protective conductor from earth electrode upto the main earthing terminal/earth bus, as the case may be) shall be of the same material as the electrode, viz. GI or copper and in the form of wire or strip as specified.

(ii) The size of earthing conductor shall be specified, but this shall not be less than the following (for calculating the size of the earthing conductor in design, Appendix-G may be referred bo).

(a) 5mm dia (6 SWG) for GI, or 4mm dia (8 SWG) for copper wire.

(b) 25mm x 3mm in the case of GI strip, or

(c) 20mm x 3mm in the case of copper strip.

(iii) Earthing conductor larger than the following sectional areas need not be used, unless otherwise specified.

(a) 150 Sqmm in case of GI, or

(b) 100 Sqmm in case of copper.

7.2.3 Earth Bus

(i) Two copper strips, each of size 50mm x 5mm shall be provided as earth bus in a 11KV Sub Station and/or diesel generating station irrespective of the capacity of the transformer of the D.G. set. Each of these strips shall be connected to an independent earth electrode. The two earth leads from the body of each transformer/panel/ generating set etc. shall be connected to these two strips of earth bus. The two strips of the earth bus shall be bonded together.

(ii) The neutral earth leads of the transformer and for generator alternator shall not be connected to this earth bus. They shall be connected directly to individual earth electrodes.

7.2.4 Hardware Items

All hardware items used for connecting the earthing conductor with the electroed shall be of GI in case of GI pipe and GI plate earth electrodes, and forged tinned brass in case of copper plate electrodes.

7.2.5 Protective (Earth continuity/Loop earthing) Conductor

(i) The material and size of protective conductors shall be as specified. (For criteria in design of these. Appendix-G may be referred to).

(ii) The minimum cross sectional area of a protective conductor (not contained with a cable or flexible cord) shall be:-

(a) 2.00mm dia (14 SWG) in case of copper.

(b) 2.64mm dia (12 SWG) in case of GI, or

(c) 2.24mm dia (13 SWG) in case of alluminium

(iii) Unless otherwise specified, GI conductor should not be ordinarily used as protective conductor within any circuit, beyond a DB down stream.

7.3 LOCATION FOR EARTH ELECTRODES

(i) Normally an earth electrode shall not be located closer than 1.5m from any building Care shall be taken to see that the excavation for earth electrode does not affect the foundation to the buildings, in such cases, electrodes may be located further away from the building with the prior approval of the Engineer-in-Charge.

(ii) The location of the earth electrode will be such that the soil has a reasonable chance to remaining moist as far as possible. Entrances, pavements and road ways, should be avoided for locating earth electrodes.

7.4 INSTALLATIONS

7.4.1 Electrodes

7.4.1.1 Various types of electrodes

(i) (a) Rod/Pipe electrode shall be buried in the ground vertically with its top at not less than 20cm below the ground level. The installation shall be carried out as per IS.

(b) In locations where the full length of pipe electrode is not possible to be installed due to meeting a water table, hard soil or rock, the electrode may be to reduced length, provided the required earth resistance result is achieved with or without additional electrode, or any alternative method of earthing may be adopted with the prior approval of the Engineer-in-Charge.

Pipe electrodes may also be installed in horizontal formation in such exceptional cases.

(ii) Plate electrode shall be buried in ground with its faces vertical, and its top not less than 3m below the ground level. The installation shall be carried out as per IS.

(iii) When more than one electrode (plate/pipe) is to be installed, a separation of not less than 2m shall be maintained between two adjacent electrodes.

(iv) (a) The strip or conductor electrode shall be buried in trench not less than 0.5m deep.

(b) If conditions necessitate the use of more than one strip or conductor electrode, they shall be laid as widely distributed as possible, in a single straight trench where feasible or preferably in a number of trenches radiating from one point.

(c) If the electrode cannot be laid in a straight length, it may be laid in a zig-zag manner with a deviation upto 45 degrees from the axis of the strip. It can also be laid in the form of an arc with curvature more than 1m or a polygon.

