भारतीय मानक ब्यूरो
(उपभोक्ता मामले, खाद्य एवं सार्वजनिक वितरण मंत्रालय, भारत सरकार)
BUREAU OF INDIAN STANDARDS
(Ministry of Consumer Affairs, Food & Public Distribution, Govt. of India)

मानक भवन, 9, बहादुर शाह ज़फर मार्ग, नई दिल्ली – 110002
Manak Bhawan, 9, Bahadur Shah Zafar Marg, New Delhi – 110002
Mob.: 7071963270, Phones: 011-23608594, Extn: 8594
Website: www.bis.org.in , www.bis.gov.in

व्यापक परिचालन मसौदा

हमारा संदर्भ: सीईडी 46 /टी-15 **02 मई 2025**

तकनीकी समिति: भारत की राष्ट्रीय भवन निर्माण विषय समिति, सीईडी 46

प्राप्तकर्ता :

1. **सिविल अभियांत्रिकी विभाग परिषद, सीईडीसी के सभी सदस्य**
2. **राष्ट्रीय भवन निर्माण संहिता विषय समिति, सीईडी 46 के सभी सदस्य**
3. **सीईडी 46 की उपसीमितयों और अन्य कार्यदल के सभी सदस्य**
4. **रुचि रखने वाले अन्य निकाय।**

महोदय/महोदया,

निम्नलिखित मानक का मसौदा संलग्न हैं:

प्रलेख संख्या	शीर्षक
सीईडी 46 (27026) WC	**भारत की राष्ट्रीय भवन निर्माण संहिता भाग 8 भवन निर्माण सेवाएँ अनुभाग 2 विद्युतीय एवं संबद्ध संस्थापन** [SP7(भाग 8 अनुभाग 2) का चौथा पुनरीक्षण] (आई सी एस नंबर: 01.120: 91.040.01)

कृपया इस मसौदे का अवलोकन करें और अपनी सम्मतियाँ यह बताते हुए भेजे कि यह मसौदा प्रकाशित हो तो इस पर अमल करने में आपको व्यवसाय अथवा कारोबार में क्या कठिनाइयां आ सकती हैं।

सम्मतियाँ भेजने की अंतिम तिथि: 02 जून 2025

सम्मति यदि कोई हो तो कृपया अधोहस्ताक्षरी को ई-मेल द्वारा ced46@bis.gov.in पर या उपरलिखित पते पर, संलग्न फोर्मेट में भेजें। सम्मतियाँ बीआईएस ई-गवर्नेंस पोर्टल, www.manakonline.in के माध्यम से ऑनलाइन भी भेजी जा सकती हैं।

यदि कोई सम्मति प्राप्त नहीं होती है अथवा सम्मति में केवल भाषा संबंधी त्रुटि हुई तो उपरोक्त प्रलेख को यथावत अंतिम रूप दे दिया जाएगा। यदि सम्मति तकनीकी प्रकृति की हुई तो विषय समिति के अध्यक्ष के परामर्श से अथवा उनकी इच्छा पर आगे की कार्यवाही के लिए विषय समिति को भेजे जाने के बाद प्रलेख को अंतिम रूप दे दिया जाएगा।

यह प्रलेख भारतीय मानक ब्यूरो की वैबसाइट www.bis.gov.in पर भी उपलब्ध हैं।
धन्यवाद।

भवदीय

ह/-
(द्वैपायन भद्र)
वैज्ञानिक 'ई' एवं प्रमुख (सिविल अभियांत्रिकी विभाग)

सलंग्न: उपरिलिखि

भारतीय मानक ब्यूरो
(उपभोक्ता मामले, खाद्य एवं सार्वजनिक वितरण मंत्रालय, भारत सरकार)
BUREAU OF INDIAN STANDARDS
(Ministry of Consumer Affairs, Food & Public Distribution, Govt. of India)
मानक भवन, 9, बहादुर शाह ज़फर मार्ग, नई दिल्ली – 110002
Manak Bhawan, 9, Bahadur Shah Zafar Marg, New Delhi – 110002
Mob.: 7071963270, Phones: 011-23608594, Extn: 8594
Website: www.bis.org.in , www.bis.gov.in

WIDE CIRCULATION DRAFT

Our Reference: CED 46/T-15 **02 May 2025**

National Building Code of India Sectional Committee, CED 46

ADDRESSED TO:

1. All Members of Civil Engineering Division Council, CEDC
2. All Members of the National Building Code Sectional Committee, CED 46
3. All Members of Subcommittees, Panels and Working Groups under CED 46
4. All other interests

Dear Sir/Madam,

Please find enclosed the following draft:

Doc No.	Title
CED 46 (27026) WC	**National Building Code of India Part 8 Building Services Section 2 Electrical and Allied Installations** [Fourth Revision of SP 7 (Part 8 Section 2)] (ICS No. 01.120: 91.040.01)

Kindly examine the attached draft and forward your views stating any difficulties which you are likely to experience in your business or profession, if this is finally adopted as National Standard.

Last Date for comments: 02 June 2025

Comments if any, may please be made in the enclosed format and emailed at ced46@bis.gov.in or sent at the above address. Additionally, comments may be sent online through the BIS e-governance portal, www.manakonline.in.

In case no comments are received or comments received are of editorial nature, kindly permit us to presume your approval for the above document as finalized. However, in case comments, technical in nature are received, then it may be finalized either in consultation with the Chairman, Sectional Committee or referred to the Sectional Committee for further necessary action if so desired by the Chairman, Sectional Committee.

The document is also hosted on BIS website www.bis.gov.in.

Thanking you,

Yours faithfully,

Sd/-
(Dwaipayan Bhadra)
Scientist 'E' / Director & Head
(Civil Engineering Department)

Encl: As above

FORMAT FOR SENDING COMMENTS ON THE DOCUMENT

[Please use A4 size sheet of paper only and type within fields indicated. Comments on each clause/sub-clause/ table/figure, etc, be stated on a fresh row. Information/comments should include reasons for comments, technical references and suggestions for modified wordings of the clause. **Comments through e-mail to ced46@bis.gov.in shall be appreciated**.

Doc. No.: CED 46 (27026) WC **BIS Letter Ref**: CED 46/T-15

Title: National Building Code of India Part 8 Building Services Section 2 Electrical and Allied Installations [Fourth Revision of SP 7 (Part 8 Section 2)] (ICS No. 01.120: 91.040.01)

Last date of comments: **02 June 2025**

Name of the Commentator/ Organization: ________________________________

Clause/ Para/ Table/ Figure No. commented	Comments/Modified Wordings	Justification of Proposed Change

NOTE- Kindly insert more rows as necessary for each clause/table, etc

BUREAU OF INDIAN STANDARDS

DRAFT FOR COMMENTS ONLY

(Not to be reproduced without the permission of BIS or used as a Standard)

Draft National Building Code of India

Part 8 Building Services

Section 2 Electrical and Allied Installations

[Fourth Revision of SP 7 (Part 8 Section 2)]

(ICS No. 01.120: 91.040.01)

National Building Code Sectional Committee, CED 46	Last Date for Comments: 02 June 2025

C O N T E N T S

National Building Code Sectional Committee, CED 46

FOREWORD

This Code (Part 8/Section 2) covers essential requirements for electrical and allied installations in buildings.

This Section was first published in 1970 and was subsequently revised in 1983, 2005 and 2016. In the first revision, general guidance for electrical wiring installation in industrial location where voltage supply normally exceeds 650 V was included. This Section was also updated based on the existing version of the Indian Standards. The importance of pre-planning and exchange of information among all concerned agencies from the earlier stages of building work was emphasized.

In the second revision of 2005, the title of this Section was modified from the erstwhile 'Electrical Installations' to 'Electrical and Allied Installations' to reflect the provisions included on certain allied installations. The significant changes incorporated in the last revision included, thorough change in the risk assessment procedure for lightning including some other changes in the provision of lightning protection of building; alignment of some of the provisions of wiring with the practices prevalent at that time; modification of definitions in line with terminologies used at national and international level and addition of some new definitions; incorporation of provisions on installation of distribution transformer inside the multi-storeyed building; introduction of concept of energy conservation in lighting and introduction of concept of various types of earthing in building installation.

In the third revision in 2016, various updates made that included: location and other requirements relating to layout, environmental and safety aspects for different substation apparatus/equipment and generating sets were reviewed and updated; location of compact substations was included; requirements for electrical supply system for life and safety services were included; provisions relating to reception and distribution of supply and wiring installations were updated; installation best practices of energy meters were updated; discrimination, cascading and limitation concepts for the coordination of protective devices in electrical circuits were introduced; socket outlets with suitable circuit breakers, conforming to Indian Standards were recommended for industrial and commercial applications, either indoors or outdoors; provisions relating to earthing/grounding were substantially revised and updated; provisions relating to lightning protection of buildings were revamped based on the national and international developments then; provisions relating to renewable energy sources for building, such as solar PV system, aviation obstacle lights, electrical supply for electric vehicle charging and car park management, etc, were included; provisions relating to electrical installations for construction sites and demolition sites were included; provisions relating to protection of human beings from electrical hazards and protection against fire in the building due to leakage current were included; typical formats for checklists for handing over and commissioning of substation equipment and earthing pit were included; and the terminology was updated.

All electrical installations in India come under the purview of The Indian Electricity Act, 2003 and the rules and regulations framed thereunder. In the context of the buildings, both buildings (the structure itself) and the building services (not just the electrical services, but all other services that use electricity or have an interface with the electrical system) are required to follow these. The erstwhile Indian Electricity Rules, 1956 were superseded by various Central Electricity Authority Regulations. While revising the provisions of this Section of the Code, care has been taken to align the same with the provisions of the relevant regulations, particularly, *Central Electricity Authority (Measures Relating to Safety and Electric Supply) Regulations*, 2023. In this revision, in addition to above, the following major modifications have been incorporated:

a) **Clause 3** on general requirements has been reviewed in light of the latest Acts/Rules/Regulations, and project management approach towards electrical work (planning, designing, construction, verification and testing, and maintenance) is introduced.
b) The lower limit of power factor has been updated, in **3.4.1**.
c) Planning of electrical installations now emphasizes the integration of different types of energy sources including grid solar PV power and other renewable energy sources, in **4.1**.
d) The location and other requirements of substation and switchrooms have been reviewed and revised, in clause 4.2.
e) The installation and other requirements of emergency power back up system have been reviewed, in clause 4.3.3.
f) Requirements for Emergency Power Backup System (Li – ion or similar Storage batteries) are included in clause 4.4.
g) Guidance on use of Multiple energy sources in the same building project are addressed in clause 4.5.
h) Safety requirements of substations have been reviewed in clause 4.6.
j) A new option of combination of power transformers and distribution transformers for the system of power supply of building complexes for certain category of load has been suggested in 5.2.2.
k) Guidance for EV chargers, their location in various building types and special requirement for independent distribution transformer have been included in clause 5.2.4.
m) Reception and Distribution of Main Supply (LV connections) have been reviewed in clause 5.4.
n) Selection and Design of Earthing System have been updated in clause 8.2.
p) Requirements for building integrated photovoltaic cells have been reviewed in clause 10.8.
q) Clause 11 on lightning protection of buildings have been reviewed in detail.
r) Annex B has been updated in view of view of updation of Central Electricity Authority (Measures Relating to Safety and Electric Supply) Regulations.
s) Requirements for MV/LV bus bar chambers were reviewed.
u) References to all the concerned Indian Standards have been updated.

This Section has to be read together with Part 8 'Building services, Section 1 Lighting and Natural Ventilation' of the Code for making provision for the desired levels of illumination as well as ventilation for different locations in different occupancies; Part 8'Building Services' Section 5: Information Technology and also with Part 4 'Fire and Life Safety' of the Code for list of emergency fire and life safety services and other sections of Part 8 'Building Services' and Part 9 'Plumbing Services' for electricity related requirements and integration thereof. Utmost importance should be given in the installation of electrical wiring to prevent short circuiting and the hazards associated therewith.

Notwithstanding the provisions given in this Section and the National Electrical Code, 2023 the provisions of the *Central Electrical Authority* regulations framed thereunder have to be necessarily complied with.

The information contained in this section is largely based on the following Indian Standards/Special Publication:

IS 732:2019	Code of practice for electrical wiring installations (*fourth revision*)
IS 3043:2018	Code of practice for earthing (second *revision*)
IS 4648:1968	Guide for electrical layout in residential buildings
IS 12032 (Part 11):1987	Specification for graphical symbols for diagrams in the field of electro technology: Part 11 Architectural and topographical installation plan and diagrams
IS/IEC 62305-1:2010	Protection against lightning: Part 1 General principles
IS/IEC 62305-2:2010	Protection against lightning: Part 2 Risk management
IS/IEC 62305-3:2010	Protection against lightning: Part 3 Physical damage to structures and life hazard
IS/IEC 62305-4:2010	Protection against lightning: Part 4 Electrical and electronic systems within structures
SP 30:2023	National Electrical Code of India, 2023 (*second revision*)

It may be noted that some of the above standards are currently under revision. The revised version when available should also be referred.

Considerable assistance has also been drawn from following International Standards while formulating this Section:

IEC 60364-4-41:2005	Low-voltage electrical installations – Part 4-41: Protection for safety – Protection against electric shock

IEC 60364-4-43:2023	Low-voltage electrical installations - Part 4-43: Protection for safety - Protection against overcurrent
IEC 60364-4-44:2007	Low-voltage electrical installations – Part 4-44: Protection for safety – Protection against voltage disturbances and electromagnetic disturbances
IEC 60364-5-51:2005	Electrical installations of buildings – Part 5-51: Selection and erection of electrical equipment – Common rules
IEC 60364-5-54:2011	Low-voltage electrical installations – Part 5-54: Selection and erection of electrical equipment – Earthing arrangements and protective conductors
IEC 60364-7 series	Low-voltage electrical installations – Part 7: Requirements for special installations or locations
IEC 61439-1:2020	Low-voltage switchgear and controlgear assemblies and bus trunking – Part 1: General rules
IEC 61439-2:2020	Low-voltage switchgear and controlgear assemblies and bus trunking – Part 2: Power switchgear and controlgear assemblies
IEC 61439-6:2012	Low-voltage switchgear and controlgear assemblies and bus trunking – Part 6: Busbar trunking systems (busways)

All standards, whether given herein above or cross-referred to in the main text of this Section, are subject to revision. The parties to agreement based on this Section are encouraged to investigate the possibility of applying the most recent editions of the standards.

For the purpose of deciding whether a particular requirement of this Section is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 2022 'Rules for rounding off numerical values (*second revision*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this Section of the Code.

DRAFT FOR COMMENTS ONLY

(Not to be reproduced without the permission of BIS or used as a Standard)

Draft National Building Code of India

Part 8 Building Services

Section 2 Electrical and Allied Installations

[Fourth Revision of SP 7 (Part 8 Section 2)]

(ICS No. 01.120: 91.040.01)

National Building Code Sectional Committee, CED 46	Last Date for Comments: 02 June 2025

1 SCOPE

This Code (Part 8/Section 2) covers the essential requirements for electrical installations in buildings to ensure efficient use of electricity including safety from fire and shock. This Section also includes general requirements relating to lightning protection of buildings and brief provisions on certain allied installations.

2 TERMINOLOGY AND CONVENTIONAL SYMBOLS

2.1 For the purpose of this Section, the following definitions shall apply. For definition of other terms, reference may be made to accepted standards [8-2(1)].

2.1.1 *Accessory* – A device, other than current using equipment, associated with such equipment or with the wiring of an installation.

2.1.2 *Apparatus* – Electrical apparatus including all machines, appliances and fittings in which conductors are used or of which they form a part.

2.1.3 *Appliance* – An item of current using equipment other than a luminaire or an independent motor.

2.1.4 *Back-up Protection* – Protection which is intended to operate when a system fault is not cleared or abnormal condition not detected in the required time, because of failure or inability of other protection to operate or failure of appropriate circuit-breaker to trip.

2.1.5 *Barrier* – A part providing a defined degree of protection against contact with live parts, from any usual direction of access.

2.1.6 *Basic Protection* – Protection against electric shock under fault-free condition.

NOTE — For low voltage installations, systems and equipment, basic protection generally corresponds to protection against direct contact that is ‘contact of persons or live parts’.

2.1.7 *Bonding Conductor* – A protective conductor providing equipotential bonding.

2.1.8 *Bonding Ring Conductor (BRC)* – A bus earthing conductor in the form of a closed ring.

NOTE — Normally the bonding ring conductor, as part of the bonding network, has multiple connections to the common bonding network (CBN) that improves its performance.

2.1.9 *Bunched* – Cables are said to be 'bunched' when two or more are contained within a single conduit, duct, ducting, or trunking, or, if not enclosed, are not separated from each other.

2.1.10 *Buried Direct* – A cable laid in the ground in intimate contact with the soil.

2.1.11 *Busbar Trunking System* – A type-tested assembly, in the form of an enclosed conductor system comprising solid conductors separated by insulating materials. The assembly may consist of units such as:

a) Busbur trunking units, with or without tap-off facilities;
b) Tap-off units where applicable; and
c) Phase-transposition, expansion, building-movement, flexible, end-feeder and adaptor units.

2.1.12 *Bypass Equipotential Bonding Conductor* – Bonding conductor connected in parallel with the screens of cables.

2.1.13 *Cable* – A length of single-insulated conductor (solid or stranded), or two or more such conductors, each provided with its own insulation, which are laid up together. The insulated conductor or conductors may or may not be provided with an overall mechanical protective covering.

2.1.14 *Cable, Fire Survival* – A cable which continues to function, that is, maintains the continuity of the circuit under circumstances of fire (against a specified temperature and period of the test).

2.1.15 *Cable, Flame Retardant (FR)* – A cable which is flame retardant as per the accepted standard [8-2(3)].

2.1.16 *Cable, Flame Retardant Low Smoke and Halogen* (FR-LSH) – A cable which is flame retardant and emits low smoke and halogen as per the accepted standard [8-2(3)].

2.1.17 *Cable, Flexible* – A cable containing one or more cores, each formed of a group of wires, the diameters of the cores and of the wires being sufficiently small to afford flexibility.

2.1.18 *Cable, Metal-Sheathed* – An insulated cable with a metal sheath.

2.1.19 *Cable, PVC Sheathed-Insulated* – A cable in which the insulation of the conductor is a polyvinylchloride (PVC) compound; with PVC sheath also providing mechanical protection to the conductor core or cores in the cable.

2.1.20 *Cable, Weatherproof* – A cable so constructed that when installed in uncovered locations, it will withstand all kinds of weather variations (*see* **2.1.185** for definition of weatherproof).

2.1.21 *Cable, XLPE* – A cable in which the insulation of the conductor is cross-linked polythene and the mechanical protection is provided for the core or cores by a sheath of a polyvinyl chloride compound.

2.1.22 *Cable Armoured* – A cable provided with a wrapping of metal (usually in the form of tape or wire) serving as a mechanical protection.

2.1.23 *Cable Bracket* – A cable support consisting of single devices fixed to elements of building or plant construction.

2.1.24 *Cable Channel* – An enclosure situated above or in the ground, open or ventilated or closed, and having dimensions which do not permit the access of persons but allow access to the conductor and/or cables throughout their length during and after installation.

NOTE — A cable channel may or may not form part of the building construction.

2.1.25 *Cable Cleat* – A component of a support system which consists of elements spread at intervals along the length of the cable or conduits and which mechanically retains the cable or conduit.

2.1.26 *Cable Coupler* – A means enabling the connection, at will, of two flexible cables. It consists of a connector and a plug.

2.1.27 *Cable Ducting* – A manufactured enclosure of metal or insulating material, other than conduit or cable trunking, intended for the protection of cables which are drawn-in after erection of the ducting, but which is not specifically intended to form part of a building structure.

2.1.28 *Cable Ladder* – A cable support occupying less than 10 percent of the plan area and consisting of a series of supporting elements rigidly fixed to each other or to a main supporting member or members.

2.1.29 *Cable Raceways* – An enclosed channel of metal or non-metallic materials designed expressly for holding wires, cables or busbars, with openable/maintainable construction having provision of ventilation. These include electrical non-metallic tubing, electrical metallic tubing, underfloor raceways, cellular concrete floor raceways, cellular metal floor raceways, surface raceways and wireways.

2.1.30 *Cable Tray* – A cable support consisting of a continuous base with raised edges and no covering. A cable tray is considered to be non-perforated, where less than 30 percent of the material is removed from the base.

2.1.31 *Cable Trunking* – A factory made closed support and protection system into which conductors and/or cables are laid after removal of the cover.

2.1.32 *Cable Tunnel* – An enclosure (corridor) containing supporting structures for conductors and/or cables and joints and whose dimensions allow free access to persons throughout the entire length.

2.1.33 *Cartridge Fuse Link* – A device comprising a fuse element or several fuse elements connected in parallel enclosed in a cartridge usually filled with an arc-extinguishing medium and connected to terminations. The fuse link is the part of a fuse which requires replacing after the fuse has operated.

2.1.34 *Ceiling Rose* – A fitting (usually used to attach to the ceiling) designed for the connection between the electrical installation wiring and a flexible cord (which is in turn connected to a lampholder).

2.1.35 *Circuit* – An assembly of electrical equipment supplied from the same origin and protected against overcurrent by the same protective device(s). Circuits are categorized as follows:

a) *Category 1 circuit* – A circuit (other than a fire alarm annunciation or emergency lighting circuit and other circuits required to work during fire in a building) operating at low voltage and supplied directly from a mains supply system.
b) *Category 2 circuit* – With the exception of Category 3 circuits, any circuit for extra low-voltage (ELV)/telecommunication [for example, radio, telephone, sound distribution, building management system (BMS), public address system (PAS), intruder alarm, bell and call and data transmission circuits)] which is supplied from a safety source.
c) *Category 3 circuit* – A fire alarm circuit or an emergency lighting circuit and other circuits required to work during fire in a building.

2.1.36 *Circuit Breaker* – A mechanical switching device, capable of making, carrying and breaking currents under normal circuit conditions and also of making, carrying for a specified time, and breaking currents under specified abnormal circuit conditions such as those of short circuit.

NOTE — A circuit breaker is usually intended to operate infrequently, although some types are suitable for frequent operation.

2.1.36.1 *Miniature circuit breaker (MCB)* – A compact mechanical switching device capable of making, carrying and breaking currents under normal circuit conditions and also making and carrying currents for specified times and automatically breaking currents under specified abnormal circuit conditions, such as those of overload and short circuits.

2.1.36.2 *Circuit breaker, linked* – A circuit breaker, the contacts of which are so arranged as to make or break all poles simultaneously or in a definite sequence.

2.1.36.3 *Moulded case circuit breaker (MCCB)* – A circuit breaker having a supporting housing of moulded insulating material forming an integral part of the circuit breaker.

2.1.36.4 *Air circuit breaker (ACB)* – A circuit breaker in which the contacts open and close in air at atmospheric pressure.

2.1.36.5 *Residual current operated circuit breaker* – A mechanical switching device designed to make, carry and break currents under normal service conditions and to cause the opening of the contacts when the residual current attains a given value under specified conditions.

2.1.36.5.1 *Residual current operated circuit breaker with integral overcurrent protection* (*RCBO*) – A residual current operated circuit breaker designed to perform the functions of protection against overload and/or short-circuit.

2.1.36.5.2 *Residual current operated circuit-breaker without integral overcurrent protection* (*RCCB*) – A residual current operated circuit breaker not designed to perform the functions of protection against overload and/or short-circuits.

NOTE — Similar function is provided by earth leakage circuit breaker (ELCB).

2.1.37 *Circuit, Final Sub* – An outgoing circuit connected to one-way distribution board and intended to supply electrical energy at one or more points to current, using appliances without the intervention of a further distribution board other than a one-way board. It includes all branches and extensions derived from that particular way in the board.

2.1.38 *Circuit Integrity Cable Support and Fixing Materials* – Supports and fixing materials for supporting circuit integrity cable (*see* **2.1.15**), which continues in service after exposure to fire for a specified duration.