7.4.1.2 Artificial treatment of soil

When artificial treatment of soil is to be resorted to, the same shall be specified in the schedule of work. The electrode shall be surrounded by charcoal/coke and salt as indicated in fig. 4, 5 and 6. In such cases, excavation for earth electrode shall be increased as per the dimensions indicated in these figures.

7.4.1.3 Watering arrangement

(i) In the case of plate earth electrodes, a watering pipe 20mm dia, medium class pipe shall be provided and attached to the electrodes as shown in Fig. 5. A funnel with mesh shall be provided on the top of this pipe for watering the earth.

(ii) In the case of rod/pipe electrodes, a 40mm x 20mm reducer shall be used for fixing the funnel with mesh.

(iii) The watering funnel attachment shall be bounded in a masonry enclosure of size not less than 30cm x 30cm x 30cm.

(iv) A cast iron/MS frame with MS cover, 6mm thick and having locking arrangement shall be suitably embedded in the masonry enclosure.

7.4.2 Earthing Conductor (Main earthing lead)

(i) In the case of plate earth electrode, the earthing conductor shall be securely terminated on to the plate with two bolts, nuts, checknuts and washers. Preferably welding to be done in place of providing nut, bolts, washers etc.

(ii) In the case of pipe earth electrode, wire type earthing conductor shall be secured as indicated in fig. 4 using a through bolt, nuts and washers and terminating socket.

(iii) A double C-clamp arrangement shall be provided for terminating tape type earthing conductor with GI watering pipe coupled to the pipe earth electrode. Galvanized 'C' shaped strips, bolts, washers, nuts and checknuts of adequate size shall be used for the purpose.

(iv) The earthing conductor from the electrode upto the building shall be protected from mechanical injury by a medium class. 15mm dia GI pipe in the case of wire, and by 40mm dia medium class GI pipe in the case of strip. The protection pipe in ground shall be burried at least 30cm deep (to be increased to 60cm in case of road

crossing and pavements). The portion within the building shall be recessed in walls and floors to adequate depth in due co-ordination with the building work.

(v) The earthing conductor shall be securely connected at the other end to the earth stud/earth bar provided on the switch board by:

(a) Soldered or preferably crimped lug, bolt, nut and washer in the case of wire, and (b) bolt, nut and washer in case of strip conductor.

In the case of substation or alternators, the termination shall be made on the earthing terminal of the neutral point on the equipment and/or earth bus, as the case may be.

7.4.3 Earth Bus and main Earthing Terminal

(i) In the case of substations and generating stations, two numbers copper/GI (as specified) earth bus shall be provided, duly connected to two numbers of independent electrodes, exclusively for equipment (body) earthing of substation or generating station equipments.

(ii) In all other installations, main earthing terminal shall be provided at the main switch board. This may be in the form of earth stud or single earth bar depending on the type of the switch board.

(iii) Following conductors shall be terminated on to the main earthing terminal.

(a) Earth connection from electric supply company (where provided)

(b) Earthing conductor from electrode.

(c) Protective conductors.

(d) Equi-potential bonding conductors.

7.4.4 Protective (Loop earthing/earth continuity) conductor

(i) Earth terminal of every switch board in the distribution system shall be bonded to the earth bar/terminal of the upstream switch board by protective conductor(s).

(ii) Two protective conductors shall be provided for a switch board carrying a 3 phase switchgear thereon.

(iii) All the mounting of industrial type switch boards shall be bonded to the earth stud/earth bar using a protective conductor looping from one to another. Loop earthing of individual units will not be however necessary in the case of cubicle type switch boards.

(iv) The earth connector in every distribution board (DB) shall be securely connected to the earth stud/earth bar of the corresponding switch board by a protective conductor.

(v) All metallic switch boxes and regulator boxes in a circuit shall be connected to the earth connector in the DB by protective conductor (also called circuit protective or loop earthing conductor). Looping from one box to another upto the DB.