2.1.39 *Compact Substation or Prefabricated Substation* – Prefabricated and type-tested assembly which can to be operated from inside (walk-in type) or outside (non-walk-in type) comprising components such as power transformer, high-voltage switchgear and controlgear, low-voltage switchgear and controlgear, corresponding interconnections (cable, busbar or other) and-auxiliary equipment and circuits located next to each other, maintaining segregation and integrity of each compartment in which they are located along with external interconnecting cables, earthing, protections, etc. The components shall be enclosed, by either a common enclosure or by an assembly of enclosures.

NOTE — *See* accepted standard [8-2(4)] for requirements of prefabricated substation.

2.1.40 *Conductor, Aerial* – Any conductor which is supported by insulators above the ground and is directly exposed to the weather.

NOTE — Following four classes of aerial conductors are recognized:

a) Bare aerial conductors,
b) Covered aerial conductors,
c) Insulated aerial conductors, and
d) Weatherproof neutral-screened cable.

2.1.41 *Conductor, Bare* – A conductor not covered with insulating material.

2.1.42 *Conductor, Earthed* – A conductor with no provision for its insulation from earth.

2.1.43 *Conductor, Insulated* – A conductor adequately covered with insulating material of such quality and thickness as to prevent danger.

2.1.44 *Conductor of a Cable or Core* – The conducting portion consisting of a single wire or group of wires, assembled together and in contact with each other or connected in parallel.

2.1.45 *Conduit* – A part of a closed wiring system, a circular or non-circular cross section for conductors and/or cables in electrical installations, allowing them to be drawn in and/or replaced. Conduits should be sufficiently closed-jointed so that the conductors can only be drawn in and not inserted laterally.

2.1.46 *Connector* – The part of a cable coupler or of an appliance coupler which is provided with female contact and is intended to be attached to the flexible cable connected to the supply.

2.1.47 *Connector Box or Joint Box* – A box forming a part of wiring installation, provided to contain joints in the conductors of cables of the installations.

2.1.48 *Connector for Portable Appliances* – A combination of a plug and socket arranged for attachment to a portable electrical appliance or to a flexible cord.

2.1.49 *Consumer's Terminals* – The ends of the electrical conductors situated upon any consumer's premises and belonging to him, at which the supply of energy is delivered from the service line.

2.1.50 *Continuous Operating Voltage* (U_c) – Maximum rms voltage which may be continuously applied to a surge protection device’s mode of protection. This is equal to rated voltage.

2.1.51 *Cord, Flexible* – A flexible cable having a large number of (typically 16 or 23 or 46 or 89, etc) strands of conductors of small cross-sectional area. Two flexible cords twisted together are known as twin ‘flexible cord’.

NOTE — Large number of fine strands of wires for each conductor makes the conductor capable of withstanding frequent bends thereby improving their flexibility.

2.1.52 *Core of a Cable* – A single conductor of a cable with its insulation but not including any mechanical protective covering.

2.1.53 *Current Carrying Capacity of a Conductor* – The maximum current which can be carried by a conductor under specified conditions without its steady state temperature exceeding a specified value.

2.1.54 *Current Using Equipment* – Equipment which converts electrical energy in to another form of energy, such as light, heat, or motive power.

2.1.55 *Cut-out* – Any appliance for automatically interrupting the transmission of energy through any conductor when the current rises above a pre-determined amount.

2.1.56 *Damp Situation* – A situation in which moisture is either permanently present or intermittently present to such an extent as likely to impair the effectiveness of an installation conforming to the requirements for ordinary situations.

2.1.57 *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.

2.1.58 *Dead* – A portion of an electrical circuit (normally expected to carry a voltage) at or near earth potential or apparently disconnected from any live system. A circuit apparently disconnected from all sources is expected to be at earth potential; but capacitive storage of charge in cables, capacitors, etc, can keep the electric circuit at a significant voltage (and often dangerous voltages from aspects of shock). Such circuits with storage components will be dead only on connection to earth.

2.1.59 *Design Current* (*of a Circuit*) – The magnitude of the current intended to be carried by the circuit in normal service.

2.1.60 *Direct Contact* – Contact of persons or live stock with live parts which may result in electric shock.

2.1.61 *Direct Earthing System* – A system of earthing in which the parts of an installation are so earthed as specified, but are not connected within the installation to the neutral conductor of the supply system or to earth through the trip coil of an earth leakage circuit-breaker.

2.1.62 *Discrimination* (*Over-Current Discrimination*) – Coordination of the operating characteristics of two or more over-current protective devices should be such that, on the incidence of over-currents within stated limits, the device intended to operate would be the device closest to the point of fault or abnormality, and if proper discrimination is achieved within these limits, only that device closest should operate, while the other circuit breakers upstream do not operate, thereby ensuring that there is minimum area of power supply which is interrupted.

NOTES

1 Protective devices should have discrimination so that only the affected part (minimum section) of the circuit is isolated, even though a number of protective devices may be in the path of the over current.

2 The electrical network requires the discrimination for all the fault circuits, including overload, short-circuit, etc. The downstream device should take care of the fault up to the level of ultimate short-circuit breaking capacity, *I*cu of the downstream breaker which should be equal to the bus which is connected.

3 Distinction is made between series discrimination involving different over-current protective devices passing substantially the same over-current and network discrimination involving identical protective devices passing different proportions of the over-current.

4 Different types of protective devices may have to be used to ensure effective discrimination in circuits where proper and effective discrimination is necessary. Apart from the built-in sensors and actuators in circuit breakers, external relays operating on different parameters, and comparison of parameters between two or more points will have to be used for complex installations.

5 *See also* relevant parts of the accepted standard [8-2(5)].

2.1.63 *Disconnector* – A mechanical switching device which, in the open position, complies with the requirements specified for the isolation function.

NOTES

1 A disconnector is otherwise known as isolator.

2 A disconnector is capable of opening and closing a circuit when either a negligible current is broken or made, or when no significant change in the voltage across the terminals of each pole of the disconnector occurs. It is also capable of carrying currents under normal circuit conditions and carrying for a specified time, current under abnormal conditions, such as those of short-circuit.

2.1.64 *Distance Area or Resistance Area (for an Earth Electrode Only)* – The surface area of ground (around an earth electrode) on which a significant voltage gradient may exist.

2.1.65 *Diversity Factor* – A measure of the probability that a particular piece of equipment will turn on coincidentally to another piece of equipment. For aggregate systems it is defined as the ratio of the sum of the individual non-coincident maximum loads of various subdivisions of the system to the maximum demand of the complete system.

2.1.66 *Duct* – A closed passage way formed underground or in a structure and intended to receive one or more cables which may be drawn in.

2.1.67 *Ducting* – *See* **2.1.27**.

2.1.68 *Earth* – The conductive mass of the earth, whose electric potential at any point is conventionally taken as zero.

2.1.69 *Earth Continuity Conductor* – The conductor, including any clamp, connecting to the earthing lead or to each other, those parts of an installation which are required to be earthed. It may be in whole or in part, the metal conduit or the metal sheath or armour of the cables, or the special continuity conductor of a cable or flexible cord incorporating such a conductor.

2.1.70 *Earthed Concentric Wiring* – A wiring system in which one or more insulated conductors are completely surrounded throughout their length by a conductor, for example a sheath, which acts as a PEN conductor.

2.1.71 *Earth Electrode* – A conductor or group of conductors in intimate contact with the ground to provide a low resistance path for flow of current to earth.

2.1.72 *Earth Electrode Network* – Part of an earthing arrangement comprising only the earth electrodes and their interconnections.

2.1.73 *Earth Electrode Resistance* – The resistance of an earth electrode to earth.

2.1.74 *Earth Fault* – An unintended and undesirable connection of phase/neutral conductor to earth. When the impedance is negligible, the connection is called a dead earth fault.

2.1.75 *Earth Fault Current* – A current resulting from a fault of negligible impedance between a line conductor and an exposed conductive part or a protective conductor.

2.1.76 *Earthing* – Connection of the exposed conductive parts of an installation to the main earthing terminal of that installation.

2.1.77 *Earthing 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.

2.1.78 *Earthing Lead* – The final conductor by which the connection to the earth electrode is made.

2.1.79 *Earth Leakage Current* – A current which flows to earth, or to extraneous conductive parts, in a circuit which is electrically sound.

NOTE — This current may have a capacitive component including that resulting from the deliberate use of capacitors.

2.1.80 *Earthing Resistance*, *Total* – The resistance between the main earthing terminal and the earth.

2.1.81 *Electrical Equipment* (*abb: Equipment*) – Any item for such purposes as generation, conversion, transmission, distribution or utilization of electrical energy, such as machines, transformers, apparatus, measuring instruments, protective devices, wiring materials, accessories, and appliances.

2.1.82 *Electrically Independent Earth Electrodes* – Earth electrodes located at such a distance from one another that the maximum current likely to flow through one of them does not significantly affect the potential of the other(s).

2.1.83 *Electrical Supply System for Life and Safety Services* – A supply system intended to maintain the operation of essential parts of an electrical installation and equipment,

a) for health and safety of persons and livestock; and
b) to avoid damage to the environment and to other equipment.

NOTES

1 The supply system includes the source and the circuit(s) up to the terminals of the electrical equipment.
2 *See also* Part 4 ‘Fire and Life Safety’ of the Code regarding emergency fire and life safety services.

2.1.84 *Electric Shock* – A dangerous patho-physiological effect resulting from the passing of an electric current through a human body or an animal.

2.1.85 *Emergency Switching* – Rapid cutting off of electrical energy to remove any hazard to persons, livestock, or property which may occur unexpectedly.

2.1.86 *Enclosure* – A part providing protection of equipment against certain external influences and, in any direction, protection against direct contact.

2.1.87 *Enclosed Distribution Board* – An enclosure containing bus bars with one or more control and protected devices for the purpose of protecting, controlling or connecting more than one outgoing circuits fed from one or more incoming circuits.

2.1.88 *Equipotential Bonding* – Electrical connection putting various exposed conductive 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 system and heating systems (if any).

2.1.89 *Exposed Conductive Part* – A conductive part of electrical equipment, which can be touched and which is not normally live, but which may become live under fault conditions.

2.1.90 *Exposed Metal* – All metal parts of an installation which are easily accessible other than,

a) parts separated from live parts by double insulation;
b) metal name-plates, screw heads, covers, or plates, which are supported on, or attached, or connected to substantial non-conducting material only in such a manner that they do not become alive in the event of failure of insulation of live parts and whose means of fixing do not come in contact with any internal metal; and
c) parts which are separated from live parts by other metal parts which are themselves earthed or have double insulation.

2.1.91 *External Influence* – Any influence external to an electrical installation which affects the design and safe operation of that installation.

2.1.92 *Extraneous Conductive Part* – A conductive part not forming part of the electrical installation and liable to introduce a potential, generally the earth potential.

2.1.93 *Fault* – A circuit condition in which current flows through an abnormal or unintended path. This may result from an insulation failure or a bridging of insulation. Conventionally the impedance between live conductors or between lives conductors and exposed or extraneous conductive parts at the fault position is considered negligible.

2.1.94 *Fault Current* – A current resulting from a fault.

2.1.95 *Final Circuit* – A circuit connected directly to current using equipment, or to socket outlets or other outlet points for the connection of such equipment.

2.1.96 *Fault Protection* – Protection against electric shock under single fault conditions.

NOTE — For low voltage installation, system's and equipment's fault protection generally corresponds to protection against indirect contact, mainly with regards to failure of basic insulation. Indirect contact is 'contact of persons or livestock with exposed-conductive parts which have become live under fault conditions'.

2.1.97 *Fire Survival Distribution Board* – A distribution board which continues in service after exposure to fire to the required system rating.

2.1.98 *Fitting, Lighting* – A device for supporting or containing a lamp or lamps [for example, fluorescent or incandescent or halogen or compact fluorescent lamp (CFL) or light-emitting diode (LED)] together with any holder, shade, or reflector, for example, a bracket, a pendant with ceiling rose, an electrolier, or a portable unit.

2.1.99 *Fixed Equipment* – Equipment fastened to a support or otherwise secured.

2.1.100 *Flameproof Enclosure* – An enclosure which will withstand without injury any explosion of inflammable gas that may occur within it under practical conditions of operation within the rating of the apparatus (and recognized overloads, if any, associated therewith) and will prevent the transmission of flame which may ignite any inflammable gas that may be present in the surrounding atmosphere.

NOTES

1 Hazardous areas are classified into different zones, depending upon the extent to which an explosive atmosphere may exist at that place. In such areas, flame proof switchgear, fittings, accessories, have to be used/installed in flameproof enclosure.

2 An electrical apparatus is not considered as flameproof unless it complies with the appropriate statutory regulations.

3 Other types of fittings are also in vogue in wiring installations, for example, 'increased safety'.

2.1.101 *Functional Earthing* – Connection to earth necessary for proper functioning of electrical equipment.

2.1.102 *Fuse* – A device which, by melting of one or more of its specially designed and proportioned components, opens the circuit in which it is inserted by breaking the current when this exceeds a given value for a sufficient time. The fuse comprises all the parts that form the complete device.

2.1.103 *Fuse Carrier* – The movable part of a fuse designed to carry a fuse link.

2.1.104 *Fuse Element* – A part of a fuse designed to melt when the fuse operates.

2.1.105 *Fuse Link* – A part of fuse, including the fuse element(s), which requires replacement by a new or renewable fuse link after the fuse has operated and before the fuse is put back into service.

2.1.106 *Hand-Held Equipment* – Portable equipment intended to be held in the hand during normal use, in which the motor, if any, forms an integral part of the equipment.

NOTE — A hand held equipment is an item of equipment, the functioning of which requires constant manual support or guidance.

2.1.107 *Harmonics (Current and Voltage)* – All alternating current which is not absolutely sinusoidal is made up of a fundamental and a certain number of current and voltage harmonics [multiples of 50 Hz (basic frequency)] which are the cause of its deformation (distortion) when compared to the theoretical sine-wave.

2.1.108 *Hazardous Live-Part* – A live part which can give, under certain condition of external influence, an electric shock.

2.1.109 *Impulse Current* – A parameter used for the classification test for SPDs; it is defined by three elements, a current peak value, a charge Q and a specific energy W/R.

2.1.110 *Impulse Withstand Voltage* – The highest peak value of impulse voltage of prescribed form and polarity which does not cause breakdown of insulation under specified condition.

2.1.111 *Indirect Contact* – Contact of persons or livestock with exposed conductive parts made live by a fault and which may result in electric shock.

2.1.112 *Industrial Plugs and Sockets* – Plugs and socket-outlets, cable couplers and appliance couplers, primarily intended for industrial use, either indoors or outdoors.

NOTE — For the purpose of this Code, industrial plugs and sockets conforming to IS/IEC 60309-1:2002 'Plugs, socket-outlets and couplers for industrial purposes – Part 1: General requirements'; and IS/IEC 60309-2:2002 'Plugs, socket-outlets and couplers for industrial purposes – Part 2: Dimensional Interchangeability Requirements for Pin and Contact–Tube Accessories' shall be used for industrial purpose.

2.1.113 *Inflammable Material* – A material capable of being easily ignited.

2.1.114 *Installation (Electrical)* – An assembly of associated electrical equipment to fulfill a specific purpose or purposes and having coordinated characteristics.

2.1.115 *Insulated* – Insulated shall mean separated from adjacent conducting material or protected from personal contact by a non-conducting substance or an air space, in either case offering permanently sufficient resistance to the passage of current or to disruptive discharges through or over the surface of the substance or space, to obviate danger or shock or injurious leakage of current.

2.1.116 *Insulation* – Suitable non-conducting material, enclosing, surrounding or supporting a conductor.

2.1.116.1 *Insulation, basic* – Insulation applied to live parts to provide basic protection against electric shock and which does not necessarily include insulation used exclusively for functional purposes.

2.1.116.2 *Insulation, double* – Insulation comprising both basic and supplementary insulation.

NOTE — Double insulation for small hand held equipment allows them to be used without a safety earth connection, without shock risk such hand held equipment.

2.1.116.3 *Insulation, reinforced* – Single insulation applied to live parts, which provides a degree of protection against electric shock equivalent to double insulation under the conditions specified in the relevant standard.

NOTE — The term 'single insulation' does not imply that the insulation is a homogeneous piece. It may comprise several layers which cannot be tested singly as supplementary or basic insulation.

2.1.116.4 *Insulation, supplementary* – Independent insulation applied in addition to basic insulation in order to provide protection against electric shock in the event of a failure of basic insulation.

2.1.117 *Isolation* – Cutting off an electrical installation, a circuit, or an item of equipment from every source of electrical energy.

2.1.118 *Isolator* – A mechanical switching device which, in the open position, complies with the requirements specified for the isolating function. An isolator is otherwise known as a disconnector.

2.1.119 *Junction Box* – A box forming a part of wiring installation, intended to conceal electrical connections and joints of conductors/ cables in order to protect the connection from external influences such as direct contact, dust, water, moisture, UV radiation, etc, depending upon the protection requirement of the space or utility.

2.1.120 *LEMP Protection Measures (SPM)* – Measures taken to protect internal systems against the effects of LEMP.

2.1.121 *Lightning Electromagnetic Impulse (LEMP)* – All electromagnetic effects of lightning current *via* resistive, inductive and capacitive coupling that create surges and radiated electromagnetic fields.

2.1.122 *Lightning Protection* – Complete system for protection of structures against lightning, including their internal systems and contents, as well as persons, in general consisting of an LPS and SPM.

2.1.123 *Lightning Protection Level (LPL)* – A number related to a set of lightning current parameters values relevant to the probability that the associated maximum and minimum design values will not be exceeded in naturally occurring lightning.

NOTE — Lightning protection level is used to design protection measures according to the relevant set of lightning current parameters.

2.1.124 *Lightning Protection System (LPS)* – Complete system used to reduce physical damage due to lightning flashes to a structure.

2.1.124.1 *External lightning protection system* – Part of the LPS consisting of an air-termination system, a down-conductor system and an earth-termination system.

2.1.124.2 *Internal lightning protection system* – Part of the LPS consisting of lightning equipotential bonding and/or electrical insulation of external LPS.

2.1.125 *Lightning Protection Zone* – Zone where the lightning electromagnetic environment is defined.

2.1.126 *Live or Alive* – Electrically charged so as to have a potential different from that of earth.

2.1.127 *Locations, Industrial* – Locations where tools and machinery requiring electrical wiring are installed for manufacture or repair.

2.1.128 *Locations, Non-Industrial* – Locations other than industrial locations, and shall include residences, offices, shops, showrooms, stores and similar premises requiring electrical wiring for lighting, or similar purposes.

2.1.129 *Leakage Current* – Electric current in an unwanted conductive path under normal operating conditions.

2.1.130 *Line Conductor* – A conductor of an a.c. system for the transmission of electrical energy other than a neutral conductor or a PEN conductor. This also means the equivalent conductor of a d.c. system unless otherwise specified in this Code.

2.1.131 *Live Part* – A conductor or conductive part intended to be energised in normal use including a neutral conductor but, by convention, not a PEN conductor.

2.1.132 *Low-Voltage Switchgear and Controlgear Assembly* – A combination of one or more low voltage switching devices together with associated control, measuring, signalling, protective, regulating equipment, etc, completely assembled under the responsibility of the manufacturer with all the internal electrical and mechanical interconnections and structural parts. The components of the assembly may be electromechanical or electronic.

2.1.133 *Luminaire* – Equipment which distributes, filters or transforms the light from one or more lamps, and which includes any parts necessary for supporting, fixing and protecting the lamps, but not the lamps themselves, and, where necessary, circuit auxiliaries together with the means for connecting them to the supply.

NOTE — For the purposes of this Code a batten lampholder, or a lampholder suspended by flexible cord, is a luminaire.

2.1.134 *Main Earthing Terminal* – The terminal or bar which is the equipotential bonding conductor of protective conductors, and conductors for functional earthing, if any, to the means of earthing.

2.1.135 *Meshed Bonding Network* (*MESH-BN*) – Bonding network in which all associated equipment frames, racks and cabinets and usually the d.c. power return conductor are bonded together as well as at multiple points to the CBN and may have the form of a mesh.

2.1.136 *Mobile Equipment* – Electrical equipment which is moved while in operation or which can be easily moved from one place to another while connected to the supply.

2.1.137 *Monitoring* – Observation of the operation of a system or part of a system to verify correct functioning or detect incorrect functioning by measuring system variables and comparing the measured value with the specified value.

2.1.138 *Multiple Earthed Neutral System* – A system of earthing in which the parts of an installation specified to be earthed are connected to the general mass of earth and, in addition, are connected within the installation to the neutral conductor of the supply system.

2.1.139 *Neutral Conductor* – Includes the conductor of a three-phase four-wire system; the conductor of a single-phase or d.c. installation, which is earthed by the supply undertaking (or otherwise at the source of the supply), and the middle wire or common return conductor of a three-wire d.c. or single-phase a.c. system.

2.1.140 *Origin of an Electrical Installation* – The point at which electrical energy is delivered to an installation.

NOTE — An electrical installation may have more than one origin.

2.1.141 *Overcurrent* – A current exceeding the rated value. For conductors the rated value is the current carrying capacity.

2.1.142 *Overload Current (of a Circuit)* – An overcurrent occurring in a circuit in the absence of an electrical fault.

2.1.143 *PEN Conductor* – A conductor combining the functions of both protective conductor and neutral conductor.

2.1.144 *Phase Conductor* – *See* **2.1.130.**

2.1.145 *Plug* – A device, provided with contact pins, which is intended to be attached to a flexible cable, and which can be engaged with a socket outlet or with a connector.

2.1.146 *Point (in Wiring)* – A termination of the fixed wiring intended for the connection of current using equipment.

2.1.147 *Portable Equipment* – Equipment which is moved while in operation or which can easily be moved from one place to another while connected to the supply.

2.1.148 *Protection, Ingress* – The degree of protection against intrusions (body parts such as hands and fingers), dust, accidental contact and water.

NOTE — The classification of degrees of ingress protection provided by enclosures for electrical equipment shall be as per the accepted standard [8-2(6)].

2.1.149 *Protection*, *Mechanical Impact* – The degrees of protection provided by enclosures for electrical equipment against external mechanical impacts.

NOTE — The classification of degrees of protection against mechanical impact provided by enclosures for electrical equipment shall be as per good practice [8-2(52)].

2.1.150 *Prospective Fault Current* (I_{pf}) – The value of overcurrent at a given point in a circuit resulting from a fault of negligible impedance between live conductor having a difference of potential under normal operating conditions, or between a live conductor and an exposed-conductive part.

2.1.151 *Protective Conductor* – A conductor used for some measures of protection against electric shock and intended for connecting together any of the following parts:

a) Exposed conductive parts,
b) Extraneous conductive parts,
c) Main earthing terminal, and
d) Earthed point of the source, or an artificial neutral.

2.1.152 *Protective Conductor Current* – Electric current appearing in a protective conductor, such as leakage current or electric current resulting from an insulation fault.

2.1.153 *Protective Earthing* – Earthing of a point or points in a system or in equivalent for the purpose of safety.

2.1.154 *Protective Separation* – Separation of one electric circuit from another by means of,

a) Double insulation;
b) Basic insulation and electrically protective screening (shielding); or
c) Reinforced insulation.

2.1.155 *Rated Current* – Value of current used for specification purposes, established for a specified set of operating conditions of a component, device, equipment or system.

2.1.156 *Rated Impulse Withstand Voltage Level* (U_w) – The level of impulse withstand voltage assigned by the manufacturer to the equipment, or to part of it, characterizing the specified withstand capability of its insulation against overvoltage .

2.1.157 *Residual Current* – The algebraic sum of the instantaneous values of current flowing through all live conductors of a circuit at a point of the electrical installation.

2.1.158 *Residual Current Device (RCD)* – A mechanical switching device or association of devices intended to cause the opening of the contacts when the residual current attains a given value under specified conditions.

2.1.159 *Residual Operating Current* – Residual current which causes the residual current device to operate under specified conditions.

2.1.160 *Service* – The conductors and equipment required for delivering energy from the electric supply system to the wiring system of the premises served.

2.1.161 *Shock Current* – A current passing through the body of a person or an animal and having characteristics likely to cause dangerous patho-physiological effects.

2.1.162 *Short-Circuit Current* – An overcurrent resulting from a fault of negligible impedance between live conductors having a difference in potential under normal operating conditions.

2.1.163 *Space Factor* – The ratio (expressed as a percentage) of the sum of the overall cross-sectional areas of cables (including insulation and sheath) to the internal cross-sectional area of the conduit or other cable enclosure in which they are installed. The effective overall cross-sectional area of a non-circular cable is taken as that of a circle of diameter equal to the major axis of the cable.

2.1.164 *Standby Supply System* – A system intended to maintain supply to the installation or part thereof, in case of interruption of the normal supply, for reasons other than safety of persons.

NOTE — Standby supplies are necessary, for example, to avoid interruption of continuous industrial processes or data processing.

2.1.165 *Stationary Equipment* – Either fixed equipment or equipment not provided with a carrying handle and having such a mass that it cannot easily be moved.

2.1.166 *Step Voltage* — The potential difference between two points on the earth's surface, separated by distance of one pace, that will be assumed to be one metre in the direction of maximum potential gradient.

2.1.167 *Socket-Outlet* – A device, provided with female contacts, which is intended to be installed with the fixed wiring, and intended to receive a plug.

NOTE — A luminaire track system is not regarded as a socket-outlet system.

2.1.168 *Surge* – A transient created by LEMP that appears as an overvoltage and/or an overcurrent.

2.1.169 *Surge Protective Devices* (*SPD*) – A device intended to limit transient overvoltages and divert surge currents. It contains at least one non-linear component.

2.1.170 *Switch* – A mechanical switching device capable of making, carrying and breaking current under normal circuit conditions, which may include specified operating overload conditions; and also of carrying for a specified time currents under specified abnormal circuit conditions, such as those of short circuit.

NOTE — A switch may also be capable of making, but not breaking, short-circuit currents.

2.1.171 *Switchboard* – 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 — The term 'switchboard' includes a distribution board.

2.1.171 *Switch Disconnector* – A switch which, in the open position, satisfies the isolating requirements specified for a disconnector**.**

NOTE — A switch disconnector is otherwise known as an isolating switch.

2.1.172 *Switch Disconnector Fuse* – A composite unit, comprising a switch with the fuse contained in or mounted on the moving member of the switch.

2.1.173 *Switch, Linked* – A switch, the contacts of which are so arranged as to make or break all poles simultaneously or in a definite sequence.

2.1.174 *Switchgear* – An assembly of main and auxiliary switching apparatus for operation, regulation, protection or other control of electrical installations.

2.1.175 *System* – An electrical system consisting of a single source or multiple sources running in parallel of electrical energy and an installation. Types of system are identified as follows, depending upon the relationship of the source, and of exposed-conductive parts of the installation, to earth:

a) *TN system* – A system having one or more points of the source of energy directly earthed, the exposed conductive-parts of the installation being connected to that point by protective conductors.

b) *TN-C system* – A system in which neutral and protective conductors are combined in a single conductor throughout the system.

c) *TN-S system* – A system having separate neutral and protective conductor throughout the system.

d) *TN-C-S system* – A system in which neutral and protective conductors are combined in a single conductor in part of the system.

e) *TT system* – A system having one point of the source of energy directly earthed, the exposed-conductive-parts of the installation being connected to the earth electrodes electrically independent of the earth electrodes of the source.

f) *IT system* – A system having no direct connection between live parts and earth, the exposed-conductive-parts of the electrical installation being earthed.

2.1.176 *Touch Voltage* – The potential difference between the ground potential rise (GPR) of a grounded metallic structure and the surface potential at the point where a person could be standing while at the same time having a hand in contact with the grounded metallic structure. Touch voltage measurements can be ‘open circuit’ (without the equivalent body resistance included in the measurement circuit) or ‘closed circuit’ (with the equivalent body resistance included in the measurement circuit) voltage by which an installation or part of an installation is designated.

2.1.177 *Usable Wall Space* – All portions of a wall, except that occupied by a door in its normal open position, or occupied by a fire place opening, but excluding wall spaces which are less than 1 m in extent measured along the wall at the floor line.

2.1.178 *Utility Building* – A standalone separate single or two storied service building structure outside the main building structure meant for only accommodating services' spaces, such as electric substation, diesel generator plant room, a.c. plant room, plumbing plant room, sewerage treatment plant, medical gases, electrical and mechanical maintenance rooms. Such buildings do not have any permanent occupancy other than by personnel on duty.

2.1.179 *Voltage Nominal (of an Installation)* – Voltage by which an installation or part of an installation is designated.

2.1.180 *Voltage, Extra Low (ELV)* – The voltage which does not normally exceed 50 V.

2.1.181 *Voltage, Low* (*LV*) – The voltage which normally exceeds 50 V but does not normally exceed 250 V.

2.1.182 *Voltage, Medium* (*MV*) – The voltage which normally exceeds 250 V but does not exceed 650 V.

2.1.183 *Voltage, High (HV)*– The voltage which normally exceeds 650 V but less than or equal to 33 kV.

2.1.184 *Voltage, Extra High (EHV)* – The voltage, which normally exceeds 33 kV.

2.1.185 *Weatherproof* – Accessories, lighting fittings, current-using appliances and cables are said to be of the weatherproof type with ingress protection according to the application, if they are so constructed that when installed in open situation they will withstand the effects of rain, snow, dust and temperature variations.

2.2 Conventional Symbols

The architectural symbols that are to be used in all drawings, wiring plans, etc, for electrical installations in buildings shall be as given in Annex A.

For other graphical symbols used in electrotechnology, reference may be made to good practice [8-2(1)].

3 GENERAL REQUIREMENTS

3.1 Statutory Requirements

Electrical installations require conformance with various norms. An electrical installation that doesn't conform to related provisions under the Act, rules, or regulations may impose risks to life and property. This part covers brief information about the statutory requirements.

3.1.1 *Electricity Act 2003*

Section 53 of the Electricity Act 2003 states requirements relating to 'Provisions relating to safety and electrical supply'. Some of the important points included in this section are protecting the public from the dangers arising out of electricity, reducing the risk of personal injury, and damage to property. In accordance Central Electricity Authority, formed under section 70 of the Act, has been empowered to specify suitable measures. Such measures are updated and notified time to time in the form of regulations. It shall be noted that, any failure to comply with any order or any attempt or abetment which contravene the rules, regulations made under the act, is punishable.

NOTE – It shall be noted that any failure to comply with the orders, directions given under the Act, an attempt to contravene or an abetment thereto is an offence and is punishable under section 146 of the Act. Section 149 decides responsibility and sections 150 further adds 'an abetment to offence is punishable'. It means that the persons who is not directly involved in construction of electrical installation but indirectly relate to integrated part of electrical installation, such as architectural or civil construction, such as keeping provision of spaces, reserving routes, maintaining clearances, civil construction with required fire rating, etc., come under the ambit of these sections. Good practice [8-2(51)] provides list of such stakeholders involved in electrical installation.

3.1.2 *Central Electricity Authority*

The Central Electricity Authority, formed under section 70, is empowered to make regulations as directed under section 53 and section 177 of the Act. In accordance, the following regulations have been notified and are in force. However, reference shall always be made to the latest versions/amendments.

a) Central Electricity Authority (Measures relating to Safety and Electric Supply) Regulations, 2023.

   These regulations state various requirements to be observed in the following activities:
   1) design,
   2) construction,
   3) verification & testing,
   4) maintenance
   5) use
   6) electric supply
   7) various activities integrated with the work of electrical installation.

   NOTE – Regulation No. 14 (2) requires electrical installations to follow relevant standards, including the National Building Code, the National Electrical Code, or the International Standards, where Indian Standards are unavailable. So, though the BIS standards and codes of practice are guidelines, their observance is no longer optional but mandatory when read with section 146 of the Act.

b) Central Electricity Authority (Technical Standards for the Construction of Electrical Plants and Electrical Lines) Regulations, 2022.

From the perspective of this code, these regulations apply to transmission and distribution licensees. That is, whenever any electrical line, whether overhead or underground, passes through the plot area of the building/building-complex, observance of these provisions, which are in the scope of the respective owner of the line, may require verification.

NOTE – Important sections of Act and the Regulation are given in Annex B.

3.2 Streamlining Electrical Work

3.2.1 From the perspective of project management, electrical work activities shall broadly be divided into the following stages:

a) Planning
b) Designing
c) Construction
d) Verification and Testing
e) Maintenance

NOTE – For existing buildings, (a) to (c) may not apply unless there is a major change or complete renovation.

3.2.2 *Coordination*

At all work stages and the activities within these stages, different persons/agencies concerning planning, civil construction, and building services are involved. Mutual coordination between the stakeholders involved directly or indirectly is very important to avoid conflicts.

3.3 Stakeholders and their responsibility

The role of stakeholders is very important in streamlining electrical work. Good practice [8-2(51)] identifies stakeholders as below:

a) Owner/Developer
b) Architect
c) Civil Contractor
d) Other Service providers
e) Electrical Consultant
f) Electrical Contractor
g) Electrical Inspector
h) Electricity Supplier

The standard states the responsibility of each stakeholder as per the related statutory compliances, quoting the clauses from related regulations, standards, and codes. While assuming responsibility, each stakeholder shall have the required qualifications and experience in the respective field as set out in rules, regulations, bylaws, or any government notification. Where such eligibility criteria are not mandated, it will be the responsibility of the employer to appoint a person with qualifications and experience comparable to similar/correlating tasks.

NOTE – Most of the time, the electrical contractor who executes the work follows the design received from the consultant. But, for an Electrical Consultant who plays a key role of electrical design, there are no set rules or regulations to determine eligibility or accreditation procedures. Under the circumstances, until such rules come into force, reference to **3.5** from good practice [8-2(51)] may be taken, or the qualification and experience of such a person may be considered on par with the Chartered Electrical Safety Engineer as stated in regulation 6 of CEA (Measures relating to Safety and Electric Supply) regulations 2023.

It should be noted that appointing technical experts like consultants/contractors from respective fields and assigning them responsibility are inherent parts of project management and need to be observed at the planning stage.

3.4 Appointment of Technical Professionals Concerning Electrical Installation

In addition to the requirements stated in good practice [8-2(51)], an electrical engineer shall be appointed on site as a registered building professional to streamline, monitor, and certify, jointly with the consultant and the electrical contractor, all works relating to electrical services.

3.5 Roles and Responsibilities of the persons appointed for electrical work

There shall be a written agreement between the developer and the appointee deciding the scope of work and the responsibilities to be undertaken. Such an agreement shall include a declaration concerning the work the appointee will undertake (*see* Annex H for declarations of design, construction and inspection and testing).

3.5.1 *Electrical Engineer on Site*

To monitor the coordination of work between all stakeholders, from planning to completion, the electrical engineer on site has an important role. In the team of technical persons often referred to as ‘Registered Building Professional’ or ‘Licensed Technical Professional / Person’, with different nomenclature in various building rules/regulations / byelaws, the inclusion of an Electrical Engineer shall be treated as an important requirement for controlling and monitoring electrical work activities. His duties and functions shall be:

a) Observe all regulatory requirements
b) Maintain coordination between all stakeholders.
c) Check electrical requirements from the perspective of location and spaces in the Architectural Plans.
d) Check the electrical design prepared by the design consultant
e) Check specifications related to material and method of construction.
f) Participate in preparing the activities chart, considering the smooth and coordinated work progress.
g) Monitor and maintain surveillance from planning to completion and handing over, with special attention to the work that will be concealed.
h) Check and jointly sign certificates/declarations and checklists as recommended in good practice [8-2(51)].
j) Check required NOCs/Permissions from respective authorities.
k) Maintain a record of all documents.

3.5.2 *Electrical Consultant*

To perform the desired role as an Electrical Consultant, he shall have the necessary qualifications and experience. Reference may be taken from the note under **3.7**. Such a person shall have an updated knowledge of all regulatory requirements, standards, and codes of practice related to the design, construction, verification, testing, and maintenance of electrical work. He shall be responsible for preparing designs with drawings and specifications that adhere to quality standards. He shall consult the architect regarding necessary points to consider at the planning and construction stage. Table 1 from good practice [8-2(51)] provides a list of activities and responsibilities. Some important points in this regard are given below:

a) Existing overhead and underground electrical lines on the proposed development plot and the mandatory requirements, compliances, and NOCs related to clearances.
b) Spaces, locations, and routes of the distribution network required for electrical installation.
c) Specific requirements related to RCC structure (static/dynamic load of electrical equipment, requirement of recess within RCC structure to avoid core cutting, required height between finished floor level and soffit of the beam.
d) Specific requirement related to wall thickness to accommodate concealed electric boxes, raised floor (false flooring) to accommodate cable work below.
e) Specific requirements where an aluminium framework system is used to cast concrete for building elements like walls, floors, columns, beams, and slabs.
f) Specific requirements related to ventilation and avoiding the accumulation of heat.
g) Assessment of electrical load. (while assessing load, other service providers shall be consulted for their requirements.
h) Space requirement for the electrical sub-station as per the assessment of the required load. *See* Annex D for suggested space provision as per the substation's capacity.
j) Consult with the electric supply company for load sanction and requirements, if any, such as space/room (*see* NOTE).

NOTE – The supply company may state the requirement for space within the consumer's premises for substation/equipment. This may be a case where there is no spare capacity or possibility to augment the existing electrical distribution infrastructure. Also, the Supply Code approved by the respective State Electricity Regulatory Commission states such conditions. The consultant shall be well aware of the conditions of the Supply Code and, in accordance, give the architect the requirements related to space. All related correspondence shall be documented.

k) Prepare drawings showing the electrical equipment locations and the electric supply distribution network on site plans. Supplier and consumer distribution networks shall be segregated.
m) Prepare drawings of electrical equipment rooms and consult with the architect and civil engineer about the requirements related to technical specifications of civil construction like fire rating, ventilation facilities, doors/openings, ducts, floor level, clean ceiling height below beam soffit, access facility, dust-free areas, etc. Some of such requirements may be:
    1) Transformer sub-station – oil draining arrangement, oil soak pit, curb to

prevent the spread of spillage / leaked/drained oil, the required clearances around apparatus considering the type of transformer dry / oil-cooled (O class) / liquid-cooled (K class), adjacent structure whether combustible / non-combustible, provision of baffle wall, etc.

2) Standby power supply – Genset, PUC norms, stack height and the building in the vicinity, safe location;
3) Standby power supply – UPS system, location, and specific requirements related to battery storage.

n) Drawings showing proposed internal routes and layouts of cables (mains, sub-mains, circuit mains, light, fan power outlet points, distribution boxes, boards with electrical accessories, outlet points, and the required clearances between other services, accessibility, etc.

NOTE – Where aluminium framework technology is used to cast concrete for building elements like walls, floors, columns, beams, and slabs, drawings showing precise locations of points and boxes are most important.

p) Design electrical installation with due consideration for general characteristics that adhere to protection for safety.
q) Consider the related requirements stated under the Energy Conservation Building Code to qualify buildings under a certain class.
r) Prepare specifications for the Selection and Erection of Electrical Equipment with due consideration to the factors of external influences.
s) State requirements relating to Fire Prevention, specific to electrical installation as given under CEA regulations, for example, placement of extinguishers, PPE, automatic fire suppression system, etc.
t) State design requirements related EV charging stations and the clearances around.
u) State if there are any specific requirements relating to the access.

NOTE – Suppose the electric control panel room is located in the basement and has only access through a single staircase. If this access gets blocked due to fire or some other reason, it may lead to a serious situation in accessing, operating, and controlling the electric supply of critical services.

v) State requirements related to verifying and testing electrical installations.
w) Maintain respective checklists updated as required under the good practice [8-2(51)].

3.5.3 *Electrical Contractor**

Electrical Contractor shall have a licence issued by the appropriate government. It shall be valid at the time of agreement and renewed when necessary. He shall be aware of the obligations mandated as per the rules and regulations. The supervisor(s) appointed by him shall have competency and updated technical knowledge of all regulatory requirements and the codes of practice. The contractor shall be responsible for:

a) Resolving differences regarding the design, drawings, and specifications provided by the consultant if any and carrying out work as per the final design. In case of unresolved points, maintain the record.

*NOTE – Where the Electrical Contractor is performing the job of Electrical Consultant, he shall be responsible for observing requirements stated under **3.5.2**.

b) Before commencing work, get the drawing approvals from the respective authority where applicable.
c) Employ the supervisor and the workmen to construct electrical installations having permits of the respective class or designated as per regulation 3 of CEA (MRSES) regulations 2023.
d) Observe workplace safety in respect of:
   1) Temporary Electrical Installation on site
   2) Provision of adequate tools and PPE to workmen.

e) Check that requirements related to civil construction concerning electrical installation are satisfied.
f) Observe the activity chart based on a time schedule, which is mutually agreed upon between all concerned service providers and shall plan the work in coordination.

NOTE—Where an aluminium framework is used to cast concrete for building elements like walls, floors, columns, beams, and slabs, the coordination with civil work needs to be observed precisely.

g) Construct electrical installation according to the plans and finalised design by the consultant or, where applicable, the design approved by the authority (Electrical Inspector).
h) The execution shall be according to the approved methods of construction stated under the national or international codes of practice, where the National Code has not set any parameters.
j) All work must be executed under the strict supervision of a competent person with the necessary permit issued by the government.
k) A Record of hidden work shall be maintained with certificates of required compliance, which shall be jointly signed by the Engineer on site before concealing.
m) Maintain electrical installation safety throughout the construction period and the defect liability period.
n) Get the installation verified and tested, preferably through a third party, at the following stages:
   1) during construction.
   2) after completion before certifying for its beneficial use.

p) Help the electrical engineer on site in maintaining updated checklists as required under the good practice [8-2(51)].
q) Prepare handing-over documents for the respective owner, stating details of the electrical installation as given the checklist.

3.6 Materials

All materials, fittings, appliances, etc, used in electrical and allied installations, shall conform to Part 5 'Building Materials' of the Code and other concerned Indian Standards.

3.7 Coordination with Local Supply Authority

a) In all cases, that is, whether the proposed electrical work is a new installation or extension of an existing one, or a modification involving major changes, the electricity supply undertaking shall be consulted about the feasibility, etc, at an early date. The wattage per square metre and permissible diversity consideration shall be defined as per the type of building (residential, commercial, mercantile, industrial, retail, convention, exhibition, hotel, hospital, institution, flatted factory, group housing, etc). The wattage per square feet shall be defined considering probable loads as per city grading such that future loading into the development is accounted.
b) *Addition to an Installation* – An addition, temporary or permanent, shall not be made to the authorized load of an existing installation, until it has been definitely ascertained that the current carrying capacity and the condition of existing accessories, conductors, switches, etc, affected, including those of the supply authority are adequate for the increased load. The size of the cable/conductor shall be suitably selected on the basis of the ratings of the protective devices. Ratings of protective devices and their types shall be based on the installed load, switching characteristics and power factor.

Load assessment and application of suitable diversity factor to estimate the full load current shall be made as a first step. This should be done for every circuit, submain and feeder. Power factor, harmonics (*see* **5.3.6.6**) and efficiency of loads shall also be considered. Diversity factor assumed shall be based on one's own experience or as per table under **4.2.2.2**. Allowance should be made for about 15 percent to 20 percent for extension in near future. The wiring system should be adopted taking into account the environmental requirements and hazards, if any in the building. The sizes of wiring cables are decided not merely to carry the load currents, but also to withstand thermal effects of likely over currents, short circuit and also ensure acceptance level of voltage drop.

3.8 Power Factor Improvement in Consumers' Installation

3.8.1 Conditions of supply of electricity boards or licensees stipulate the lower-limit of power factor which is generally 0.95 or better.

3.8.2 Principal causes of low power factor are many. For guidance to the consumers of electric energy who take supply at low and medium voltages for improvement of power factor, reference shall be made to good practice [8-2(7)].

3.9 Execution of Work

Unless otherwise exempted under the appropriate regulation of the *CEA (Measures relating to Safety and Electricity Supply) Regulations*, 2023 as amended from time to time, the work of electrical installations shall be carried out by a licensed electrical contractor and under the direct supervision of a person holding a certificate of competency and by persons holding a valid permit issued and recognized by any State government.

3.10 Safety procedures and practices shall be kept in view during execution of the work in accordance with good practice [8-2(8)].

3.11 Safety provisions given in Part 4 'Fire and Life Safety' of the Code shall be followed.

4 PLANNING OF ELECTRICAL INSTALLATIONS

4.1 General

The design and planning of an electrical wiring installation involve consideration of all prevailing conditions and is usually influenced by the type and requirements of the consumer. Various utility services including ELV systems namely intercom, data cabling (*see* Part 8 'Building Services, Section 6 Information and Communication Enabled Installations' of the Code), CCTV, fire alarm shall also be taken into account with anticipated future requirements. A competent electrical design engineer should be involved at the planning stage with a view to providing for an installation that will prove adequate for its intended purpose and ensure safety, reliability and energy efficiency in its use. The information/requirements given in **3** shall also be kept in to consideration while designing and planning an electrical wiring installation. With the proliferation of the use of electrical and electronic devices in buildings as well as the increase in the generation/distribution capacities of power systems, the hazards of energy feed to a fault or defect in the electrical installation has increased. Reliability of power supply and continued supply even under abnormal conditions are becoming very important not only for the operation of services and activities in a building, but also for the life safety of occupants. Reference is drawn to Part 0 'Integrated Approach – Prerequisite for Applying Provisions of the Code' of the Code, which defines the requirements of interdisciplinary coordination right from the sketch design of the building. Electricity is linked to all services and addition of standby and emergency power supply systems adds to the complexity requiring proper coordinated design. Generally, it is not difficult to provide proper pathways and equipment installation spaces, if an integrated approach is taken from the beginning. The designs should also have to keep the availability of optimum access to installations to ensure proper maintenance. Considering various utility services and to avoid conflict amongst them, it is most important to estimate space requirement for electrical work including LV systems, at planning stage and allocate it in consultation with an architect/civil engineer.

4.1.1 The design and planning of an electrical wiring installation shall take into consideration the following:

a) Type of supply, building utility, occupancy, envisaged load and the earthing arrangement available;
b) Provisioning of air conditioning systems in present and/or future loading;
c) Climatic condition, such as cooling air temperature, moisture or such other conditions which are likely to affect the installation adversely;
d) Possible presence of inflammable or explosive dust, vapour or gas;
e) Degree of electrical and mechanical protection necessary;
f) Importance of continuity of service including the possible need for standby supply;

g) Probability of need for modification or future extension;
h) Probable operation and maintenance cost taking into account the electricity supply tariffs available;
j) Relative cost of various alternative methods;
k) Need for radio and telecommunication interference suppression;
m) Ease of maintenance;
n) Safety aspects;
p) Energy conservation;
q) Importance of proper discrimination between protective devices for continuity of supply and limited isolation of only the affected portion; and
r) Reliability of power supply and redundancy (of sources and distribution paths) to cater to the needs for emergency power and standby power for continued operation of systems as well as integration of alternate sources of energy such as diesel generation, solar energy, wind power, etc.
s) Integration of different types of energy sources such as (single or multi) grid power, DG Set power backup, battery storage energy system, on grid solar PV power, on grid other renewable energy sources such as wind power, micro wind wheel, etc.

4.1.2 All electrical apparatus shall be suitable for the services these are intended for.

4.1.3 *Coordination*

Proper coordination and collaboration between the architect, civil engineer, electrical engineer and mechanical engineer shall be effected from the planning stage of the installation. The electrical engineer shall be conversant with the needs of the electrical supply provider for making electrical supply arrangement. Electrical supplier's installation, as per Regulations, needs to be segregated from consumer's installation. Wherever required, prior approval of drawings shall be taken from concerned electrical supplier/electrical inspector. Further, depending on load and regulation provisions, consumer will need to submit to the electrical supplier the details regarding the accommodation of substation including transformers, switch-rooms, standby power, solar photovoltaic panels, lightning scheme for the approval. Additional information may be sought by the Authority regarding cable ducts, rising mains and distribution cables, sub-distribution boards, openings and chases in floors and walls for all required electrical installations, etc.