(vi) The earth pin of socket outlets as well as metallic body of fan regulators shall be connected to the earth stud in switch boxes by protective conductor. Where the switch boxes are or non-metallic type, these shall be looped at the socket earth

terminals or at an independent screwed, connector inside the switch box, twisted earth connections shall not be accepted in any case.

(vii) Double earthing strips in rising mains, bus trunking etc. shall be securely connected to the earth bar/earth stud at the sending end switch board. In the case of overhead bus bar systems, protective conductors shall be provided in addition to feeder cable armouring connection.

7.5 EARTH RESISTANCE

(i) The earth resistance at each electrode shall be measured. 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 upto 8 ohms.

(ii) Where the above stated earth resistance is not achieved necessary improvement shall be made by additional provisions, such as additional electrode(s), different type of electrode or artificial chemical treatment of soil etc. as may be directed by the Engineer-in-Charge.

7.6 MARKING

(i) Earth bars/terminals at all switch boards shall be marked permanently, either as "E" or as.

(ii) Main earthing terminal shall be marked "SAFETY EARTH" - DO NOT DISCONNECT.

7.7. USE OF RESIDUAL CURRENT DEVICES (RCDs)

An extract on selection and application of RCDs (also known as RCCBs) from IS:12640-1-2000 and 12640-2-2001 is given at Appendix-H. Provision of RCD shall be specified in individual cases keeping in view the type use, importance system of earthing and nature of electrical installations to be protected by the RCCbs requirements of the local electric supply company etc. The sensitivity shall be 30mA, 100mA, 300mA or 500mA as specified.

GUIDELINES FOR SELECTION AND APPLICATION OF RCCBs (RCDs)

1. GENERAL

(i) IS:732-1989 recognizes two forms of shock hazard, 'Indirect contact' and 'Direct contact'. The objective is to achieve safety to personnel and property through the best possible means in the most economic manner.

(ii) The most commonly used protective measure against Indirect contact is termed "main equi potential ponding" and automatic disconnection of supply. Irrespective of the type of protective device used, the aim is to prevent dangerous 'touch voltages' persisting on accessible conductive parts which become live under earth fault conditions. Use of RCCBs is only one of the means that would provide automatic disconnection of supply in the event of shock hazard. The use of RCCB is not considered as a sole means of

protection and it does not obviate the need to apply other protective measures. Some broad guidelines are provided in this Appendix on these issues.

2. RESIDUAL CURRENT OPERATED CIRCUIT BREAKER (RCCB)

(i) In general, every circuit is provided with a means of over current protection. If the earth fult loop impedance low enough to cause these devices to operate within the specified times, such devices can be relied upon a give the requisite automatic disconnection of supply. Where the earth fault loop impedance is too large, efforts are required to make it low enough. Guidelines are available in IS:3043-1987. When protection against indirect contact is decided to be provided by RCCB, IS:732-1989 prescribes that the product of its rated residual current (rated tripping current) in amperes and the earth loop impedance in ohms should not exceed the value 50.

(ii) Fault voltage operated circuit breakers (voltage operated ELCB) are not preferred devices against shock protection. This Appendix covers only truly current operated devices. These are of different types. The following are the two main types:-

(a) Residual current devices not dependent on line voltage, and

(b) Residual current devices dependent on line voltage.

3. CHOICE OF RCCBs

(i) Where RCCBs are required to be used for affording shock protection, there are several broad parameters that are required to be carefully chosen. These are described in the following clauses.

(ii) Location

RCCB can be used as a protective measure to the entire installation, or part, or to an item of equipment. This is determined by the security of supply desired in certain parts of the same installation when RCCB operates. Where only one RCCB is being employed to protect the entire installation, it is necessary that it is located at the main distribution board, at the origin of the installation.

(iii) Type of RCCB

RCCBs are suitable in general for various applications. However, devices suitable for household applications are to be verified for additional requirements as given in this Appendex. RCCB which has its automatic opening internationally delayed may be preferred under certain circumstances. Protable RCCBs may be necessary specially in situations where portable/mobile equipment pose a shock hazard against which other suitable means of protection are not available. Portable RCCBs are required to be tested (using the test button) each time they are used.