4.1.4 Before starting wiring and installation of fittings and accessories, information should be exchanged between the owner of the building/ architect/ consultant/ electrical contractor and the local supply authority in respect of tariffs applicable, types of apparatus that may be connected under each tariff, requirement of space for installing meters, switches, etc, and for total load requirements of lights, fans and power.

4.1.5 While planning an installation, consideration should be taken of the anticipated increase in the use of electricity for lighting, general purpose socket-outlet, kitchen equipment, air conditioning, utility sockets, heating, etc.

It is essential that adequate provision should be made for all the services which may be required immediately and during the intended useful life of the building, for the householder, who may otherwise be tempted to carry out extension of the installation himself or to rely upon use of multi-plug adaptors and long flexible cords, both of which are not recommended.

4.2 Substation and Switchrooms

4.2.1 *Location and Other Requirements*

The location and other requirements of a substation and switchrooms shall be as given below:

1) Availability of power lines nearby may be kept in view while deciding the location of the substation.
2) The substation should preferably be located in a separate utility building and may be adjacent to the generator room, if any. Location of substation in the basement should be avoided, as far as possible.
3) In case there is only one basement in a building, the substation/ switchroom shall not be provided in the basement. Also, the floor level of the substation shall not be lowest point of the basement.
4) In case of more than 2 basements in a building \ buildings, the substation\ switchroom shall be provided in either first or second basement with floor of the Substation not more than 10 meters below Site Ground level.
5) In places where flooding can occur and water level may go above 1 000 mm, the base substation may be located on one level above the ground level of a utility building or of Main building. In such cases, one feeder should feed ground level and levels below with automatic tripping of the feeder to avoid electrocution in case of live electricity coming in contact with water. Designers shall use their discretion in special cases and depending on the degree of reliability, redundancy and the category of load and make suitable provisions.

   NOTE — In cases, where the substation is located one level above ground level of utility building or main building, this should be after due evaluation of the other risks posed by such a location combined with the concurrence for such a decision from State Electricity Authority comprising the electrical inspectorate and the distribution licensee and the fire service. There should be s direct access from Outside the building for Substation without entering building to Substation.

6) In Topology of city (in mountains\ stepped terrain), location of substation and DG Set should be such that flooding in equipment area is not feasible, with substation and DG Set located 300 mm above flooding level with natural drainage of the Substation\ DG sets areas.
7) Ideal location for an electrical substation for a group of buildings will be at the electrical load centre. Generally, the load centre will be somewhere between the geometrical centre and the air conditioning plant room, as air conditioning plant room will normally be the largest load, if the building(s) are centrally air conditioned.
8) In order to prevent storm water entering the transformer and switch rooms through the soak-pits, the floor level of the substation/ switchroom shall be at least 300 mm above the highest flood water level that may be anticipated in the locality. Also, facility shall be provided for automatic removal of water.

9) Substation shall not be located immediately above or below plumbing water tanks or sewage treatment plant (STP) water tanks at the same location.
10) All door openings from substation, electrical rooms, etc, should open outwards. Vertical shutters (like fire rated rolling shutters) may also be acceptable provided they are combined with a single leaf door opening outwards for exit in case of emergency. For large substation room/electrical room having multiple equipment, two or more doors shall be provided which shall be remotely located from each other.
11) If substation is located at a height 1 000 m above MSL, then adequate derating of equipment shall be considered.
12) In case of HV panel and transformers located at different floors or at a distance more than 20 m, HV isolator shall be provided at transformer end.
13) In case transformer and main MV/ LV panel room are located at different floors or are at a distance more than 20 m, MV/LV isolator shall be provided at transformer end. In case transformer and main MV/LV panel room are located at different floors, the designer should also take care of the safety requirements caused by lack of direct visibility of the status of the controlling switch. To cater to the safety requirements under different conditions of operation as well as maintenance, it may be necessary to provide additional isolator or an emergency push button in the vicinity to trip the supply. Decision has to be taken based on the possible risks.
14) No services or ventilation shafts shall open into substation or switch room unless specific to substation or switch room.
15) Oil-filled installation – Substations with oil-filled equipment require great consideration for the fire detection, protection and suppression. Oil-filled transformers require a suitable soak pit with gravity flow to contain the oil in the event of the possibility of oil spillage from the transformer on its failure. Installation of oil-filled equipment shall meet the following requirements:
    i) Substations with oil-filled equipment/ apparatus [transformers and high voltage panels] shall be either located in open or in a utility building. They shall not be located in any floor other than the ground floor or the first basement of a utility building. They shall not be located below first basement slab of utility building. They shall have direct access from outside the building for operation and maintenance of the equipment.
    ii) Substations/Utility buildings (where the substation or oil-filled transformer is located) shall be separated from the adjoining buildings including the main building by at least 6 m clear distance to allow passage of fire tender between the substation/utility building and adjoining building/main building.
    iii) There shall be no interconnecting basement with the main building underneath the oil-filled transformers.
    iv) Provisions for oil drainage to a tank (from which oil can be decanted and reused) at a lower level and separated by adequate fire barrier shall be provided. If there is a floor directly below the ground floor level or first basement where the oil-filled transformers and oil-filled circuit breakers are placed, then they shall be separated by a fire barrier of appropriate fire rating as per Part 4 ‘Fire and Life Safety’ of the Code and proper oil drainage system shall be provided to avoid possible leakage of oil into the lower floor.

v) Substation equipment having more than 2 000 litre of oil whether located indoors in the utility building or outdoors shall have baffle walls of 4 h fire rating between apparatus (*see also* Part 4 'Fire and Life Safety' of the Code for fire safety related requirements).

vi) Provisions shall be made for suitable oil soak-pit, and where use of more than 9 000 litre of oil in any one oil tank, receptacle or chamber is involved, provision shall be made for the draining away or removal of any oil which may leak or escape from the tank, receptacle or chamber containing the same. Special precautions shall be taken to prevent the spread of any fire resulting from the ignition of the oil from any cause and adequate provision shall be made for extinguishing any fire which may occur.

vii) In respect of all oil type transformers located at basement, a kerb (sill) of a suitable height shall be provided at the entrance in order to prevent the flow of oil from a ruptured transformer into other parts of the basement in the event of the possibility of oil spillage from the transformer on its failure.

viii) Oil filled transformers\ stabilizers\ auto transformers (with oil capacity more than 50 liters) or any equivalent electrical equipment shall not be used within the buildings other than utility buildings. Utility building should not be used) for any other activity other than services high side equipment. In case of less than 50 liters equipment placed in building, it should be kept in naturally ventilated areas and fire segregated from occupied areas and other areas prone to accidental fires.

ix) Adequate fire barriers or deflectors shall be provided to avoid flames from the substation reaching or affecting the adjacent areas including upper floors (*see also* Part 4 'Fire and Life Safety' of the Code).

x) Transformer, MV Panel, LV Isolator shall not be kept one above the other in a way that incase of oil leakage or fire in an equipment the other becomes unapproachable. Stacking of electrical equipment's should not be done.

xi) For transformers having large oil content (more than 2 000 litre), Rule 46 of the Central Electricity Authority as amended from time-to-time shall apply (*see* Annex B).

16) Dry-type installation – In case electric substation has to be located within the main multi-storeyed building itself for unavoidable reasons, it shall be a dry-type installation with very little combustible material, such as, a dry type transformer with vacuum (or SF6) breakers as HT switchgear and ACB or MCCB as medium voltage (MV) switchgear. Such substations shall be located on the ground level or on first basement and shall have direct access from the outside of the building for operation and maintenance of the equipment.

Exceptionally, in case of functional buildings, such as air traffic control towers, high rise non – residential buildings, data centres and mixed use buildings of height more than 150 m having high electrical load requirement, dry-type installations/substations may also be provided at upper level without emergency backup systems requiring diesel or any inflammable material storage. This measure will decrease the current flow and short-circuit rating at various points, thereby reducing vulnerability to fire. In such cases, a base substation shall be located at ground floor/ first basement to cater to the main MV/ LV panel which feeds life and safety services loads as defined in **4.2.1** (29). The base substation shall be located in such a way to provide direct access to the firemen in case of any emergency. The power supply control to any substation or transformer located at upper floors shall be from the base substation so that in case of fire, the electrical supply can be easily disconnected to avoid additional losses.

17) The power supply HV cables voltage shall not be more than 12 kV and a separate dedicated and fire compartmented shaft should be provided for carrying such high voltage cables to upper floors in a building. These shall not be mixed with any other shaft and suitable fire detection and suppression measures shall be provided throughout the length of the cable on each floor.
18) The provision for installation and removal of substation equipment should be provided from inside or outside the building without disturbing the associate major equipment in the substation. Incase of inside building path a designated elevator should be installed which is capable of handling weight & size of transformer parts being transported to designated floor for installation, maintenance and removal from the floor.
19) In case of compact substation {see accepted standard [8-2(4)]}, design and location of the substation shall ensure safety of the people around the compact substation installed along walkways, playgrounds, etc. Compact substation with incomer voltage of 12 kV or less, when located in open areas shall have fencing or barrier (of any metal based protection, such as wire mesh or chain link, which is duly earthed) against unauthorized contact possibility around it at a minimum distance of 750 mm around it with access for maintenance from all four sides. For incomer voltage more than 12 kV and less than 24 kV the fencing distance from substation may be 1 000 mm minimum. In case of more than 24 kV incomer, the distance may be further increased accordingly. The fencing design should take care of the servicing and maintenance requirements of the substation equipment.
20) In case of two transformers (dry type or transformers with cumulative oil quantity less than 2 000 litres) located next to each other without intermittent wall, the distance between the two shall be minimum 1 500 mm for 11 kV, minimum 2 000 mm for 22 kV and 33 kV. Beyond 33 kV, two transformers shall be separated by baffle wall of 4 h fire rating.
21) Horizontal routing of HT cable through functional/ occupied areas should be avoided in view of safety.
22) If dry type transformer is used, it may be located adjacent to medium voltage switchgear in the form of unit type substation. In such a case, no separate room or fire barrier for the transformer is required either between transformers or between transformer and the switchgear, thereby decreasing the room space requirement; however, minimum distances as specified in 4.2.1 (17) shall be maintained between the apparatus depending upon voltage ratings. Layout of equipment should take care of the need that any one piece of equipment or sub-assembly can be taken out of service and out of the installed location, while keeping the remaining system in service. Working space for access for maintenance of equipment, while keeping an adjoining section of the substation live to maintain power supply to essential loads, may require additional space between such sections of equipment.
23) For acoustical enclosures/treatment, reference may be made to Part 8 ‘Building Services’, Section 4 ‘Acoustics, Sound Insulation and Noise Control’ of the Code and CPCB norms requirements.

24) The minimum recommended spacing between the walls and the transformer periphery from the point of proper ventilation shall be in accordance with good practice [8-2(9)] (see also Fig. 1A). The actual spacing may be different than those given in the figure, depending on the circumstances, such as access to the accessories. Other requirements relating to installation of transformers shall also be in accordance with good practice [8-2(9)].
25) High voltage switch room/space – The design should take care of HV equipment space and clearance required around for maintenance and personnel safety as given in **5.3.6.7**. This room may preferably have direct access from outside. In case of substation having one transformer and one source of supply, the owner shall provide one high voltage switch. In case of single point supply with two or more transformers, the number of switch required will be one for incoming supply and one for each transformer. Additional space may be provided keeping in mind future requirement, if any. In case of duplicate supply, two switches shall be provided with mechanical/electrical inter locking arrangement. In case the number of incoming and outgoing switches exceed five, bus coupler of suitable capacity should invariably be provided.
26) Medium voltage switch room/space – The floor area required in respect of medium voltage switchgear room may be determined keeping in view the number and type of incoming/outgoing bus coupler switches including likely expansion in future and space requirement as given in **5.3.6.7**. The additional requirements of MV switchroom when located separate from the substation shall be as per **4.2.4**.
27) Other requirements relating to installation of switchgears and controlgears as given in good practice [8-2(10)] shall also be complied with.
28) The minimum height of substation room/HV switch room/MV switch room shall be arrived at considering 1 200 mm clearance requirement from top of the equipment to the below of the soffit of the beam (see also Annex C). In case cable entry/exit is from above the equipment (transformer, HV switchgear, MV switchgear), height of substation room/HV switch room/MV switch room shall also take into account requirement of space for turning radius of cable above the equipment height.
29) All the rooms shall be provided with partitions up to the ceiling and shall have proper ventilation. Special care should be taken to dissipate transformer heat and where necessary fresh air louvers at lower level and exhaust fans at higher level shall be provided at suitable locations.
30) In case of cable trench in substation/HV switch room/MV switch room, the same shall be adequately drained to ensure no water is stagnated at any time with live cables.
31) Power supply to emergency fire and life safety systems – Emergency power supplying distribution system for critical requirement for functioning of fire and life safety system and equipment, shall be planned for efficient and reliable power and control supply to the following systems and equipment where provided:

    i) Fire pumps;
    ii) Pressurization and smoke venting; including its ancillary systems such as dampers and actuators;
    iii) Fireman’s lifts (including all lifts).

iv) Exit signage lighting;
v) Emergency lighting;
vi) Fire alarm system;
vii) Public address (PA) system (relating to emergency voice evacuation and annunciation);
viii) Magnetic door hold open devices; and
ix) Lighting in fire command control and security room.

Power supply to these systems and equipment shall be from normal and emergency (standby generator) power sources with change over facility. It shall be ensured that in case the power supply is from HT source/HT generation, transformers should be planned in stand-by capacity to ensure continuity of power to such systems. Wherever transformers are installed at higher levels in buildings and backup DG sets are of higher voltage rating, then dual redundant cables shall be taken to all transformers. The generator shall be capable of taking starting current of all the fire and life safety systems and equipment as above. Where parallel HV/LV supply from a separate substation fed from different grid is provided with appropriate transformer for emergency, the provision of generator may be waived in consultation with the Authority.

The power supply to the panel/distribution board of these fire and life safety systems shall be through fire proof enclosures or fire survival cables or through alternate route in the adjoining fire compartment to ensure that supply of power is reliable to these systems and equipment. It is to be ensured that the cabling from the adjoining fire compartment is to be protected within the compartment of vulnerability. The location of the panel/distribution board feeding the fire and life safety system shall be in fire safe zone ensuring supply of power to these systems.

Cables for fire alarm and PA system shall be laid in metal conduits or armoured to provide physical segregation from the power cables.

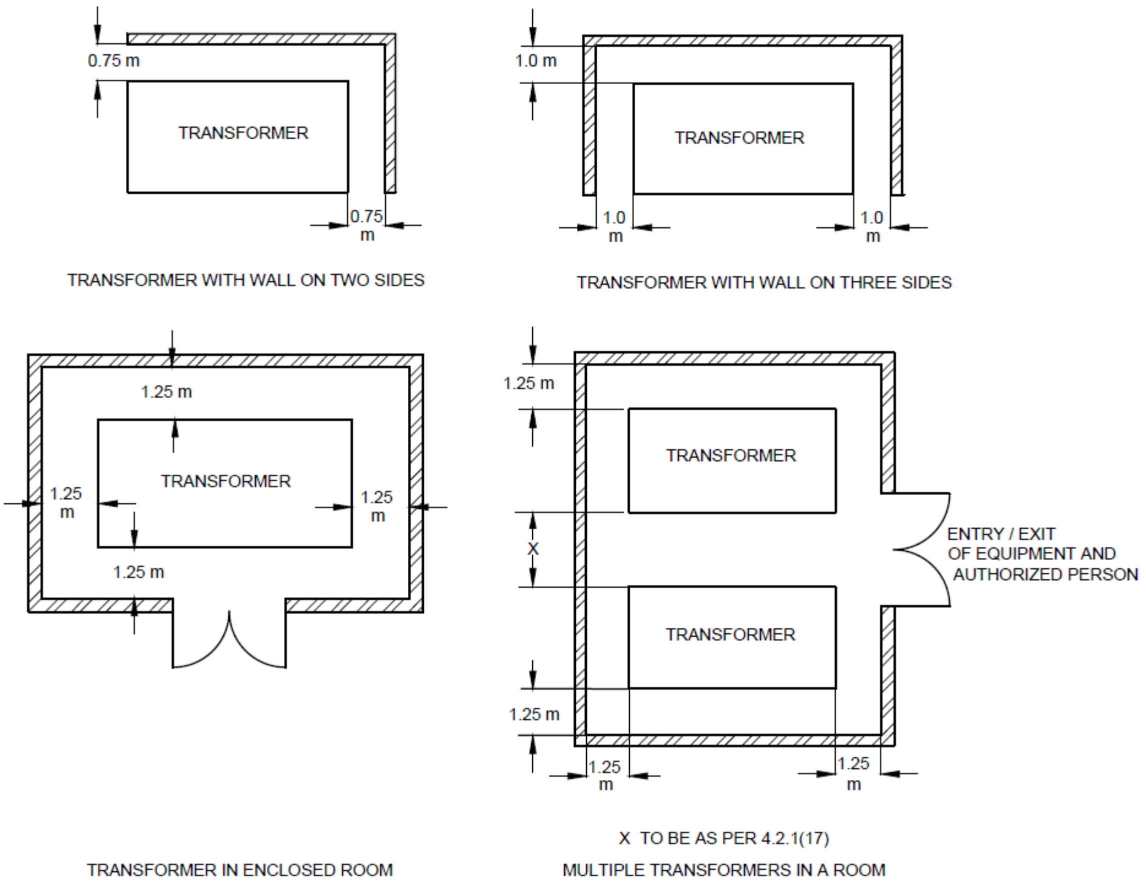
32) Other requirements as given in Central Electricity Authority (Measures relating to Safety and Electricity Supply) Regulations, 2023 as amended shall also be complied with. The fire safety requirements for substation and electrical rooms, including fire rating requirements of substations enclosure, that is, walls, floor, ceiling, openings, doors, etc, as given in Part 4 'Fire and Life Safety' of the Code shall also be complied with.

4.2.2 *Layout of Substation*

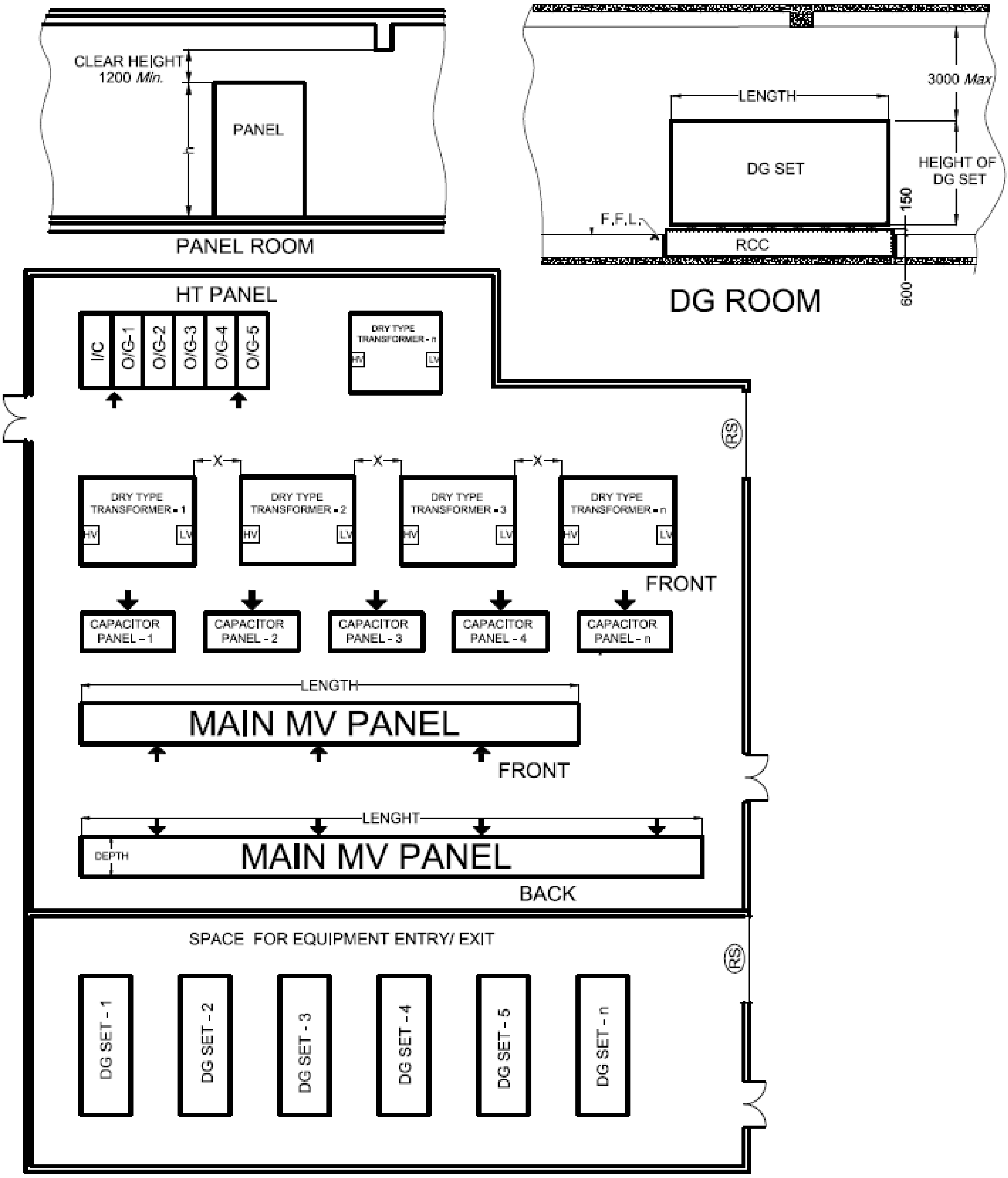
4.2.2.1 In allocating the area of substation, it is to be noted that the flow of electric power is from supply company's meter room to HV room, then to transformer and finally to the MV switchgear room. The layout of the room and trenches of required depth shall be in accordance with this flow, so as to optimize the cables, bus-trunking, etc. Visibility of equipment controlled from the operating point of the controlling switchgear is also a desirable feature, though it may not be achievable in case of large substations. Substations shall not be located at or across expansion joints. The rooms/spaces required in a substation shall be provided as below:

a) *Supply company's meter room*, generally at the periphery of the premise with direct access from the road/outside;
b) *HV isolation room*, required in case the substation is away from the meter room and is planned adjacent to meter room for disconnecting supply in case of any repair required between meter room and substation;
c) *HV panel room/space*, located adjacent to transformer;
d) *Transformer room/space*, separate space in case of oil-filled transformer and combined space in case of dry type transformer;
e) *MV isolation room/space*, required in case MV panel is away from transformer or on a different level for isolating supply in case of any repair required between transformer and MV switchgear; and
f) *Main MV panel room/space*, required for distribution to different facility/utility in a building.

A typical layout of a substation is shown in Fig. 1B.



1A MINIMUM RECOMMENDED SPACING BETWEEN THE TRANSFORMER PERIPHERY AND WALLS



X TO BE AS PER 4.2.1 (17)

All dimensions in millimeters.

1B TYPICAL LAYOUT OF SUBSTATION WITH DRY TYPE EQUIPMENT IN A SINGLE ROOM

Fig. 1 Typical Layout of Substation including Minimum Recommended Spacing of Transformer Periphery from Walls

4.2.2.2 *Capacity and size of substation*

The capacity of a substation depends upon the area of the building and its type. The capacity of substation may be determined based on the load requirements (*see also* **3.7**). Ratings of electrical equipment as given in **6.1,** may be assumed, unless the values are known or specified and diversity requirements as given below may be used for load assessment:

Sl No.	*Purpose of Final Circuit Fed from Conductors or Switchgear to which Diversity Applies*	*Typical Allowances for Diversity Based on*: *Type of Building*		
		Individual House-Hold Installations, Including Individual Dwelling of a Block	Small Shops, Stores, Offices and Business Premises	Small Hotels, Boarding Houses, etc
(1)	(2)	(3)	(4)	(5)
i)	Lighting and convenience power	66 percent of total current demand	90 percent of total current demand	75 percent of total current demand
ii)	Heating and power [*see also* Sl. No. (iii) to (iv)]	100 percent of total current demand up to 10 A + 50 percent of any current demand in excess of 10 A	100 percent of full load of largest appliance + 75 percent of remaining appliances	100 percent of full load of largest appliance + 60 percent of second largest appliance + 40 percent of remaining appliances
iii)	Air – conditioning (non-centralized)	100 percent of connected AC load for spaces upto 100 sqm and 60 – 75 percentage of connected AC load beyond 100 sqm	100 percent of connected AC load for spaces upto 200 sqm and 80 – 85 percentage of connected AC load beyond 200 sqm	90 percent of full load for public spaces and FOTH\BOTH spaces + 60 – 75 percent of Rooms
iv)	Air – conditioning (centralized)	70 percentage of high side equipment and 80 percentage of low side equipment	80 percentage of high side equipment and 90 percentage of low side equipment	80 percentage of high side equipments and 90 percentage of low side equipments
iii)	Cooking appliances	10 A + 30 percent full load of connected cooking appliances in excess of 10 A + 6 A if socket-outlet incorporated in the unit	100 percent of full load of largest appliance + 80 percent of full load of second largest appliance + 60 percent of full load of	70 – 60 percent of full load of Kitchen equipment and its corresponding ventilation equipment.

Sl No.	*Purpose of Final Circuit Fed from Conductors or Switchgear to which Diversity Applies*	*Typical Allowances for Diversity Based on*: *Type of Building*		
		Individual House-Hold Installations, Including Individual Dwelling of a Block	Small Shops, Stores, Offices and Business Premises	Small Hotels, Boarding Houses, etc
(1)	(2)	(3)	(4)	(5)
			remaining appliances	
iv)	Laundry equipment's	100 percent of full load of largest motor + 50 percent of full load of remaining motors	100 percent of full load of largest motor + 50 percent of full load of remaining motors	100 percent of full load of largest motor + 50 percent of full load of remaining motors
iv)	Motors (other than lift, escalators & Travellators motors which are subject to special consideration)	100 percent of full load of largest motor + 50 percent of full load of remaining motors	100 percent of full load of largest motor + 80 percent of full load of second largest motor + 60 percent of full load of remaining motors	100 percent of full load of largest motor + 50 percent of full load of remaining motors
iv)	lift, escalators & Travellators	100 percentage of cumulative loads	100 percentage of cumulative loads	100 percentage of cumulative loads
v)	Water heater \ Heat Pump (instantaneous type[1)])	100 percent of full load of largest appliance + 100 percent of full load of second largest appliance + 25 percent of full load of remaining appliances	100 percent of full load of largest appliance + 100 percent of full load of second largest appliance + 25 percent of full load of remaining appliances	100 percent of full load of largest appliance + 100 percent of full load of second largest appliance + 25 percent of full load of remaining appliances
vi)	Water heater (thermostatically controlled)	No diversity allowable[2)]		
vii)	Floor warming installations	No diversity allowable[2)]		
viii)	Water heaters thermal storage	No diversity allowable[2)]		

Sl No.	*Purpose of Final Circuit Fed from Conductors or Switchgear to which Diversity Applies*	*Typical Allowances for Diversity Based on*: *Type of Building*		
		Individual House-Hold Installations, Including Individual Dwelling of a Block	Small Shops, Stores, Offices and Business Premises	Small Hotels, Boarding Houses, etc
(1)	(2)	(3)	(4)	(5)
	space heating installations			
ix)	Standard arrangements of final circuits in accordance with good practice [8-2(11)]	100 percent of the current demand of the largest circuit + 40 percent of the current demand of every other circuit	100 percent of the current demand of the largest circuit + 50 percent of the current demand of every other circuit	100 percent of the current demand of the largest circuit + 40 percent of the current demand of every other circuit
x)	Socket outlets other than those included in Sl No. (ix) and stationary equipment other than those listed above	100 percent of the current demand of the largest point + 40 percent of the current demand of every other point	100 percent of the current demand of the largest point + 75 percent of the current demand of every other point	100 percent of the current demand of the largest point + 75 percent of the current demand of every point in main rooms (dining rooms, etc) + 40 percent of the current demand of every other point
	[1] For the purpose of the table, an instantaneous water heater is deemed to be a water heater of any loading which heats water only while the tap is turned on and therefore uses electricity intermittently. [2] It is important to ensure that the distribution boards are of sufficient rating to take the total load connected to them without the application of any diversity. NOTE — Diversity may be considered if multiple units of water heater are there in an individual house-hold installation, including individual dwelling of a block			

After calculating the electrical load on the above basis, an overall load factor of 50 to 90 percent is to be applied to arrive at the minimum capacity of substation. A future load may also be considered for substation sizing (*see* **3.7**). The area required for substation and transformer room for different capacities is given in Annex C for general guidance. For reliability, it is recommended to split the load into more than one transformer and also provide for standby transformer as well as multiple sources, bus-section, etc.

4.3 Emergency Power Backup System (DG Sets/ Gas Generators)

4.3.1 *Location*

The emergency power supply (such as generating sets) should not be allowed to be installed above ground floor or below the first basement level of the building. In case of DG set located in basement, the ceiling of the DG room shall be the ground floor slab. It is preferable to install the standby generator in utility building. If installed in the enclosed space, facilities for forced ventilation shall be provided such that there is minimum derating of the equipment. The generating set should preferably be housed adjacent to MV switchgear in the substation building to enable transfer of electrical load efficiently and also to avoid transfer of vibration and noise to the main building.

4.3.2 *Room for Emergency Power Backup System*

The capacity of standby generating set shall be chosen on the basis of essential light load, essential air conditioning load, essential life and safety services load [*see* **4.2.1** (29)], essential equipment load and essential services load, such as minimum one lift out of the bank of lifts and minimum one or all water pumps. Having chosen the capacity and number of generating sets, required space may be provided for their installation (*see* Annex D for general guidance). There shall be provision of separate direct escape and entry from outside so that in case of fire, electrical supplies can be disconnected to avoid additional losses which may be caused due to electrical supply, present at the time of fire. The height of diesel generating (DG) set rooms shall however be not more than 3 000 mm above the DG set height, unless required due to DG room ventilation requirements. Adequate space shall be provided for storing of fuel. Facilities including space at appropriate positions, relative to the location of the installed equipment has to be kept in the layout design for removal of equipment or sub-assemblies for repair or maintenance. When it is located at a place, other than the ground level with direct equipment access, a hatch or ramp shall be provided.

4.3.3 *Installation and Other Requirements*

Following installation and other requirements shall also be complied with:

a) Day-oil tanks for the DG sets shall be in compliance with *The Petroleum Act*, 1934. Preferrable to have Day Oil tanks in separate rooms adjacent to DG Sets \ DG Room.
b) The emergency installation shall comply with the norms laid down by the Central Pollution Control Board (CPCB) and shall also be in compliance with *The Petroleum Act*, 1934 and guidelines of Oil Industry Safety Directorate (OISD). Compartmentation for fire protection with detection and first-aid protection measures is essential.

NOTE — Different type of fire safety requirements exists for the diesel engine and generator for the oil storage area and for the switchgear (*see also* Part 4 ‘Fire and Life Safety ’of the Code).

c) Acoustic enclosure for DG sets/acoustic lining of the DG room and ventilation system for DG room shall be in line with the requirements of CPCB. If DG set is located outdoor, it shall be housed in acoustics enclosure as per the requirements of CPCB norms. For acoustical enclosures/treatment, reference shall also be made to Part 8 'Building Services', Section 4 'Acoustics, Sound Insulation and Noise Control' of the Code.

d) Stacking of DG Sets should be avoided to ensure atleast one DG Set is in operation when the other set is on fire. IN case stacking of DG Sets is unavoidable on ground, a proper fire barrier of 2-hour fire rating between the two DG Sets should be ensured. Both DG Sets should be kept on free standing civil structure with fire barriers in between such that fire in one doesn't jump\ drip to other. Also, both should be equally maintenance\ approach friendly independently.

e) DG Sets should be located on either Ground or first basement (in case of multiple basements only) or on first floor (with dedicated approach and in separate fire compartment.

f) The generator house should have proper ventilation for engine combustion requirements and as well as for the body heat removal apart from the heat removal from radiator or cooling tower, fire fighting equipment, etc. The other requirements given in Part 4 'Fire and Life safety' of the Code for room for emergency power backup system including DG set room shall also be complied with.

g) Other environmental requirements under the provisions of Petroleum Act 2002 and norms laid down by CPCB, as amended from time to time shall be taken into account particularly from the aspect of engine emissions including the height of exhaust pipe and permitted noise levels/ controls.

4.4 Emergency Power Backup System (Storage batteries – Li – ion or similar)

The emergency power supply (such as bulk storage batteries) should not be allowed to be installed on same floors as human occupied. These should be kept either on open ground or on terrace of Utility buildings with proper ventilation around the storage container. These batteries should be properly maintained and connected to avoid any sparking/ flashing leading to fire. Protection measures shall be taken to avoid heat runway, short circuiting, overheating of connecting cables, etc. Container must be air – conditioned and kept as per OEM guidelines. Only AC wiring should be taken out of the container for synchronizing with other emergency sources or feeding solar to premise as individual supply.

4.5 Multiple energy sources

When multiple energy sources such as grid, DG Set power backup, battery storage energy system, on grid solar PV power, on grid other renewable energy sources such as wind power, micro wind wheel, etc. are to be used in the same project simultaneously, synchronization of voltage & frequency is required for energies to be used optimized including setting priorities of source utilization.

4.6 Location of LV Switch Room Other Than in Substation

In large installations other than where a substation is provided, a separate switch room shall be provided; this shall be located as close to the electrical load centre as possible, on the ground floor or on the first basement level of the building, preferably on the same floor as Transformers. In case LT Panel and Transformer and DG Sets are on different floors then LT Isolators shall be proposed adjacent to Transformer and DG Sets.

Suitable cable trays\ Busducts shall be laid with minimum number of bends from the points of entry of the main supply cable to the position of the main switchgear. The switch room shall also be placed in such a position that riser shafts may readily be provided therefrom to the upper floors of the building in one straight vertical run. In larger buildings, more than one riser shaft may be required and then horizontal cable trays \ bus ducts may also be required for running cables from the switch room to the foot of each rising main.

Such cable trays shall either be reserved for specific voltage grades or provided with a means of segregation for medium, low and extra low voltage installations, such as call-bell systems, telephone installations, fire detection and alarm system, security systems, data cables and announcement or public address system. Cables/wires for emergency fire and life safety services and their routing shall be in accordance with **4.2.1** (29) and Part 4 'Fire and Life Safety' of the Code so that these services are maintained even in the event of a fire.

Clear space around Panels should be kept for access and maintenance required depending on circuit breaker type required. In case of ACB\ MCCB front and back access should be planned with all sides movement clearance. 1 000 mm access on back and sides and 2 000 mm access in front of Panel.

4.7 Location and Requirements of Distribution Panels

All distribution panels, switchgears shall be installed in readily accessible position. The electrical control gear distribution panels and other apparatus, which are required on each floor may conveniently be mounted adjacent to the rising mains, and adequate space considering clearances required as per **5.3.6.7** shall be provided at each floor for this purpose.

4.8 Substation Safety

The owner and the operator of any substation shall be collectively and severally be responsible for any lapse or neglect leading to an accident or an incidence of an avoidable abnormality and shall take care of the following safety requirements:

a) Enclose the substation or similar equipment where necessary to prevent, so far as is reasonably practicable, danger of electric shock or unauthorized access;
b) All equipment entry \ exit shall be always kept accessible.
c) Substation should be a separate fire compartment and it's ventilation should be independent of any other fire compartment.
d) All substation rooms shall have two (2) doors at opposite ends. Distance between all equipment's such that exit\ entry of equipment is feasible without removable of any equipment, light, cable or bus duct, etc.

e) Enclose any part of the substation which is open to the air, with a fence (earthed efficiently at both ends) or wall atleast 600 mm above the height of tallest equipment; to prevent, so far as is reasonably practicable, danger of electric shock or unauthorized access;
f) Transformers (oil filled) when placed in open shall have fencing\ wall atleast 600 mm above the height of Transformer. If trees are there around the Substation, then a temporary cover should be provided to avoid leaves falling on the terminals of HT\ LT terminations.
g) Ensure that there are at all times displayed,
   1) sufficient safety signs of such size and placed in such positions as are necessary to give due warning of such danger as is reasonably foreseeable in the circumstances;
   2) a notice which is placed in a conspicuous position and which gives the location or identification of the substation, the name of each generator or distributor who owns or operates the substation equipment making up the substation and the telephone number where a suitably qualified person appointed for this purpose by the generator or distributor will be in constant attendance; and
   3) such other signs, which are of such size and placed in such positions, as are necessary to give due warning of danger having regard to the siting of, the nature of, and the measures taken to ensure the physical security of, the substation equipment;
h) Take all reasonable precautions to minimize the risk of fire associated with the equipment; and
j) Ensure that, in addition to provisions mentioned in (c), name and emergency telephone number of the authorized personnel shall also be displayed at the substation and instructions covering schematic diagram; requirements of switchgear interlocking, if any; and permission requirements, if any, for load limitations on (incoming) feeders; be also prominently displayed.

4.9 Overhead Lines, Wires and Cables

All erections/alterations having relation to overhead lines, wires and cables shall comply with Central Electricity Authority regulations and the following. However, in case of any conflict, the regulations shall prevail.

4.9.1 *Height Requirement*

4.9.1.1 While overhead lines may not be relevant within buildings, regulations related to overhead lines are of concern from different angles as follows:

a) Overhead lines may be required in building complexes, though use of underground cables is the preferred alternative.
b) Overhead lines may be passing through the site of a building. In such a case the safety aspects are important for the construction activity in the vicinity of the overhead line as well as portions of low height buildings that may have to be constructed below the overhead lines. Overhead lines running adjacent to buildings pose hazard from the aspect of certain maintenance activity (such as use of a ladder on external face of a building) causing temporary compromise of the minimum safety clearance.

4.9.1.2 If at any time subsequent to the erection of an overhead line, whether covered with insulating material or not, or underground cable, any person who proposes to erect a new building or structure or to raise any road level or to carry out any other type of work whether permanent or temporary or to make in or upon any building, or structure or road, any permanent or temporary addition or alteration, in proximity to an overhead line or underground cable, such person and the contractor whom he employs to carry out the erection, addition or alteration, shall give intimation in writing of his intention to do so, to the supplier or owner and to the Electrical Inspector and shall furnish therewith a scale drawing showing the proposed building, structure, road or any addition or alteration and scaffolding thereof required during the construction. In this connection, Regulation 65 of *Central Electricity Authority (Measures Relating to Safety and Electricity Supply) Regulations*, 2023, as amended from time-to-time shall also be complied with (*see* Annex B).

4.9.1.3 Any person responsible for erecting an overhead line will keep informed the authority(s) responsible for services in that area for telecommunication, gas distribution, water and sewage network, roads so as to have proper coordination to ensure safety. He shall also publish the testing, energizing programme for the line in the interest of safety.

4.9.1.4 For minimum distance (vertical and horizontal) of electric lines/wires/cables from buildings, reference may be made to Part 3 'Development Control Rules and General Building Requirements' of the Code. In this connection, Regulation 60, 62, 63, and 67 of *Central Electricity Authority (Measures Relating to Safety and Electricity Supply) Regulations*, 2023, as amended from time-to-time shall also be complied with (*see* Annex B).

4.9.1.5 Regulation 66 of *Central Electricity Authority (Measures Relating to Safety and Electricity Supply) Regulations*, 2023, as amended from time-to-time, which govern conditions related to the storage of material including storage of construction material at a construction site, or other materials in a building in vicinity of overhead lines and underground cables shall also be complied with (*see* Annex B).

4.9.2 *Position, Insulation and Protection of Overhead Lines*

4.9.2.1 Any part of an overhead line which is not connected with earth and which is not ordinarily accessible shall be supported on insulators or surrounded by insulation. Any part of an overhead line which is not connected with earth and which is ordinarily accessible shall be,

a) made dead; or
b) so insulated that it is protected, so far it is reasonably practicable, against mechanical damage or interference; or
c) adequately protected to prevent danger.

4.9.2.2 Any person responsible for erecting a building or structure which will cause any part of an overhead line which is not connected with earth to become ordinarily accessible shall give reasonable notice to the licensee or distributor who owns or operates the overhead line of his intention to erect that building or structure.

The expression 'ordinarily accessible' means the overhead line might be reachable by hand if any scaffolding, ladder or other construction was erected or placed on/in, against or near to a building or structure.

4.9.2.3 Any bare conductor not connected with earth, which is part of a low voltage overhead line, shall be situated throughout its length directly above a bare conductor which is connected with earth.

4.9.3 *Precautions against Access and Warnings of Dangers*

4.9.3.1 Every support carrying a high voltage overhead line shall be fitted with anti-climbing devices to prevent any unauthorized person from reaching a position at which any such line will be a source of danger. In this connection, Regulation 75 of *Central Electricity Authority (Measures Relating to Safety and Electricity Supply) Regulations*, 2023, as amended from time-to-time shall also be complied with (*see* Annex B).

4.9.3.2 Every support carrying a high voltage overhead line, and every support carrying a low voltage overhead line incorporating bare phase conductors, shall have attached to it sufficient safety signs and placed in such positions as are necessary to give due warning of such danger as is reasonably foreseeable in the circumstances.

4.9.3.3 Poles supporting overhead lines near the road junctions and turnings shall be protected by a masonry or earth fill structure or metal barricade, to prevent a vehicle from directly hitting the pole, so that the vehicle, if out of control, is restrained from causing total damage to the live conductor system, likely to lead to a hazardous condition on the road or footpath or building.

4.9.4 *Fitting of Insulators to Stay Wires*

Every stay wire which forms part of, or is attached to, any support carrying an overhead line incorporating bare phase conductors (except where the support is a lattice steel structure or other structure entirely of metal and connected to earth) shall be fitted with an insulator, no part of which shall be less than 3 m above ground or above the normal height of any such line attached to that support.

4.10 Maps of Underground Networks

4.10.1 Any person or organization or authority laying cables shall contact the local authority in charge of that area and find out the layout of,

a) water distribution pipe lines in the area;
b) sewage distribution network;
c) telecommunication network,
d) gas pipeline network; and
e) existing power cable network,

and plan the cable network in such a manner that the system is compatible, safe and non-interfering either during its installation or during its operation and maintenance.

Plan of the proposed cable installation shall be brought to the notice of the other authorities referred above.

4.10.2 Suitable cable markers and danger sign as will be appropriate for the safety of the workmen of any of the systems shall be installed along with the cable installation. Cable route markers shall be provided at every 20 m and also at turnings and/or crossings.

4.10.3 Notification of testing and energization of the system shall also be suitably publicized for ensuring safety.

4.10.4 Any person or organization or authority associated with the operation and maintenance of services in a complex is required to have a complete integrated diagram or drawings of all services with particular emphasis on the hidden pipes, cables, etc, duly kept up-to-date by frequent interaction with all agencies associated with the maintenance work.

Organization or agency responsible for laying cables shall have and, so far it is reasonably practicable, keep up-to-date, a map or series of maps indicating the position and depth below surface level of all networks or parts thereof which he owns or operates. Where adequate mapping has not been done and the excavation for cable laying reveals lines pertaining to any of the other services, record of three dimensional location should be marked and recorded. Even where mapping exists, it may be examined if the records have become obsolete due to change such as, in road level. Any map prepared or kept shall be available for inspection by any authority, such as municipality, water supply, sewage, service providers, general public provided they have a reasonable cause for requiring reference to any part of the map.

4.10.5 Any agency working on any one or more service (occupying the underground space for service pipes, cables, etc) should keep the other agencies informed of the work so that an inadvertent action will not cause a disruption of service. Each agency should be responsible for keeping the latest information with the central authority of such records and should be responsible to ensure that the modifications, if any are duly updated and notified among the other agencies.

5 DISTRIBUTION OF SUPPLY AND CABLING

5.1 General

5.1.1 In the planning and design of an electrical wiring installation, due consideration shall be made of all the prevailing conditions. It is recommended that advice of a competent electrical engineer be sought at the initial stage itself with a view to providing an installation that will prove adequate for its intended purpose, be reliable, safe and efficient.

5.1.2 A certain redundancy in the electrical system is necessary and has to be built in from the initial design stage itself. The extent of redundancy will depend on the type of load, its criticality, normal hours of use, quality of power supply in that area, coordination with the standby power supply, capacity to meet the starting current requirements of large motors, etc.

5.1.3 In modern building technology, following high demands are made of the power distribution system and its individual components:

a) Long life and good service quality;
b) Safe protection in the event of fire;
c) Low fire load;
d) Flexibility in load location and connection, but critical in design;
e) Low space requirement; and
f) Minimum effort involved in carrying out retrofits.

5.1.4 The high load density in modern large buildings and high-rise buildings demands compact and safe solution for the supply of power. The use of busbar trunking system is ideal for such applications. Busbar trunking can be installed in vertical risers shafts or horizontally in passages for transmission and distribution of power. They allow electrical installations to be planned in a simple and neat manner. In the building complexes, additional safety demands with respect to fire barriers and fire load can also be met with the use of busbar trunking. Busbar trunking system also reduces the combustible material near the area with high energy in comparison with other distribution systems such as cables and makes the building safe from the aspect of vulnerability to fire of electrical origin. In addition, unlike cable systems the reliability of a busbar trunking system is very high. These systems also require very little periodic maintenance. Choice of busbar trunking for distribution in buildings can be made on the basis of,

a) reduced fire load (drastically reduced in comparison to the cable system);

NOTE — Insulation materials of cables are required to be fire resistant and an essential performance requirement is that the insulation material may burn or melt and flow when directly exposed to a temperature (or fire) higher than what it is class designated, but should not continue to burn after the flame or the source of heat or file is withdrawn. Even if the above fire resistant property is exhibited by the cable insulation, a large collection of cables will make the cable insulation fail to exhibit this retardant property. While specific guidelines for limiting number of cable & bunching is not available and in such cases the switch over to a bus trunking system is the proper alternative.

b) reduced maintenance over its entire lifetime;
c) longer service lifetime in comparison with a cable distribution; and
d) enhanced reliability due to rigid bolted joints and terminations and extremely low possibility of insulation failure.

5.2 System of Supply

5.2.1 All electrical apparatus shall be suitable for the voltage and frequency of supply.

5.2.2 In case of connected load of 100 kVA and above, the relative advantage of high voltage three-phase supply should be considered. Though the use of high voltage supply entails the provisions of space and the capital cost of providing suitable transformer substation at the consumer's premises, the following advantages are gained:

a) advantage in tariff;
b) more effective earth fault protection for heavy current circuits;
c) elimination of interference with supplies to other consumers permitting the use of large size motors, welding plant, etc; and
d) better control of voltage regulation and more constant supply voltage.

NOTE — Additional safety precautions required to be observed in HV installations shall also be kept in view.

In many cases there may be no choice available to the consumer, as most of the licensees have formulated their policy of correlating the supply voltage with the connected load or the contract demand. Generally, the supply is at 240 V single phase up to 5 kVA, 415/240 V 3-phase from 5 kVA to 100 kVA, 11 kV (or 22 kV) for loads up to 5 MVA and 33 kV or 66 kV for consumers of connected load or contract demand more than 5 MVA.