(iv) Rated current

The ISS restricts the rated current of the device to an order of magnitude of 125 A. Use of RCCB in circuits of higher rated currents is not envisaged for the time being.

(v) Rated tripping current

(a) The preferred rated currents of RCCBs are 10, 30, 100 and 300 mA. RCCBs having minimum operating currents greater than 30 mA are intended to give protection against

'indirect contact', RCCB having minimum operating currents of 30 mA and below are generally referred to as having 'high sensitivity' and can given protection against 'direct contact' in case of failure of other protective measures. It is essential that an RCCB is not used as a sole means for protection against direct contact.

(b) It is empnasized that the value of leakage current that can flow before the RCCB has operated can be higher than the rated tripping current, the actual value being determined by the impedance of the circuit on which the fault occurs. The rated tripping current is a value assigned by the manufacturer at which the RCCB opens under specified conditions. While the speed of operation will not be significantly affected by the value of leakage current, RCCB can open at any value between 50 to 100 percent of the rated tripping current.

(c) The RCCB should be so chosen as to have the lowest suitable tripping current. Lower the tripping current, the greater is the degree of protection afforded. Nevertheless, it would introduce the possibility of nuisance tripping and may also becomes unnecessarily expensive. The minimum operating current will, therefore, have to be above any standing leakage that may be unavoidable in the installation.

(vi) Discrimination

When more than one RCCB is required to be used by grading the sensitivities, it is possible to achieve discrimination amongst RCCB in the same circuit. Discrimination may also be achieved by selectively employing devices having their tripping times intentionally delayed.

(vii) Type of system earthing

The choice of right sensitivity of RCCB would also be determined by the type of earthing system adopted in the installation. The vectoral sum of leakage currents of equipment supplied by an installation or part of an installation protected by an RCCB shall be less than one-half of the rated residual operating current of the device and it may be necessary to sub-divide the earthing arrangement for this reason. Reference is also invited to IS:3043-1987 'Code of practice for earthing', which gives guidelines on the use of RCCB for different types of system earthing.

(viii) Breaking Capacity

(a) When using RCCBs, it is necessary to assess the prospective current value in the location where it is likely to be installed and ensure that where higher withstanding or breaking capacities are desirable, suitable back up protection is available in the system. This could be by means of a fuse or another circuit breaker (MCB) which is in series with the RCCB. The over current short circuit protective device is then said to provide back up protection for the RCCB. Alternatively, RCCBs with integral over current/short circuit protection could be employed.

(b) In practice, the functions of RCCB and that of the over current/short circuit protective device in series may tend to overlap and under certain conditions both may attempt to clear the fault. This may occur, for example, when a severe earth fault produces a

current of similar magnitude to that under short circuit conditions, or when an earth fault and short circuit occur simultaneously or when an earth fault and short circuit occur simultaneously. Another possible cause is the inherent out of balance in the primary windings of the balance transformer causing the RCCB to trip. Care is, therefore, necessary, to be exercised in ensuring that RCCB is coordinated with over current devices.

(ix) Neutral grounding or failure

Use of RCCBs assumes adequate care in wiring and earthing design. Use of RCCB is not a sole means of affording shock protection. Attention should be given to bonding and choosing the right cross-sectional area of the conductors, specially the protective conductor. Different types of RCCB in different circuits may react differently to the presence of a neutral to earth fault together with the earthing of the supply at the neutral point will constitute a shunt across the neutral winding on the RCCB transformer. Consequently a part of the neutral load current will be shunted away and this may result in the device tripping. On the other hand, the shunting may result in reduced sensitivity and prevent its tripping in general. Therefore, care should be taken to avoid neutral to ground fault when RCCBs are in use. In the event of the neutral failure on the supply side the RCCB should either open automatically, or is of such a design that it remains functions.