In case of load exceeding 10 MVA at 33 kV for building complex, designer may explore option of having a combination of power transformers and distribution transformers to reduce the numbers & long lengths of power cables. 33 kV\ 11 kV power substation at Site level\ utility building for stepping down at 11 kV and then having 11 kV \ 415 Volt distribution Substation at basement \ ground\ first floor\ usage floors, near load centers to avoid long lengths of 415 Volt cables.

5.2.3 In very large industrial buildings where heavy electric demands occur at scattered locations, the economics of electrical distribution at high voltage from the main substation to other subsidiary transformer substations or to certain items of plant, such as large motors and furnaces, should be considered. The relative economy attainable by use of medium or high voltage distribution and high voltage plant is a matter for expert judgment and individual assessment in the light of experience by a professionally qualified electrical engineer.

5.2.4 In case of complex buildings\ mixed use buildings where individual load of usage category (such as commercial, mercantile, residential, Hotels, Hospitals, Storage, industry, etc has cumulative load of 1000 kVA, then it should be proposed with independent distribution Transformer(s) for EV chargers (exceeding 200 kVA) to avoid mixing of different type of loads, harmonics, to have separate metering possibility, etc.

It shall be ensured that the same is not fed from Diesel Generator Sets or Gas generators or similar fuel based power generating systems.

Location of electric vehicle chargers shall be preferred to be located on Ground or Podium levels in a segregated fire compartment. EV chargers\ charging points shall not be considered in stack parking or automated car parking system.

All EV Charging Station must be provided with MCB / MCCB (protection against overload of input supply and output supply fittings). All chargers for EV shall be as per standard IS 17017. EV parking area shall be provided with an adequate fire alarm and protection system.

In case of non – residential building, it maybe considered to provide an independent MV\ LV feeder for EV charger to be operated as EV charging station by independent agency with a dedicated meter. For other than residential complexes only AC\DC charging station with pre-paid metering system shall be provided.

For residential complexes shall be provided with provision of meters, cables and charging points for Owner\ Users to install 4-Wheeler\ 2-Wheeler\3-Wheeler charger specific to the vehicle requiring charging.

5.3 Substation Equipment and Accessories

Substations require an approval from the Electrical Inspectorate. Such approval is mandatory before energizing the substation. It is desirable to get the approval for the general layout, schematic layout, protection plan, etc, before the start of the work from the Inspectorate. All substation equipment and accessories and materials, etc, shall conform to relevant Indian Standards, wherever they exist, otherwise the consumer (or his consultant) shall specify the standards to which the equipment to be supplied confirms and that shall be approved by the authority. Manufacturers of equipment have to furnish certificate of conformity as well as type test certificates for record, in addition to specified test certificates for acceptance tests and installation related tests for earthing, earth continuity, load tests and tests for performance of protective gear.

5.3.1 *Supply Company's High Voltage Meter Board*

In case of single point high voltage metering, energy meters shall be installed in building premise as per **4.2.2.1**, at such a place which is readily accessible\ unobstructed access to the owner/operator of the building and the Authority. The supplier or owner of the installation shall provide at the point of commencement of supply a suitable isolating device fixed in a conspicuous position at not more than 1.7 m above the ground so as to completely isolate the supply to the building in case of emergency.

In case of multipoint metering, main energy meter and reference meters shall be installed in building premises as per **4.2.2.1**, at a place which is readily accessible to the owner\ operator of the building and the authority. These should be accompanied with smart metering system (with dual source pre-paid meters)

In this connection, *Central Electricity Authority (Installation and Operation of Meters) Regulations*, 2006, as amended from time-to-time shall be complied with.

5.3.2 *High\ Medium Voltage Switchgear*

5.3.2.1 The selection of the type of high\ medium voltage switchgear for any installation *inter alia* depends upon the following:

a) Voltage of the supply system;
b) Prospective short-circuit current at the point of supply;
c) Size and layout of electrical installation;
d) Accommodation available; and
e) Nature of industry.

Making and breaking capacity of switchgear shall be commensurate with short-circuit potentialities of the supply system and the supply authority shall be consulted on this subject. HV switchgear and controlgear shall conform to the accepted standards [8-2(14)].

5.3.2.2 Guidelines on various types of switchgear equipment and their choice for a particular application shall be in accordance with good practice [8-2(12)].

5.3.2.3 In extensive installations of switchgear (having more than four incoming supply cables or having more than 12 circuit breakers), banks of switchgears shall be segregated from each other in order to prevent spreading of the risk of damage by fire or explosion arising from switch failure. Where a bus-bar section switch is installed, it shall also be segregated from adjoining banks in the same way {*see* good practice [8-2(13)]}.

5.3.2.4 It should be possible to isolate any section from the rest of the switchboards such that work might be undertaken on this section without the necessity of making the switchboard dead. Isolating switches used for the interconnection of sections or for the purpose of isolating circuit-breakers of other apparatus, shall also be segregated within its compartment so that no live part is accessible when work in a neighbouring section is in progress.

5.3.2.5 In the case of double or ring main supply, switchgears with interlocking arrangement shall be provided to prevent simultaneous switching of two different supply sources. Electrical and/or mechanical interlocks may preferably be provided.

5.3.3 *HV Cables*

5.3.3.1 The sizing of the cable shall depend upon the method of laying cable, current to be carried, permissible maximum temperature it shall withstand, voltage drop over the length of the cable, the prospective short-circuit current to which the cable may be subjected, the characteristics of the overload protection gear installed, load cycle, thermal resistivity of the soil and the operating voltage {*see also* good practice [8-2(15)]}.

5.3.3.2 All HV cables shall be installed in accordance with good practice [8-2(15)]. The HV cables shall either be laid on the cable rack/built-up concrete trenches/tunnel/basement or directly buried in the ground depending upon the specific requirement. When HV cable is hanging/running below the basement ceiling slab, the cable shall be laid in a fire rated enclosure/cable tray. The advice of the cable manufacturer with regard to installation, jointing and sealing should also be followed.

5.3.4 *High Voltage Bus Bar Trunking/Ducting*

HV bus bar system is used for transporting power between HV generators, transformers and the infeed main switchgear of the main HV switchgear.

Generally, three types of bus ducts, namely non-segregated, segregated and isolated phase bus duct are used. The non-segregated bus ducts consists of three phase bus bars running in a common enclosure made of steel or aluminium. The enclosure shall provide safety for the operational personnel and shall reduce chances of faults. HV interconnecting bus bar trunking for a.c. voltage above 1 kV up to and including 36 kV shall conform to accepted standard [8-2(16)]. The enclosures shall be effectively grounded.

Segregated phase bus duct are similar to non-segregated phase duct except that metal or isolation barriers are provided between phase conductors to reduce chances of phase to phase faults. However, it is preferable to use metal barriers.

In the case of isolated bus ducts, each phase conductor shall be housed in a separate non-magnetic enclosure. The bus duct shall be made of sections which are assembled together at site to make complete assembly. The enclosure shall be of either round or square shape and welded construction. The enclosures of all phases in general should be supported on a common steel structure.

Seismic supports shall be provided for busbar trunking having continuous straight lengths of more than 24 m at a single stretch.

The bus duct system shall be coordinated with connecting switchgear so as to provide adequate protection.

When busbar trunking is crossing different fire compartments, they shall have fire barriers of same rating as that of the compartment (*see also* Part 4 ‘Fire and Life Safety’ of the Code).

5.3.5 *Transformers*

5.3.5.1 General design objective while selecting the transformer(s) for a substation should be to provide at least two or more transformers, so that a certain amount of redundancy is built in, even if a standby system is provided. The total installed transformer capacity shall be at least 15 to 20 percent higher than the anticipated maximum demand. With growing emphasis on energy conservation, the system design is made for both extremes of loading. During the periods of lowest load in the system, it would be desirable to operate only one transformer and subsequently switching on the additional transformers as the load increases during the day. Total transformer capacity is generally selected on the basis of present load, possible future load, operation and maintenance cost and other system conditions. The selection of the maximum size (capacity) of the transformer is guided by the short-circuit making and breaking capacity of the switchgear used in the medium voltage distribution system. Maximum size limitation is important from the aspect of feed to a downstream fault. The transformers shall conform to accepted standards [8-2(17)].

5.3.5.2 For reasons of reliability and redundancy it is normal practice to provide at least two transformers (especially where electrical load is beyond 1500 kVA) for functional buildings, hospitals, hotels, institutes, etc. providing distribution transformers beyond 1600\ 2000 kVA is not recommended. Interlinking by tie lines is an alternative to enhance reliability/ redundancy in areas where there are a number of substations in close vicinity, such as a campus with three or four multi-storeyed blocks, each with a substation. Ring main type of distribution is preferred for complexes having a number of substations.

5.3.6 *Medium or Low Voltage Switchgear and Controlgear and their Assemblies*

5.3.6.1 The selection of the type of medium or low voltage switchgear for any installation *inter alia* depends upon the following:

a) Voltage of the distribution system;
b) Prospective circuit current at the point at which the switchgear is proposed;
c) Prospective short-circuit current at which the switchgear is proposed;
d) Accommodation available; and
e) Nature of industry.

The switchgear and controlgear and their assemblies so selected shall comply with the relevant accepted standards [8-2(18)].

5.3.6.2 Switchgear (and its protective device) shall have breaking capacity not less than the anticipated fault level in the system at that point. System fault level at a point in distribution systems is predominantly dependent on the transformer size and its reactance. Parallel operation of transformers increases the fault level.

5.3.6.3 Where two or more transformers are to be installed in a substation to supply a medium voltage distribution system, the distribution system shall be divided into separate sections each of which shall be normally fed from one transformer only unless the medium voltage switchgear has the requisite short-circuit capacity. Provision may, however, be made to interconnect separate sections, through a bus coupler in the event of failure or disconnection of one transformer. *See* **4.2** for details of location and requirements of substation.

5.3.6.4 Isolation and controlling circuit breaker shall be interlocked so that the isolator cannot be operated unless the corresponding breaker is in open condition. The choice between alternative types of equipment may be influenced by the following considerations:

a) In certain installations supplied with electric power from remote transformer substations, it may be necessary to protect main circuits with circuit-breakers operated by earth fault, in order to ensure effective earth fault protection.
b) Where large electric motors, furnaces or other heavy electrical equipment is installed, the main circuits shall be protected from short-circuits by switch disconnector fuse or circuit breakers. For motor protection, the combination of contactor overload device and fuse or circuit breakers shall have total co-ordination at least for motor ratings up to 10 kW and for ratings above 10 kW, it shall be Type 2 co-ordination in accordance with relevant part of accepted standards [8-2(18)]. Wherever necessary, back up protection and earth fault protection shall be provided to the main circuit.
c) Where means of isolating main circuits is separately required, switch disconnector fuse or switch disconnector may form part of main switchboards.

5.3.6.5 It shall be mandatory to provide power factor improvement capacitor at the substation bus. Suitable capacitor may be selected in consultation with the capacitor as well as switchgear manufacture depending upon the nature of electrical load anticipated on the system. Necessary switchgear/feeder circuit breaker shall be provided for controlling of capacitor bank.

Power factor of individual motor may be improved by connecting individual capacitor banks in parallel. For higher range of motors, which are running continuously without much variation in load, individual power factor correction at load end is advisable.

NOTE — Care should be taken in deciding the kVAr rating of the capacitor in relation to the magnetizing kVA of the motor. Over rating of the capacitor may cause injury to the motor and capacitor bank. The motor still rotating after disconnection from the supply, may act as generator by self-excitation and produce a voltage higher than supply voltage. If the motor is again switched on before the speed has fallen to about 80 percent of the normal running speed, the high voltage will be superimposed on the supply circuits and will damage both the motor and the capacitor.

As a general rule, the kVAr rating of the capacitor should not exceed the no-load magnetizing kVA of the motor.

Generally, it will be necessary to provide an automatic control for switching on the capacitors matching the load power factor and the bus voltage. Such a scheme will be necessary as capacitors permanently switched in the circuit may cause over voltage at times of light load. Capacitor panel shall be provided with adequate ventilation facility.

With the wide spread use of thyristor and rectifier based loads, there is a necessity of providing a full size neutral; but this requirement is generally limited to the 3-phase 4-wire distribution generally in the 415 V.

5.3.6.6 Harmonics on the supply systems are becoming a greater problem due to the increasing use of electronic equipment, computer, fluorescent lamps, LEDs and CFLs (both types have control/driver circuits operating in switch mode), mercury vapour and sodium vapour lighting, TV, microwave ovens, latest air conditioners, refrigerators, controlled rectifier and inverters for variable speed drives, power electronics and other non-linear loads. Harmonics may lead to almost as much current in the neutral as in the phases. This current is almost third, fifth, seventh and ninth harmonic. In such cases, phase rectification devices may be considered at the planning stage itself for the limits of harmonic voltage distortion. Use of active filters in combination\ independent use with capacitor banks should be proposed with either 3 phase 3 wire or 3 phase 4 wire depending upon the equipment for which electricity is utilized. The active filters alongwith Capacitor Panel should be proposed to be located in controlled environment.

5.3.6.7 Sufficient clearances as below shall be provided for isolating the switchboard to allow access for servicing, testing and maintenance (*see* Fig. 2):

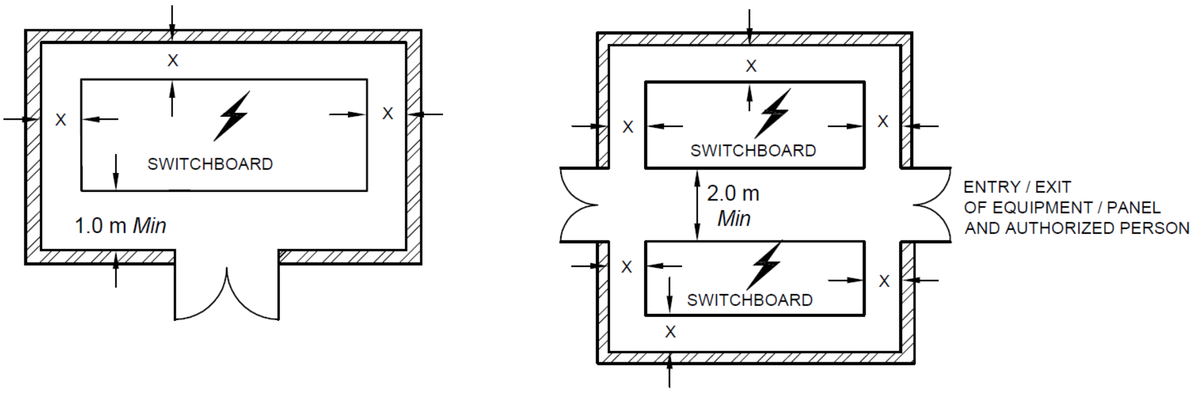
a) A clear space of not less than 1 m in width shall be provided in front of the switchboard.

NOTE — In case the board has a shutter in the front for aesthetic reasons, provided the opening of the shutter shall satisfy the requirement of working/ safety space of 1 m in front of the switchgear.

b) If access behind the switchboard is provided then it shall be either less than 200 mm or more than 750 mm in width, measured from the farthest protruding part of any attachment or conductor.
c) If the space behind the switchboard exceeds 750 mm in width, there shall be a passageway from either end of the switchboard, clear to a height of 1.8 m.
d) If two switchboards are facing each other, a minimum distance of 2.0 m shall be maintained between them.

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

There shall be a clear distance of not less than 250 mm between the board and the insulation cover, the distance being increased for larger boards in order that on closing of the cover, the insulation of the cables is not subjected to damage and no excessive twisting or bending in any case. The cable alley in the metal board should enable within prescribed limit twisting or bending of cable such that insulation of the cables is not subjected to damage.



2A ONE SWITCHBOARD/PANEL

2B TWO SWITCHBOARDS/PANELS FACING EACH OTHER

X = LESS THAN 200 mm (IF SWITCHBOARD/PANEL IS NOT ACCESSIBLE FROM BEHIND)
= MORE THAN 750 mm (IF SWITCHBOARD/PANEL IS ACCESSIBLE FROM BEHIND)

FIG. 2 CLEARANCES AROUND SWITCHBOARDS

In this connection, for installation of voltages exceeding 250 V, Regulation 39 of *Central Electricity Authority (Measures Relating to Safety and Electricity Supply) Regulations*, 2023, as amended from time-to-time shall also be complied with (*see* Annex B).

5.3.6.8 Sufficient additional space shall be allowed in substations and switchrooms to allow operation and maintenance. Sufficient additional space shall be allowed for temporary location and installation of standard servicing and testing equipment. Space should also be provided to allow for anticipated future extensions.

5.3.6.9 Panels in a room or cubicle or in an area surrounded by wall/fence, access to which is controlled by lock and key shall be accessible to authorized persons only.

Such installations shall be efficiently protected by fencing not less than 1 800 mm in height or other means so as to prevent access to the electric supply lines and apparatus therein by an undesignated person and the fencing of such area shall be earthed efficiently. Sufficient clearances as per **5.3.6.7** shall be provided between the switchboard and the wall/fence.

5.3.6.10 Except main LV panel, it will be preferable to locate the sub-panels/distribution boards/sub-meter boards near load centre. Further, it should be ensured that these panels are easily approachable. The panels should have clear access from common areas excluding staircase.

Where the switchboard is erected in a room of a building isolated from the source of supply or at a distance from it, adequate means of control and isolation shall be provided both near the boards and at the origin of supply. Sufficient clearances as per **5.3.6.7** shall be provided.

5.3.6.11 All switchboards shall be of metal clad totally enclosed type or any insulated enclosed pattern.

5.3.7 *Medium or Low Voltage Cables*

5.3.7.1 The sizing of the cable shall depend upon the current to be carried, method of laying cable, permissible maximum temperature it shall withstand, voltage drop over the length of the cable, the prospective short-circuit current to which the cable may be subjected, the characteristics of the overload protection gear installed, load cycle, thermal resistivity of the soil and the operating voltage {*see also* good practice [8-2(11)]}.

It is desirable to use flame retardant cables and wires in electrical distribution systems. Availability of flame retardant low smoke and halogen cable may also be noted and considered accordingly.

It is recommended to use four core cable in place of three and half core to minimize heating of neutral core due to harmonic content in the supply system and also avoidance of overload failures. All cables shall be installed in accordance with good practice [8-2(11)]. The advice of the cable manufacturer with regard to installation, jointing and sealing should also be followed.

In final circuits where cable size of 16 mm^2 and below are used, these shall be 4 core cables only to avoid the possibility of neutral overload, (except for equipment such as motors, heaters which offer balanced 3 phase load and not require a neutral connection. As a result, it is not desirable to use half-size neutral conductor as possibility of neutral conductor overload due to harmonics is likely. Larger feeders (size greater than 16 mm^2) may revert to use 3½ core cables.

5.3.7.2 *Colour identification of cores of non-flexible cables* {*see also* good practice [8-2(19)]}

The colour of cores of non-flexible cables shall be in accordance with the following:

Sl No. (1)	*Function* (2)	*Colour Identification of Core of Rubber of PVC Insulated Non-flexible Cable, or of Sleeve or Disc to be Applied to Conductor or Cable Code* (3)
i)	Protective or earthing	Green and yellow (*see* Note 1)
ii)	Phase of a.c. single-phase circuit	Red [or yellow or blue (*see* Note 2)]
iii)	Neutral of a.c. single or three-phase circuit	Black
iv)	Phase R of 3-phase a.c. circuit	Red
v)	Phase Y of 3-phase a.c. circuit	Yellow
vi)	Phase B of 3-phase a.c. circuit	Blue
vii)	Positive of d.c. 2-wire circuit	Red
viii)	Negative of d.c. 2-wire circuit	Black
ix)	Outer (positive or negative) of d.c. 2-wire circuit derived from 3-wire system	Red
x)	Positive of 3-wire system (positive of 3-wire d.c. circuit)	Red
xi)	Middle wire of 3-wire d.c. circuit	Black
xii)	Negative of 3-wire d.c. circuit	Blue
xiii)	Functional earth-telecommunication	Cream\ grey

NOTES

1 Bare conductors are also used for earthing and earth continuity conductors. But it is preferable to use insulated conductors with green coloured insulation with yellow stripes.

2 As alternative to the use of red, if desired in large installations, up to the final distribution board.

3 For armoured PVC-insulated cables and paper-insulated cables, *see* relevant Indian Standard.

5.3.7.3 *Colour, identification of cores of flexible cables and flexible cords* {*see also* good practice [8-2(19)]}

The colour of cores of flexible cables and flexible cords shall be in accordance with the following:

Sl No.	*Number of Cores*	*Function of Core*	*Colour(s) of Core*
(1)	(2)	(3)	(4)
i)	1	Phase	Brown[1)]
		Neutral	(Light) Blue
		Protective or earthing	Green and yellow
ii)	2	Phase	Brown
		Neutral	(Light) Blue[1)]
iii)	3	Phase	Brown
		Neutral	(Light) Blue[1)]
		Protective or earthing	Green and yellow
iv)	4 or 5	Phase	Brown or black[1)]
		Neutral	(Light) Blue[1)]
		Protective or earthing	Green and yellow

[1)] Certain alternatives are allowed in wiring regulations.

5.3.8 *MV/LV Bus bar Trunking/Rising Mains*

5.3.8.1 Where heavy loads and/or multiple distribution feeders are required to be supplied, busbar/rising main systems are preferred. The busbars are available for continuous run from point to point or with tap offs at standard intervals and have to be chosen as per specific requirement. Seismic supports shall be provided for bus trunking having continuous straight lengths of more than 24 m at a single stretch. There are following two types of MV/LV bus duct system for power distribution:

a) Conventional type; and
b) Compact and sandwich type.

5.3.8.1.1 *Conventional type bus duct*

These are used for large power handling between transformer and switchgear or between switchgear and large power loads such as compressor drive motor, etc. This type is generally used in plant rooms, riser shafts, substations, etc. These are generally air insulated with intermediate ceramic support insulators enclosed in a metallic enclosure, which should be earthed. They have the least amount of combustible material. However, when these are crossing different fire compartments, they shall have fire barriers of same rating as that of the compartment (*see also* Part 4 'Fire and Life Safety' of the Code).

Conventional type bus ducts with non-metallic enclosures are also available. However, such bus ducts shall be used only if essential and with appropriate additional care.

5.3.8.1.2 *Compact type bus duct*

Compact type bus ducts are used within areas of the building which have space restrictions, etc, for aesthetic and functional reasons. These are either air insulated or sandwich type. They may be used in false ceiling spaces or even in corridors and shafts for distribution without any false ceiling as they provide an aesthetically acceptable finish to merge with other building elements such as beams, ducts or pipes in functional buildings.

The insulation material in such ducts which are generally glass fibre tape or epoxy encapsulation in combination with ceramic supports/spacers. These bus ducts should be duly enclosed by a metallic enclosure, which should be earthed.

In case of compact air insulated type bus ducts crossing different fire compartments, they shall have fire barriers of same rating as that of the compartment (*see also* Part 4 'Fire and Life Safety' of the Code).

5.3.8.2 The bus duct system shall be coordinated with connecting switchgear so as to provide adequate protection.

5.3.8.3 Seismic supports shall be provided for busbar trunking having continuous straight lengths of more than 24 m at a single stretch.

5.3.8.4 Where the number of individual units/flats/shops/offices on a floor in a building are more than 24, multiple rising mains is recommended for power distribution.

5.3.8.5 The low voltage bus bar trunking shall conform to accepted standard [8-2(20)].

5.4 Reception and Distribution of Main Supply (LV connections)

5.4.1 *Control at Point of Commencement of Supply*

5.4.1.1 The supplier shall provide a suitable metering switchboard in which each meter units hall have its individual compartment housing meter, wiring, Circuit breaker, etc within a consumer's premises, in an accessible position and such metering switchboard shall be contained within adequately enclosed fireproof receptacle. Where more than one consumer is supplied through a common service line, such consumer shall be provided with an independent metering unit in a switchboard housed in common area with an incoming breaker. Such meter switchboards should be housed in an enclosed and lockable space. Cables\ wires from such switchboards connecting to individual consumers should terminate directly to consumers Distribution Board without any interim termination or change of conductor. Such switchboards maybe located at Ground floor or first basement (incase it is not the lowest basement) if building height is not exceeding 45 meters. All Metering Panel \ Connection arrangements will have interconnection between circuit breakers, fuses, individual meters, etc should be using solid busbar instead of cables (where length of cables is less than 10 meters).

However, for buildings above height of 45 meters shall be having meters on individual floors. In case of commercial buildings\ shopping malls\ multi – use spaces where combining of units maybe envisaged, meter switchboards should be placed on the floor where consumer unit is located.

In case of high rise buildings, the supplier or owner of the installation shall provide at the point of commencement of supply a suitable isolating device with cut-out or breaker to operate on all phases except neutral in the 3-phase, 4-wire circuit and fixed in a conspicuous position at not more than 1.7 m above the ground so as to completely isolate the supply to the building in case of emergency. In this connection, Regulation 38 of *Central Electricity Authority (Measures Relating to Safety and Electricity Supply) Regulations*, 2023, as amended from time-to-time shall also be complied with (*see* Annex B).

The supplier shall provide and maintain on the consumer's premises for the consumer's use, a suitable earthed terminal in an accessible position at or near the point of commencement of supply. In this connection, Regulation 18 of *Central Electricity Authority (Measures Relating to Safety and Electricity Supply) Regulations*, 2023, as amended from time-to-time shall also be complied with (*see* Annex B).

No cut-out, link or switch other than a linked switch arranged to operate simultaneously on the earthed or earthed neutral conductor and live conductor shall be inserted or remain inserted in any earthed or earthed neutral conductor of a two wire-system or in any earthed or earthed neutral conductor of a multi-wire system or in any conductor connected thereto. This requirement shall however not apply in case of,

a) a link for testing purposes, or
b) a switch for use in controlling a generator or transformer.

In this connection, Regulation 17 of *Central Electricity Authority (Measures Relating to Safety and Electricity Supply) Regulations*, 2023, as amended from time-to-time shall also be complied with (*see* Annex B).

The neutral shall also be distinctly marked.

5.4.1.2 The main switch shall be easily accessible and situated as near as practicable to the termination of service line.

5.4.1.3 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 for identification in accordance with Regulation 17 of *Central Electricity Authority (Measures Relating to Safety and Electricity Supply) Regulations*, 2023, as amended from time-to-time (*see* Annex B).

5.4.1.4 *Energy meters*

5.4.1.4.1 Energy meters conforming to accepted standards [8-2(21)] shall be installed in all buildings at such a place which is readily accessible to the owner/operator/occupant of the building and the Authority. Meters should not be located at an elevated area or a depressed area that does not have access by means of a stairway of normal rise. The height of meter display shall be between 750 mm and 1 800 mm. In case the meter is provided with a secondary display unit, this requirement applies to the secondary display unit only. A minimum clearance of 50 mm should be maintained around the meter itself for better inspection. This includes the space between two meters, between meter and the mounting box and between two mounting boxes as the case may be. The energy meters should either be provided with a protecting covering, enclosing it completely except the glass window through which the readings are noted or should be mounted inside a completely enclosed panel provided with hinged arrangement for locking. Additionally, for outdoor installations, the meters and associated accessories shall be protected by appropriate enclosure of level of protection IP 55 and ensuring compliance with above conditions. The enclosure should preferably be light coloured.

In large multi-storeyed buildings, installation of a large number of energy meters at the ground floor (or first basement) switch-room for the convenience of the meter-reader poses high fire hazard. More than 24 energy meters on one switchboard is undesirable. In such cases, where number of energy meters to be installed for feeding exceeds 24, energy meters shall be installed at each floor and therefore, the rising main (bus trunking) with tapping point at individual floor shall be provided for meters.

The energy meters shall be protected by suitable circuit breaker. The provisions of **5.3.6.7** shall apply in case of energy meters installed in boards.

5.4.1.4.2 Main sources of energy, as given below shall be metered, as required at entry into the premise/control panel:

1) Utility grid points (high voltage/medium voltage/low voltage),
2) Captive generator sets, and
3) On-site renewable energy system (if installed/operational).

5.4.1.4.3 Testing, evaluation, installation and maintenance of energy meters shall be in accordance with the good practice [8-2(22)].

5.4.1.4.4 *Centralized metering system*

Smart metering and energy monitoring in a centralized metering system are used to monitor, measure, and control the demand of electrical loads in a building. These systems are designed specifically for the control and monitoring of those facilities in a building which have significant electrical consumption, such as heating, ventilation, air conditioning, lifts, pumps, and lighting installations at multiple locations in a campus. The scope may span from a single building to a group of buildings, such as residential apartments under common ownership, large multi-storeyed buildings, malls, university campuses, office buildings, retail store networks, factories, or any building with multi-tenanted occupancy. These systems provide metering, submetering and monitoring functions to allow facility and building managers to gather data and insight that allows them to make more informed decisions about demand management and demand control across their sites.

For such buildings with centralized metering, several main meters and sub-meters with following requirements should be provided:

a) Main meters should be digital energy meters with high accuracy, high sampling rates and power quality parameters, that is, harmonics, etc, for meters installed at incomer level.
b) Separate sub-meters should be provided for all energy end uses and functional areas that individually account for reasonable energy consumption in the building. These may include, but are not limited to, sub-meters for HVAC

system; common area lighting, raw power, UPS, other common utility; lifts and escalators, pumps, external and internal lighting, individual units/flats/shops/ offices; etc.

c) The sub-meters should be able to communicate data for monitoring. At a minimum, the sub-metering infrastructure should facilitate the aggregation of total energy use. For individual residential or commercial meters, if required it shall be controlled by the Local Electrical Authority to take data for grid metering and later data be shared for emergency metering.

d) Adequate smart metering and energy monitoring infrastructure should be installed in order to help monitor operational energy use and costs and to enable continuous energy performance improvement.

Smart metering and energy monitoring system that can display the following parameters should be installed with two-way communicable smart meters:

1) Hourly energy demand and use;
2) Energy breakdown and mix and energy consumption patterns;
3) Power quality analysis;
4) Energy consumption by process, department, building, floor, etc;
5) Comparison of actual energy use with targets or historical trends and benchmark energy key performance indicators; and
6) Reporting on energy efficiency achieved.

These systems should also have the ability to utilize near-real-time or time-of-use pricing through integration of smart meters with the monitoring and control system. The system should be capable of supporting predictive demand for better demand management and proactive demand control.

5.4.1.4.5 The *Central Electricity Authority (Installation and Operation of Meters) Regulations* 2006, as amended from time-to-time shall also be complied with.

5.4.2 *Main Switches and Switchboard*

5.4.2.1 All main switches shall be either of metal-clad enclosed pattern or of any insulated enclosed pattern which shall be fixed at close proximity to the point of entry of supply. Every switch shall have suitable ingress protection level rating (IP), so that its operation is satisfactory and safe in the environment of the installation.

NOTE — Woodwork shall not be used for the construction or mounting of switches and switch boards installed in a building.

5.4.2.2 *Location*

The main switchboard shall comply with the following requirements relating to its location:

a) The location of the main board should be such that it is easily accessible to fireman and other personnel to quickly disconnect the supply in case of emergencies. If the room is locked for security reasons, means of emergency access, by schemes such as break glass cupboard, shall be incorporated.

b) Main switch board shall be installed in rooms or fire safe cupboards so as to safeguard against operation by unauthorized personnel. Otherwise, the main switch board shall have lock and key facility for small installations in residences or other occupancies having sanctioned loads less than 5 kW.
c) Switchboards shall be placed only in dry situations and in ventilated rooms and they shall not be placed in the vicinity of storage batteries or exposed to chemical fumes.
d) In damp situation or where inflammable or explosive dust, gas or vapour is likely to be present, the switchboard shall be totally enclosed and shall have adequate degree of ingress protection (IP). In some cases flameproof enclosure may be necessitated by particular circumstances [*see* 8-2(23)].
e) Switchboards shall not be erected above gas stoves or sinks, or within 2.5 m of any washing unit in the washing rooms or laundries, or in bathrooms, lavatories or toilets, or kitchens.
f) In case of switchboards unavoidably fixed in places likely to be located outdoor, exposed to weather, to drip, or to abnormal moist temperature, the outer casing shall be weatherproof and shall be provided with glands or bushings or adopted to receive screwed conduit, according to the manner in which the cables are run. The casing as well as cable entries shall have suitable IP ratings according to the installation.
g) Adequate illumination shall be provided for all working spaces around the switchboards.
h) Easy access to the enclosure around switchgear is essential to enable easy and safe operation and maintenance. The provisions as given in **5.3.6.7** including requirements for sufficient clearances shall be complied with.

5.4.2.3 Metal-clad switchgear shall be mounted on any of the following types of boards:

a) *Hinged-type metal boards* – These shall consist of a box made of sheet metal not less than 2 mm thick and shall be provided with a hinged cover to enable the board to swing open for examination of the wiring at the back. The board shall be securely fixed to the wall by means of proper nuts and bolts designed to take weight of the switch board and shall be provided with a locking arrangement and an earthing and neutral stud or bus. All wires passing through the metal board shall be protected by cable termination glands at the entry hole. The earth stud should commensurate with the size of earth lead/leads. Alternatively, metal boards may be made of suitable size iron angle section of minimum size 35 mm x 35 mm x 6 mm or iron channel section of minimum size 35 mm x 25 mm x 6 mm frame work suitably mounted on front with a 3 mm thick mild steel plate and on back with 1.5 mm thick mild steel sheet. No apparatus shall project beyond any edge of panel. No fuse body shall be mounted within 25 mm of any edge of the panel.

   NOTE — Such type of boards are particularly suitable for small switchboard for mounting metal-clad switchgear connected to supply at low voltages.

b) *Fixed-type metal boards* – These shall consist of an angle or channel iron frame fixed on the wall or on floor and supported on the wall at the top, if necessary.

NOTE — Such type of boards are suitable for both small and large switchboards. They are particularly suitable for large switchboards for mounting number of switchgears or high capacity metal-clad switchgear or both in an arrangement which do not require rear access.

c) *Protected-type switchboard* – A protected switchboard is one where all of the switchgear and conductors are protected by metal or halogen free plastic enclosures. They may consist of a metal/plastic cubicle panel, or an iron frame upon which metal-clad switchgears are mounted. They usually consist of a main switch, bus bars and circuit breakers or fuses controlling outgoing circuits.

d) *Outdoor-type switchboard* – An outdoor-type switchboard is one which is totally enclosed and UV ray protected and having high ingress protection against dust and moisture and vermin-proof and high impact resistance (IP 55 or higher and IK 10). Such switchboards are of cubicle type and also provide high impact resistance. Cubicle type boards shall be with hinged doors interlocked with switch-operating mechanisms. The doors of these switchboards shall have facility to ensure that it is always in closed conditions. All such switches shall bear labels indicating their functions.

NOTE — Such switchboards shall be located away from areas likely to be crowded by the public.

Open type switchboards wherever existing in old buildings shall be phased out and replaced with protected-type switchboards with suitable circuit breakers. Switchboards should be composite including incoming & outgoing circuit breakers, meters, cable alleys, busbars, accessories, etc.

5.4.2.4 *Recessing of boards*

Where so specified, the switchboards shall be recessed in the wall. Ample room shall be provided at the back for connection and at the front between the switchgear mountings (*see* **5.3.6.7**).

5.4.2.5 *Marking of apparatus* [*see also* good practices 8-2(24)]

Where a board is connected to voltage higher than 250 V, all the apparatus mounted on it shall be marked with the following colours to indicate the different poles or phases to which the apparatus or its different terminals may have been connected:

a) *Alternating Current (Three-phase) system:*

Phase 1 – red, Phase 2 – yellow and Phase 3 – blue; and
1 Neutral – black

b) *Direct Current (Three-wire system)*:

2 outer wire, Positive – red and Negative – blue; and
1 Mid wire (Neutral) – black

Where four-wire three-phase wiring is done, the neutral shall be in one colour and the other three phase conductors in another colour (preferably brown) or shall be suitably tagged or sleeved to ensure fool proof identification.

NOTE — Generally brown colour identification is adopted for the phase conductors and black for neutral with additional tags or sleeves or coloured tapes at terminations.

Earth continuity conductor shall be marked with green colour or green with yellow line.

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

All markings shall be clear and permanent.

5.4.2.6 *Drawings*

Before proceeding with the actual construction, a proper drawing showing the detailed dimensions and design including the disposition of the mountings of the boards, which shall be symmetrically and neatly arranged for arriving at the overall dimensions, shall be prepared along the building drawing. Such drawings will show the mandatory clearance spaces if any, and clear height below the soffit of the beam required to satisfy regulations and safety considerations, so that other designers or installers do not get into such areas or spaces for their equipment.

5.4.3 *Distribution Boards*

A distribution board comprises of one or more protective devices against over current and ensuring the distribution of electrical energy to the circuits. Distribution board shall provide plenty of wiring space, to allow working as well as to allow keeping the extra length of connecting cables, likely to be required for maintenance.

5.4.3.1 Main distribution board shall be provided with a circuit breaker on each pole of each circuit, or a switch with a fuse on the phase or live conductor and a link on the neutral or earthed conductor of each circuit. The switches shall always be linked.

All incomers should be provided with surge protection devices depending upon the current carrying capacity and fault level (*see* **11**). Surge protecting devices should be provided with backup circuit breaker/fuses, wherever required.

5.4.4 *Branch Distribution Boards*

5.4.4.1 Branch MCB distribution boards shall be provided, along with earth leakage protective device (RCCB/RCD) in the incoming, with a fuse or a miniature circuit breaker or both of adequate rating/setting chosen on the live conductor of each sub-circuit and the earthed neutral conductor shall be connected to a common link and be capable of being disconnected individually for testing purposes. At least one spare circuit of the same capacity shall be provided on each branch distribution board.

Further, the individual branching circuits (outgoing) shall be protected against over-current with miniature circuit breaker of adequate rating. In residential/industrial lighting installations, the various circuits shall be separated and each circuit shall be individually protected so that in the event of fault, only the particular circuit gets disconnected. In order to provide protection against electric shock due to leakage current for human being, a 30 mA RCCB/ RCD shall be installed at distribution board incomer of buildings, such as residential, schools and hospitals. For all other buildings, a 100 mA RCCB/RCD will suffice for protection against leakage current.

In case of phase segregated distribution boards, earth leakage protective device shall be provided in the sub-incomer to provide phase- wise earth fault protection. The provision of sub-incomer in distribution board shall be as per consumer requirement.

5.4.4.2 Common circuit shall be provided for installations at higher level (those in the ceiling and at higher levels, above 1 m, on the walls) and for installations at lower level but with separate switch control (sockets for portable or stationery plug in equipment). For devices consuming high power and which are to be supplied through supply cord and plug, separate wiring shall be done. For plug-in equipment provisions shall be made for providing RCCB/RCD protection in the distribution board.

5.4.4.3 It is preferable to have additional circuit for kitchen and bathrooms. Such sub-circuit shall not have more than a total of ten points of light, fans and 6 A socket outlets. The load of such circuit shall be restricted to 800 W and the wiring with 1.5 mm^2 copper conductor cable is recommended. If a dedicated circuit is planned for light fixtures, the load of such circuit shall be restricted to 400 W and the wiring with 1.5 mm^2 copper conductor cable is recommended. If a dedicated circuit is planned for 6A sockets the load of such circuit shall be restricted to 800 W or a maximum of 8 numbers whichever is lesser, controlling MCB should be sized accordingly. The wiring shall be with 1.5 mm^2 copper conductor cable. If a separate fan circuit is provided, the number of fans in the circuit shall not exceed ten. Power sub-circuit shall be designed according to the load but in no case shall there be more than two 16 A outlets on each sub-circuit which can be wired with 4 mm^2 for miscellaneous socket loads and shall be with 4 mm^2 copper conductor cable for equipment consuming more than 1 kW. Power sockets complying with the accepted standards [8-2(25)] with current rated according to their starting load, wiring, MCB, etc, shall be designed for special equipment space heaters, air conditioners, heat pumps, VRF, etc.

For feeding final single phase domestic type of loads or general office loads it is advisable to introduce additional cables if required to allow lowering of short circuit rating of the switchgear required at user end. Use of hand held equipment fed through flexible cords is safe.

5.4.4.4 The circuits for lighting of common area shall be separate. For large halls 3-wire control with individual control and master control installed near the entrance shall be provided for effective conservation of energy. Occupancy sensors, movement sensors, lux level sensors, etc, may also be considered as switching options for lights, fans, TV, etc, for different closed spaces (*see also* Part 11 ‘Approach to Sustainability’ of the Code).

5.4.4.5 Where daylight is abundantly available, particularly in large halls, lighting in the area near the windows likely to receive daylight shall have separate controls for lights, so that they can be switched off/automatically reduce intensity selectively when daylight is adequate, while keeping the lights in the areas remote from the windows on (*see also* Part 11 'Approach to Sustainability' of the Code).

5.4.4.6 Circuits for socket outlets may be kept separate from circuits feeding fans and lights. Normally, fans and lights may be wired on a common circuit. In large spaces, circuits for fans and lights may also be segregated. Lights may have group control in large halls and industrial areas. While providing group control, consideration may be given for the nature of use of the area lit by a group. Consideration has to be given for the daylight utilization, while grouping, so that a group feeding areas near windows receiving daylight can be selectively switched off during daylight period.

5.4.4.7 The load on any low voltage sub-circuit shall not exceed 3 000 W. In case of a new installation, all circuits and sub-circuits shall be designed with an initial load of about 2 500 W, so as to allow a provision of 20 percent increase in load due to any future modification. Power sub-circuits shall be designed according to the load, where the circuit is meant for a specific equipment. Good practice is to limit a circuit to a maximum of three sockets, where it is expected that there will be diversity due to use of very few sockets in large spaces (example sockets for use of vacuum cleaner). General practice is to limit it to two sockets in a circuit, in both residential and non-residential buildings and to provide a single socket on a circuit for a known heavy load appliance such as air conditioner, cooking range, etc.

5.4.4.8 In wiring installations at special places like construction sites, stadia, shipyards, open yards in industrial plants, etc, where a large number of high wattage lamps may be required, there shall be no restriction of load on any circuit but conductors used in such circuits shall be of adequate size for the load and proper circuit protection shall be provided. The distribution boards (DBs) used in these areas shall be of UV resistant, double insulated type with IP 66 or higher degree of protection. Power tools and other temporary equipment connected to these DBs shall be sufficiently protected against electrical faults. Insulated IP 66 sockets complying with the accepted standards [8-2(25)] used in these DBs shall have interlocking facility in addition to protection to ensure safe plugging and unplugging of these equipment.

5.4.5 *Location of Distribution Boards*

a) The distribution boards shall be located as near as possible to the centre of the load they are intended to control.
b) These shall be fixed on suitable stanchion or wall and shall be accessible for replacement/reset of protective devices, and shall not be more than 1.8 m from floor level.
c) These shall be of either metal-clad type, or polycarbonate enclosure of minimum IP 42. But, if exposed to weather or damp situations, these shall be of the weatherproof type conforming to IP 55 and, if installed where exposed to explosive dust, vapour or gas, these shall be of flameproof type in accordance with accepted standards [8-2(26)]. In corrosive atmospheres, these shall be treated with anti-corrosive preservative or covered with suitable plastic compound.

d) Where two and/or more distribution boards feeding low voltage circuits are fed from a supply of medium voltage, the metal case shall be marked 'Danger 415 Volts' and identified with proper phase marking and danger marks.

e) Each shall be provided with a circuit list giving diagram of each circuit which it controls and the current rating of the circuit and size of fuse element.

f) In wiring branch distribution board, total load of consuming devices shall be divided as far as possible evenly between the number of ways in the board leaving spare circuits for future extension.

g) Distribution board shall not be located at structural expansion joints of the building.

h) Distribution board/other electrical outlets shall have a minimum calculated separation distance from lightning protection down-conductors to avoid flash over in case of lightning.

j) Walls with flushed distribution boards shall have adequate support behind and surrounding so that there is no physical weight on the distribution board of the civil structure around. Electrical switch sockets, etc, shall also be avoided to be mounted behind the distribution board to avoid touching the board from behind.

5.4.6 *Protection of Circuits*

a) Appropriate protection shall be provided at switchboards, distribution boards and at all levels of panels for all circuits and sub-circuits against short circuit, over-current and other parameters as required. The protective device shall be capable of interrupting maximum prospective short circuit current that may occur, without danger. The ratings and settings of fuses and the protective devices shall be coordinated so as to afford selectivity in operation and in accordance with accepted standards [8-2(27)].

b) Where circuit-breakers are used for protection of a main circuit and of the sub-circuits derived therefrom, discrimination in operation may be achieved by adjusting the protective devices of the sub-main circuit-breakers to operate at lower current settings and shorter time-lag than the main circuit-breaker.

c) Where HRC type fuses are used for back-up protection of circuit-breakers, or where HRC fuses are used for protection of main circuits, and circuit-breakers for the protection of sub-circuits derived there from, in the event of short-circuits protection exceeding the short-circuits protection exceeding the short-circuits capacity of the circuit-breakers, the HRC fuses shall operate earlier than the circuit-breakers; but for smaller overloads within the short-circuit capacity of the circuit-breakers, the circuit-breakers shall operate earlier than the HRC fuse blows.

d) If rewireable type fuses are used to protect sub-circuits derived from a main circuit protected by HRC type fuses, the main circuit fuse shall normally blow in the event of a short-circuit or earth fault occurring on sub-circuit, although discrimination may be achieved in respect of overload currents. The use of rewireable fuses is restricted to the circuits with short-circuit level of 4 kA; for higher level either cartridge or HRC fuses shall be used. However, use of rewireable fuse is not desirable, even for lower fault level areas. MCB's provide a better and dependable protection, as their current setting is not temperable.

e) A fuse carrier shall not be fitted with a fuse element larger than that for which the carrier is designed.

f) The current rating of a fuse or circuit breaker shall not exceed the current rating of the smallest cable in the circuit protected by the fuse.

g) Every fuse shall have its own case or cover for the protection of the circuit and an indelible indication of its appropriate current rating in an adjacent conspicuous position.

h) All distribution board or panel incomer may be protected by a surge protection device, if found necessary (*see* **11**). Separate HRC fuse/CB with proper enclosure may be required in series with the surge protection device with main incomer. Back-up fuse/CB shall be of the capacity not lower than that recommended by the SPD manufacturer. Short Circuit Withstand capability of the SPDs should be coordinated with the HRC fuse/CB and SPD should be selected to be matching the fault power expected/calculated at that point.

5.4.7 *Cascading, Discrimination and Limitation*

Cascading and discrimination in switchgear downstream and upstream shall be designed and maintained such that the continuity of power in case of any abnormal conditions such as overload, short circuit and earth faults, etc is maintained and only faulty circuit is isolated and power is made available to other loads.

Cascading technique allows the designer to select circuit breakers of lower breaking capacities. Utilizing the current limiting effect of the incoming breaker, outgoing breaker can sustain the higher faults than it’s capacity and even maintain the discrimination.

5.5 Protection Class of Equipment and Accessories

The class of ingress protection (IP) and protection against mechanical impact (IK) {*see also* good practice [8-2(6)]} shall be specific depending on the requirement at the place of installation.

5.6 Voltage and Frequency of Supply

It should be ensured that all equipment connected to the system including any appliances to be used on it are suitable for the voltage and frequency of supply of the system. The nominal values of low and medium voltage systems in India are 240 V and 415 V a.c., respectively, and the frequency is 50 Hz.

NOTE — The design of the wiring system and the sizes of the cables should be decided taking into account following factors:

a) *Voltage drop* – This should be kept below 6 percent to ensure proper functioning of all electrical appliances and equipment including motors;

b) Thermal limit based current carrying capacity of the cable with appropriate derating factors applicable to the installation conditions;

c) Capacity to withstand the let through fault current based on the fault level and the controlling switchgear disconnection characteristics.