4. GUIDELINES FOR SPECIFIC OCCUPANCIES OR LOCATIONS

(i) Household and similar installations

The rated tripping current of RCCBs for use in household and similar installation shall not exceed 30 mA. Use of devices with intentional time delay is not recommended.

(ii) Locations containing bath tub/shower basin and swimming pools.

Where socket outlets and other appliances are to be protected by RCCB, the rated tripping current shall not exceed 30 mA.

(iii) Where individual socket outlets are required to be protected by RCCB, the rated tripping current shall not exceed 30 mA.

(iv) Industrial Installations

For industrial installations, use of RCCB would be dependent upon already available devices capable of offering protection against harmful earth leakages. For example, use of a separate RCCB may not be necessary for installations equipped with protective devices with in-built releases initiating trip signals due to harmful earth leakages. Similarly, individual or group of motors otherwise adequately protected need not be provided additional protection through RCCBs.

(v) Data processing installations/industrial control/telecomm-nication equipment.

Radio frequency interference suppression filters fitted to these equipment may produce high earth leakages. Failure of the protective earth connection may cause a dangerous touch voltage. Use of RCCBs under such circumstances should be carefully considered owing to their frequent tripping, besides capacitor charging currents at

switching on shall have to be considered. Under such circumstances, where leakages exceed 10 mA. one of the three measures given below may be necessary.

(a) Use of high integrity protective earth circuits by robust or duplicate conductors.

(b) Earth continuity monitoring, or provision for automatic disconnection when earth continuity fails, or

(c) Use of double wound transformers to enable localization of path of leakage and minimize the possibility of breakages.

(vi) The presence of generating sets within an installation may charge the conditions of application of RCCB. The contribution to the prospective short circuit current by the.

(vii) Medical establishment and electrical installations in hazardous locations.

The use of RCCB and their selection in such installations has to be carefully considered. Reference is invited to SP:30:1985. 'National Electrical Code'.

CHAPTER - 8

PROTECTION OF BUILDINGS AGAINST LIGHTNING

8.0 SCOPE

This chapter covers the detailed requirements of installation of lightning conductor for protection of buildings against lighting. The principles of this type of protection are outlined in these specification. For details not covered in these specifications reference may be made to IS:2309-1989.

8.1 APPLICATION

This system shall be provided where specified. The decision whether or not to provide this system should be taken by the competent authority considering all relevant factors as per Appendix-I.

8.2 PRINCIPAL COMPONENTS

The principal components of a lightning protective system as:

(a) Air terminations

(b) Down conductors

(c) Joints and bonds

(d) Testing joints

(e) Earth terminations, and

(f) Earth electrodes

8.3 MATERIALS

8.3.1 The materials of air terminations, down conductors, earth termination etc. of the protective system shall be reliably resistant to corrosion, or be adequately protected against corrosion. The material shall be one of the following as specified.

(a) Copper

Solid or flat copper strip of at least 98% conductivity conforming to relevant IS: Specifications shall be used.

(b) 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.

(c) Galvanized Steel

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

(d) Alluminium

Alluminium 99% pure, and with sufficient mechanical strength, and protected against corrosion shall be used.

8.3.2 Alluminium should not be used underground, or in direct contact with walls.

8.3.3 All air terminations shall be of GI and all down conductors shall be of GI or alluminium, except where the atmospheric conditions necessitate the use of copper or copper clad steel for air terminations and down conductors.

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

TABLE - IX
Shapes and minimum sizes of conductors for use above ground
(Clause 8.3.4)

S.No.	Material and shape	Minimum Size
1.	Round copper wire or copper clad steel wire	6mm diameter
2.	Stranded copper wire	50 Sqmm or (7/3.0mm dia)
3.	Copper strip	20mm x 3mm
4.	Round galvanized iron wire	8mm diameter
5.	Galvanized iron strip	20mm x 3mm
6.	Round alluminium wire	8mm diameter
7.	Alluminium strip	25mm x 3mm

TABLE - X
Shapes and minimum sizes of conductors for use above ground
(Clause 8.3.4)

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

8.4 LAYOUT

8.4.1 The sysem design and layout shall be done in accordance with IS:2309-1989 and specified in the tender documents. The work shall be carried out accordingly satisfying at the same time, the requirements of clauses 8.4.2 to 8.4.3.

8.4.2 Air terminations

(i) Air termination networks may consist of vertical of horizontal conductors, or combinations of both. For the purpose of lightning protection, the vertical and horizontal conductors are considered equivalent and the use of pointed air terminations, or vertical finials is therefore, not regarded as essential.

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

(iii) For a flat roof, horizontal air termination along the outer perimeter of the roof shall be used. For a roof of larger area a network of parallel horizontal conductors shall be installed. No part of the roof should be more than 9m from the nearest horizontal protective conductor.

(iv) Horizontal air terminations should be carried along the contours such as ridges, parapets and edges of flat roofs, 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.

(v) All metallic projections including reinforcement, on or above main surface of the roof which are connected to the general mass the earth should bonded and form a part of the air termination network.

(vi) If portions of a structure vary considerably in height, a necessary air termination or air termination network for the low portions should be bonded to the down conductors of the taller portions, in addition to their own down conductors.

8.4.3 Down Conductors

(i) The number and spacing of down conductors shall be as specific or as directed by the Engineer-in-Charge.

(ii) Routing

(a) A down conductor should follow the most direct path possible between the air terminal network and the earth termination network. Where more than one down conductor is used, the conductors should arranged as evenly as practicable around the outside walls of the structure.

(b) The walls of light wells may be used for fixing down conductors, but lift shafts should not be used for this purpose.

(c) Metal pipes leading rainwater from the roof to the ground must be connected to the down conductors, but cannot replace them, sub connections should have disconnecting joints.

(d) In deciding on the routing of the down conductor, its accessibility for inspection, testing and maintenance should be taken in consideration.

(iii) Provision when external route is not available

(a) Where the provision of external routes for down conductors impracticable, for example, in buildings or cantilever construction from first floor upwards, down conductors should not follow the outside contours of the building. To do so would create a hazar to persons standing under the over hang. In such cases, the conductors may be housed in an air space provided by a non-metallic and non combustible internal duct and taken straight down to the ground.

(b) Any suitable covered recess, not smaller than 76mm x 13mm, or any suitable vertical service duct running the full height of the building may be used for this purpose, provided it does not contain an unarmoured or a non metal sheathed cable.

(c) In cases where an unrestricted duct is used, seals at each floor level may be required for fire protection. As far as possible, access to the interior of the dust should be available.

8.4.4 The lightning protective system should be so installed that it does not spoil the architectural or aesthetic beauty of the buildings.

8.5 INSTALLATION

8.5.1 General

(i) The entire lighting protective system should be mechanically strong to withstand the mechanical forces produced in the event of a lightning strike.

(ii) Conductors shall be securely attached to the building, of other object to be protected by fasteners, which shall be substantial in construction, not subject to breakage, and shall be of galvanized steel or other suitable materials, with suitable precautions to avoid corrosion.

(iii) The lightning conductors shall be secured not more than 1.2m apart for horizontal run, and 1m for vertical run.

8.5.2 Air Terminations

All air terminals shall be effectively secured overturning either by attachment to the object to be protected or by means of substantial bracings and fixing 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 the climatic conditions and possible corrosion.

8.5.3 Down conductors

(i) The down conductor system must, where practicable, be directly routed from the air termination to the earth termination network, and as far as possible, be symmetrically placed around the outside walls of the structure starting from the corners. In all cases consideration to side flashing must always be given.

(ii) (a) Practical reasons may not sometimes allow the most direct route to be followed/While sharp bends, such as arise at the end of a roof are in escapable (and hence permissible), re-entrant loops in a conductor can produce high inductive voltage drops so that the lightning discharge may jump across the open side of a loop. As a rough guide, this risk may arise when the length of the conductor forming the loop exceeds 8 times the width of the open side of the loop.

(d) When large re-entrant loops as defined above cannot be avoided, such as in the case of some cornices or parapets, the conductors should be arranged in such a way that the distance across the open side of a loop complies with the requirement indicated above. Alternatively such cornices or parapets should be provided with holes through which the conductor can pass freely.

(iii) Bonding to prevent side flashing

Any metal in, or forming a part of the structure, or any building services having metallic parts which are in contact with the general mass of the earth, should be either isolated from, or bonded to the down conductor. This also applies to all

exposed large metal items having any dimension greater than 2m whether connected to the earth or not.

8.5.4 Joints and bonds

8.5.4.1 Joints

(i) A lightning protective system should have as few joints as possible.

(ii) Joints should be mechanically and electrically effective, for example, clamped, screwed, bolted, crimped, riveted or welded.

(iii) With overlapping joints, the length of the overlap should not be less than 20mm for all types of conductors.

(iv) Contact surfaces should first be cleaned then inhibited from oxidation with a suitable non-corrosive compound.

(v) Joints of dissimilar metals should be protected against corrosion or erosion from the elements or the environment and should present an adequate contact area.

8.5.4 Bonds

(i) Bonds have to join a variety of metallic part of different shape and composition and cannot therefore be of a standard from.

(ii) There is the constant problem of corrosion and careful attention must be given to the metals involved, i.e. the metal from which the bond is made, and those of the items being bonded.

(iii) The bond must be mechanically and electrically effective, and protected from corrosion in, and erosion by the operating environment.

(iv) External metal on, or forming part of a structure may have to discharge the full lightning current, and its bond to the lighting protective system should have a cross sectional area not less than that employed for the main conductors.

(v) Structures supporting overhead electric supply, telephone and other lines must not be bonded to a lightning protective system without the permission of the appropriate authority.

(vi) Gas pipe in no case shall be bonded to the lighting protective earth termination system.

8.5.5 Test Joints

Each down conductor should be provided with a test clamp in such a position that, while not inviting unauthorized interference, it is convenient for use when testing.

8.5.6 Earth Termination network

(i) An earth station comprising one or more earth electrodes as required should be connected to each down conductor. This shall be specified.

(ii) Each of the earth stations should have a resistance not exceeding the product given by 10 ohms multiplied by the number of earth electrodes to be provided therein. The whole of the lighting protective system, including any ring earth, should have a combined resistance to earth not exceeding 10 ohms without taking account of any bonding [as per 8.5.3 (iii)].

(iii) If the value obtained for the whole of the lightning protection system exceeds 10 ohms a reduction can be achieved by extending or adding to the electrodes, or by Interconnecting the individual earth terminations of the down conductors by a conductor installed below ground, sometimes referred to as a ring conductor. Burried conductors laid in this manner are considered to be an integral part of the earth termination network, and should be taken into account when assessing the overall value of resistance of earth of the installation.

(iv) A reduction of the resistance to the earth to a value below 10 ohms has the advantage of further reducing the potential gradient around the earth electrode when discharging lightning current. It also further reduces the risk of side flashing to metal in, or of structure.

(v) Earth electrodes should be capable of being isolated and a reference earth point should be provided for testing purposes.

CHAPTER - 10
TESTING OF INSTALLATION

10.0 SCOPE

This chapter describes the details of tests to be conducted in the completed internal electrical installations, before commission.

10.1 GENERAL

10.1.1 Tests

One completion of installation, the following tests shall be carried out.

1. Insulation resistance test.
2. Polarity test of switch.
3. Earth continuity test.
4. Earth electrode resistance test.

10**.1.2 Witnessing of tests**

Testing shall be carried out for the completed installations, in the presence of and to the satisfaction of the Engineer-in-Charge by the contractor. All test results shall be recorded and submitted to the Department.

10.1.3 Test instruments

All necessary test instruments for the tests shall be arranged by the contractor if so required by the Engineer-in-Charge.

10.2 INSULATION RESISTANCE

10.2.1 The insulation resistance shall be measured by applying between earth and the whole system of conductors, or any section thereof with all fuses in place, and all switches closed, and except in earthed 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 it need not exceed 500 volts for medium voltage, circuits, where the supply is derived from a three wire D.C. or a polyphane A.C. system the neutral pole of which is connected to earth either directly or through added resistance, the working pressure shall be deemed to that which is maintained between the phase conductor and the neutral.

10.2.2 The insulation resistance shall also be measured between all the conductors connected to one pole, or phase conductor of the supply, and all the conductors connect to the neutral, or to the other pole or phase conductors of the supply with all the lamps in position, and switches in off position, and its value shall be not less than that specified in sub case 10.1.3.

10.2.3 The insulation resistance in megaohms measured as above shall not less than 12.5 megaohms for the wiring with PVC insulated cable subject to a minimum of 1 megaohm.

10.2.4 Where a whole installation is being tested, a lower value than that given by the formula, subject to a minimum of 1 megaohm, is acceptable.

10.2.5 A preliminary and similar test may be made before the lamps etc. are installed and in this event the insulation resistance to earth should not be less than 25 megaohms for the wiring with PVC insulated cables, subject to a minimum of 2 megaohms.

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

10.2.7 Control rheostats, heating and power appliances and electric signs may, if required, be disconnected from the circuit during the test, but in that event the insulation resistance between the case or frame work, and all live parts of each rheostat, appliance and sign shall be not less than that specified in the relevant Indian Standard Specifications, or where there is no such specification, shall be not less than one megaohm.

10.3 POLARITY TEST OF SWITCH

10.3.1 In a two wire installation a test shall be made to verify that all the switches in every circuit have been fitted in the same conduits throughout, and such conductor shall be labeled or marked for connection to the phase conductor or to the non-earthed conductors of the supply.

10.3.2 In a three wire or a four wire installation, a test shall be made to verify that every non linked single pole switch is fitted in a conductor which is labeled, or marked for connection to one of the phase conductors of the supply.

10.3.3 The installation shall be connected to the supply for testing the terminals of all switches shall be tested by a test lamp, one lead of which is connected to the earth. 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.

10.4 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 alongwith 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.

10.5 MEASUREMENT OF EARTH ELECTRODE RESISTANCE

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

R=

R = V/I

Where,

R = Resistance of the test electrode in ohms.

V = Reading of the voltmeter in volts.

I = Reading of the ammeter in amps.

REF. CLAUSE 10.5.1

10.5.2 (i) Stray currents flowing in the soil may produce serious errors in the measurement of earth resistance. To climinate this, hand driven generator is used.

(ii) If the frequency of the supply of hand driven generator coincides with the frequency of stray current, there will be wandering of instrument pointer. An increase or decrease of generator speed will cause this to disappear.

10.5.3 At the time of test, the test electrode shall be separated from the earthing system.

10.5.4 The auxiliary electrodes shall be of 13mm diameter mild steel rod driven upto 1m into the ground.

10.5.5 All the three electrodes shall be so placed that they are independent of the resistance area of each other. If the test electrode is in the form of a rod, pipe or plate, the auxiliary current electrode 'C' shall be placed at least 30m away from it, and the auxiliary potential electrode 'B' shall be placed mid way between them.

10.5.6 Unless three consecutive readings of test electrode resistance agree, the test shall be repeated by increasing the distance between electrodes A and C upto 50m and each time placing the electrode B midway between them.

10.5.7 On these principles, 'Megger Earth Tester' containing a direct reading ohm-meter, a hand driven generator and auxiliary electrodes are manufactured for direct reading of earth resistance of electrodes.

10.6 TEST CERTIFICATE

One completion of an electrical installation (or an extension to an installation) a certificates shall be furnished by the contractor, countersigned by the certified supervisor under whose direct supervision the installation was carried out. This certificate shall be in the prescribed form as given in Appendix 'F' in addition to the test certificate required by the Local Electric Supply Authorities.