5.7 Rating of Cables and Equipment

5.7.1 The current-carrying capacity of different types of cables shall be chosen in accordance with good practice [8-2(28].

5.7.2 The current ratings of switches for domestic and similar purposes are 6 A, 16 A, 20 A and 25 A.

5.7.3 The current ratings of isolators and normal duty switches and composite units of switches and fuses shall be selected from one of the following values:

16, 25, 32, 63, 100, 160, 200, 320, 400, 500, 630, 800, 1 000 and 1 250 A.

5.7.4 The ratings of rewireable and HRC fuses shall be in accordance with good practice [8-2(29)].

5.7.5 The current ratings of miniature circuit-breakers shall be chosen from the values given below:

6, 10, 16, 20, 25, 32, 40, 50, 63, 80, 100 and 125 A.

5.7.6 The current ratings of moulded case circuit breakers shall be chosen from the values given below:

100, 125, 160, 200, 250, 315, 400, 630, 800, 1 000, 1 250 and 1 600A.

5.7.7 The current ratings of air circuit-breakers shall be chosen from the values given below:

630, 800, 1 000, 1 250, 1 600, 2 000, 2 500, 3 200, 4 000A 5 000 and 6 300 A.

5.7.8 The current ratings of the distribution fuse board shall be selected from one of the following values:

6, 16, 25, 32, 63 and 100 A.

5.8 Installation Circuits

5.8.1 The nominal cross-sectional area of copper phase conductors in a.c. circuits and of live conductors in d.c. circuits shall be not less than the values specified below:

Sl No.	*Type of Circuit*	*Minimum Copper Wire size*	*Number of Circuits*
(1)	(2)	(3)	(4)
i)	Lighting	1.5 mm^2	2 or more

Sl No.	*Type of Circuit*	*Minimum Copper Wire size*	*Number of Circuits*
(1)	(2)	(3)	(4)
ii)	Socket-outlets, 6 A	2.5 mm^2	Any number Areas such as kitchens and laundries 3 x double socket-outlets per circuit. Other areas up to 12 double socket-outlets
iii)	Signaling and control circuits	0.5 mm^2 (*see* Note)	
iv)	Socket-outlets, 16 A	2.5 mm^2	1
v)	Water heater < 3 kW	2.5 mm^2	1
vi)	Heaters or electric equipment more than or equal to 3 kW	4.0 mm^2	1
vii)	Free standing electric range Separate oven and/or cook top	4.0 mm^2	1
viii)	Air conditioner > 1.5 t	4.0 mm^2	1
ix)	Permanently connected appliances including dishwashers, heaters, etc	2.5 mm^2	1 above 10 A. Up to 10 A can be wired as part of a socket-outlet circuit
x)	Appliance rated >3 kW<6 kW	6.0 mm^2	
xi)	Submains to garage or out-building	2.5 mm^2	1 for each
xii)	Mains cable		It should be based on demand load/peaking loads and future loading.

NOTE — In multi-core flexible cables containing 7 or more cores and in signalling control circuits intended for electronic equipment a minimum nominal cross-sectional area of 0.1 mm^2 is permitted.

5.8.2 Aluminum conductor cables in sizes less than 16 mm^2 cause termination problems leading to heating at the terminals and enhance the possibility of a fire. For conductor sizes less than or equal 16 mm^2, only copper conductor cables should be used.

5.8.3 Switch or isolator controlling a water heater or geyser should not be located within 1 m from the location of a shower or bath tub, to avoid a person in wet condition reaching the switch or isolator. It is preferable to provide the control switch outside the bath room near the entrance and provide an indication at the water heater. A socket or a connector block with suitable protection against water spray should be provided to connect the water heater. The above considerations apply to switches for outdoor lights and other appliances, with the object of avoidance of operation of a switch when a person is wet.

5.8.4 Sockets in kitchen, bathroom, toilet, garage, etc, should not be provided within a height of 1 m from the ground level. Similar care has to be taken for installations involving fountains, swimming pools, etc. Light fittings in such areas should be fed at low voltage, preferably through an isolating transformer with a proper earth leakage protection. Where possibility of a person in contact with a wet surface has to operate or touch an electrical switch or an appliance the circuit should be protected by a 100/30 mA RCCB/RCD as applicable.

5.8.5 *Selecting and Installing Cables*

5.8.5.1 *Cable insulation types*

For the purpose of this Code, cables above 1 mm^2 shall have stranded conductors. All cables when installed, shall be adequately protected against mechanical damage. This can be carried out by either having additional protection, such as being enclosed in PVC conduit or metal pipes, or placing the cables in a suitable location that requires no additional protection. The cables for wiring circuits in electrical installation shall have the appropriate wire size matching the requirement of the loads and the following table gives the recommendations for different types of loads:

For the mains cable	Tough plastic sheathed (TPS) cable
For installation wiring	Tough plastic sheathed (TPS) cables
For main earth or main equipotential wire	Poly vinyl chloride (PVC) insulated conduit wire
Underground installation and installation in cable trench, feeders between buildings, etc	PVC insulated, PVC sheathed armored cables or XLPE insulated, PVC sheathed cables armoured cables
Installation in plant rooms, switch rooms etc, on cable tray or ladder or protected trench, where risk of mechanical damage to cable does not exist.	PVC insulated, PVC sheathed or XLPE insulated, PVC sheathed unarmoured cables

5.8.5.2 *Circuit wire sizes*

Recommended minimum wire sizes for various circuits is given below:

Sl No.	*Circuits*	*Minimum Wire Size*	*Wire Colour*
(1)	(2)	(3)	(4)
i)	1-way lighting	2 + E cable wires 1.5 mm^2	Red-Black-Green or Green/Yellow
ii)	2-way lighting control (straps between the 2 switches)	3 wire cable 1.5 mm^2	Red-White-Blue
iii)	Storage water heaters up to 3 kW	2 + E cable 2.5 mm^2 (stranded conductors)	Red-Black-Green or Green/Yellow
iv)	Storage water heaters between 3 kW and 6 kW	2 + E cable 4 mm^2 (stranded conductors)	Red-Black-Green or Green/Yellow
v)	Socket-outlets and permanent connection units	2 + E cable 2.5 mm^2 (stranded conductors)	Red-Black-Green or Green/Yellow
vi)	Submains to garages or out buildings	2 + E cable 2.5 mm^2 (stranded conductors)	Red-Black-Green or Green/Yellow
vii)	Cooking hobs	2 + E cable 1.5 mm^2	Red-Black-Green or Green/Yellow
viii)	Separate ovens	2 + E cable 4 mm^2 (stranded conductors)	
ix)	Electric range	2 + E cable 6 mm^2 (stranded conductors)	Red-Black- Green or Green/Yellow
x)	Mains	2 wire cable 16 mm^2 (stranded conductors)	Red-Black
xi)	Main equipotential bonding wire	Conduit wire 4 mm^2 (stranded conductors)	Green or Green/Yellow

Sl No.	*Circuits*	*Minimum Wire Size*	*Wire Colour*
(1)	(2)	(3)	(4)
xii)	Main earth wire	Conduit wire 6 mm^2 (stranded conductors)	Green or Green/Yellow

NOTES

1 2 + E is also known as twin and earth.
2 Earth wire can be as per the following:
a) Green/Yellow throughout their length with, in addition, light blue markings at the terminations, or
b) Light blue throughout their length with, in addition, green/yellow markings at the terminations.
3 The above sizes are recommendatory and shall be modified as per voltage drop, starting current, distance from DB, etc.

5.8.6 *Requirements for Physical Protection of Underground Cables*

Sl No.	*Protective Element*	*Specifications*
(1)	(2)	(3)
i)	Bricks	(a) 100 mm minimum width (b) 25 mm thick (c) sand cushioning 100 mm and sand cover 100 mm.
ii)	Concrete slabs	At least 50 mm thick.
iii)	Plastic slabs (polymeric cover strips) Fibre reinforced plastic	At least 10 mm thick, depending on properties and has to be matched with the protective cushioning and cover
iv)	PVC conduit or PVC pipe or stoneware pipe or hume pipe	The pipe diameter should be such so that the cable is able to easily slip down the pipe.
v)	Galvanized pipe	The pipe diameter should be such so that the cable is able to easily slip down the pipe.

The trench shall be backfilled to cover the cable initially by 200 mm of sand fill; and then a plastic marker strip shall be put over the full length of cable in the trench. The marker signs shall be provided where any cable enters or leaves a building. This will identify that there is a cable located underground near the building. The trench shall then be completely filled. If the cables rise above ground to enter a building or other structure, a mechanical protection such as a GI pipe or PVC pipe for the cable from the trench depth to a height of 2.0 m above ground shall be provided.

5.9 Lighting and Levels of Illumination

5.9.1 *General*

Lighting installation shall take into consideration many factors on which the quality and quantity of artificial lighting depends. Recent practice in illumination is to provide the required illumination with a large number of light sources (not of higher illumination level) instead of fewer number of light sources of higher illumination level, to produce higher uniformity in illumination level.

Now a wide variety of light sources, such as, fluorescent lamps [tubular (TL) and compact (CFL)], light emitting diodes (LED) and induction lighting are available in addition to the incandescent lamps (GLS and halogen), for application in buildings. Most of them are competitive when applied in the segment for which a particular type is well suited.

With the increase in energy costs and awareness of the need to conserve energy for the protection of the environment, lighting design is becoming complex. With the developments in the types of light sources and their control systems now available, lighting design goes with the concept of better light with less energy and least impact on environment.

Automatic lighting control schemes may be considered to have efficient utilization of lights. Automatic controls can take care of the switching off when the space served has no activity or is illuminated by daylight.

5.9.2 *Electrical Installations for Lighting*

The concepts or needs of energy conservation today require more lights to be provided so that different sets of lights are used to light up the area of activity to the required higher level of lighting needed for the activity and provide a general minimum background level of lighting. Any space requires two or three different combination of lighting sets associated with the activity and this may require the wiring to be provided to accommodate the lighting groups in different circuits with group controls, automatic controls and remote controls.

Availability of LED lights with a wide range from 1 W to 100 W allows designers to provide spot task lighting of a high illumination level combined with a general space lighting of low illumination. As light follows the inverse square law, provision of the light source close to the task reduces the energy need.

Lighting demand for buildings should be considered as per type of building. Where nothing is specified, for lighting demand of any type of building a maximum of 13 W/m^2 of all built-up areas including balconies. Covered parking areas may be considered at 3.23 W/m^2 including balconies, service areas, corridors, etc, may be considered with very basic diversity of 80 percent to 100 percent. Power requirements shall be considered at least 55 W/m^2 with an overall diversity not exceeding 50 percent. These shall be excluding defined loads such as lifts, plumbing system, fire fighting systems, ventilation requirement, etc.

While incandescent lamps (GLS or halogen) does not require any control gear, other light sources such as tubular fluorescent lamps, compact fluorescent lamps, mercury vapour lamps, sodium vapour lamps, metal halide lamps and light emitting diode (LED) lamps have non-linear characteristics and require specifically made control gear for each type of lamp for their proper operation. In some cases the control gear is integral with the lamp and in some it is with light fitting and in some it is external. The electrical installation and wiring has to take this into account and provide appropriate space for such control gear. There will be heat emission, introduction of harmonics etc, and they also consume some energy. The electrical and lighting system design has to keep this aspect in the wiring design and installation. Control gear contributes or influences energy conservation significantly and due care should be taken to ensure a proper choice.

5.9.3 *Principles of Lighting*

When considering the function of artificial lighting, attention shall be given to the following principle characteristics before designing an installation:

a) Illumination and its uniformity;
b) Special distribution of light. This includes a reference to the composition of diffused and directional light, direction of incidence, the distribution of luminances and the degree of glare;
c) Colour of the light and colour rendition;
d) Natural light sources, if possible, such as light tubes; and
e) System wattage of the luminaire proposed.

5.9.4 The variety of purposes which have to be kept in mind while planning the lighting installation may be broadly grouped as:

a) Industrial buildings and processes;
b) Offices, schools and public buildings;
c) Surgeries and hospitals; and
d) Hostels, restaurants, shops and residential buildings.

5.9.4.1 It is important that appropriate levels of illumination for these and the types and positions of fittings determined to suit the task and the disposition of the working planes.

5.9.5 For detailed requirements for lighting and lighting design and installations, reference shall be made to National Lighting Code. For specific requirements for lighting of special occupancies, reference shall be made to good practice [8-2(30)] and the National Lighting Code.

5.9.6 *Energy Conservation*

Energy conservation may be achieved by using the following:

a) Energy efficient lamps, chokes, ballast, etc, for lighting equipment.

b) Efficient switching systems such as remote sensors, infrared switches, master switches, occupancy sensors, light sensors, light automation, remote switches, etc for switching 'ON' and 'OFF' of lighting circuits.
c) Properly made/connected joints/contacts to avoid loose joints leading to loss of power.

5.10 In locations where the system voltage exceeds 650 V, as in the case of industrial locations, for details of design and construction of wiring installation, reference may be made to good practice [8-2(11)].

5.11 Guideline for Electrical Layout in Residential Buildings

For guidelines for electrical installation in residential buildings, reference may be made to good practice [8-2(31)].

A typical distribution scheme in a residential building with separate circuits for lights and fans and for power appliances is given in Fig. 3.

5.12 For detailed information regarding the installation of different electrical equipment, reference may be made to good practice [8-2(32)].

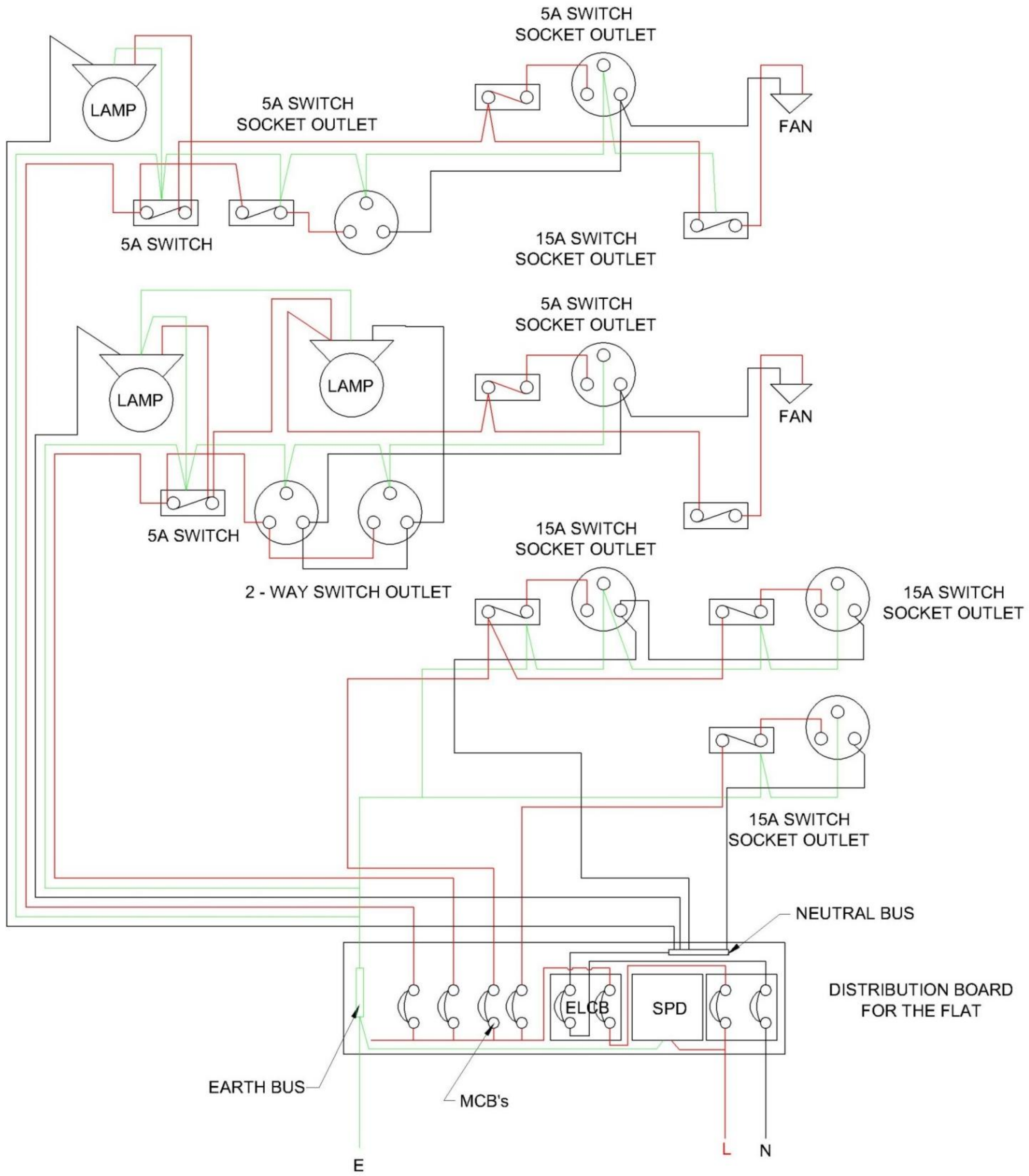


FIG. 3 WIRING DIAGRAM FOR A TYPICAL DISTRIBUTION SCHEME IN A RESIDENTIAL BUILDING FLAT

6 WIRING

6.1 Provision for Maximum Load

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

6.1.1 *Estimation of Load Requirements*

In estimating the current to be carried by any conductor the following ratings shall be taken, unless the actual values are known or specified for these elements:

Sl No.	*Element*	*Rating* W
(1)	(2)	(3)
i)	Incandescent lamp	60
ii)	Ceiling fan	60
iii)	Table fan	60
iv)	6 A socket outlet	100, unless the actual value of loads are specified
v)	16 A socket outlet	1 000, unless the actual value of loads are specified
vi)	LED light:	
	Length : a) 600 mm	25
	b) 1 200 mm	50
	c) 1 500 mm	90
vii)	High pressure mercury vapour (HPMV) lamps, high pressure sodium vapour (HPSV) lamps	According to their capacity, control gear losses shall be also considered as applicable
viii)		
ix)	Light emitting diode (LED)	5- 60
x)	Exhaust fan	50
xi)	Geyser (storage type)	2 000
xii)	Geyser (instant)	3 000
xiii)	Computer point	150
xiv)	Computer (laptop)	50
xv)	Printer, laser	1 500
xvi)	Printer, inkjet	70
xvii)	Kitchen outlet	1 500
xviii)	Air conditioner:	
	1 TR	1 250
	1.5 TR	1 875
	2 TR	2 500
	2.5 TR	3 200

6.1.2 Electrical installation in a new building shall normally begin immediately on the commencement of the main structural building work and before finishing work such as plastering has begun except in the case of surface wiring which can be carried out after the plaster work. Usually, no installation work should start until the building is reasonably weatherproof, but where electric wiring is to be concealed within the structures as may be the case with a reinforced concrete building, the necessary conduits and ducts shall be positioned firmly by tying the conduit to the reinforcement before concreting. Care should be taken to avoid use of damaged conduit or ducts, the conduits ends shall be given suitable anti-corrosive treatment and holes blocked off by putties or caps to protect conduits from getting blocked. All conduit openings and junction box openings, etc shall be properly protected against entry of mortar, concrete, etc, during construction.

6.2 Selection of Size of Conductors

The size of conductors of circuits shall be so selected that the drop in voltage from consumer's terminals in a public supply (or from the bus-bars of the main switchboard controlling the various circuits in a private generation plant) to any point on the installation does not exceed three percent of the voltage at the consumer's terminals (or at two bus-bars as these may be) when the conductors are carrying the maximum current under the normal conditions of service. The overall voltage drop from the transformer end to consumer's final distribution board shall not exceed six percent.

6.2.1 If the cable size is increased to reduce voltage drop in the circuit, the rating of the cable shall be sufficient to carry the current which the circuit is designed for. In each circuit or sub-circuit the fuse/circuit-breaker shall be selected to match the current rating of the circuit to ensure the desired protection.

6.3 Branch Switches

Where the supply is derived from a three-wire or four-wire source, and distribution is done on the two-wire system, all branch switches shall be placed in the outer or live conductor of the circuit and no single phase switch or protective device shall be inserted in the middle wire, earth or earthed neutral conductor of the circuit. Single-pole switches (other than for multiple control) carrying not more than 16 A may be of tumbler type or flush type which shall be on when the handle or knob is down.

6.4 Layout and Installation Drawing

6.4.1 The electrical layout should be drawn indicating properly the locations of all outlets, such as, lamps, fans, appliances (both fixed and movable) and motors and best suit for wiring.

6.4.2 All runs of wiring and the exact positions of all points of switch-boxes and other outlets shall be first marked on the plans of the building and approved by the Engineer-in-Charge or the owner before actual commencement of the work.

6.4.3 Industrial layout drawings should indicate the relative civil and mechanical details.

6.4.4 *Layout of Wiring*

The layout of wiring should be designed keeping in view disposition of the lighting system to meet the illumination levels. All wirings shall be done on the distribution system with main and branch distribution boards at convenient physical and electrical load centres. All types of wiring, whether concealed or unconcealed should be as near the ceiling as possible. In all types of wirings due consideration shall be given for neatness and good appearance.

6.4.5 Balancing of circuits in three-wire or poly-phase installation shall be arranged beforehand. Proper balancing can be done only under actual load conditions. Conductors shall be so enclosed in earthed metal or incombustible insulating material that it is not possible to have ready access to them. Means of access shall be marked to indicate the voltage present.

Where terminals or other fixed live parts between which a voltage exceeding 250 V exists are housed in separate enclosures or items of apparatus which, although separated are within reach of each other, a notice shall be placed in such a position that anyone gaining access to live parts is warned of the magnitude of the voltage that exists between them.

Where loads are single phase, balancing should be for the peak load condition based on equipment usage. Facility for change should be built into the distribution design.

NOTE — The above requirements apply equally to three-phase circuits in which the voltage between lines or to earth exceeds 250 V and to groups of two or more single-phase circuits, between which medium voltage may be present, derived therefrom. They apply also to 3-wire d.c. or 3-wire single-phase a.c. circuits in which the voltage between lines or to earth exceeds 250 V and to groups of 2-wire circuits, between which medium voltage may be present, derived there from.

6.4.6 Medium voltage wiring and associated apparatus shall comply, in all respects, with the requirements of Regulation 37, 38, 39, 42, 43 and 44 of *Central Electricity Authority (Measures Relating to Safety and Electricity Supply) Regulations*, 2023, as amended from time-to-time (*see* Annex B).

6.5 Conductors and Accessories

6.5.1 *Conductors*

Conductors for all the internal wiring shall be of copper. Conductors for power and lighting circuits shall be of adequate size to carry the designed circuit load without exceeding the permissible thermal limits for the insulation. For final section wiring to larger loads, the current carrying capacity will preside. The conductor size shall also be based on the voltage drop in the line so as to provide a terminal voltage not below the prescribed voltage requirement.

The conductor for final sub-circuit for fan and light wiring shall have a nominal cross-sectional area not less than 1.50 mm^2 copper. The cross-sectional area of conductor for power wiring shall be not less than 2.5 mm^2 copper. The minimum cross-sectional area of conductor of flexible cord shall be 1.50 mm^2 copper.

In existing buildings where aluminum wiring has been used for internal electrification, changeover from aluminum conductor cables to copper conductor cables is recommended as it has been found that aluminum conductors below 10 mm^2 size pose a number of hazards.

> NOTE — It is advisable to replace wiring, which is more than 30 years old as the insulation also would have deteriorated, and will be in a state to cause failure on the slightest of mechanical or electrical disturbance.

6.5.2 *Flexible Cables and Flexible Cords*

Flexible cables and cords shall be of copper and stranded and protected by flexible conduits or tough rubber or PVC sheath to prevent mechanical damage.

6.5.3 *Cable Ends*

When a stranded conductor having a nominal sectional area less than 6 mm^2 is not provided with cable sockets, all strands at the exposed ends of the cable shall be soldered together or crimped using suitable sleeve or ferrules.

6.5.4 *Special Risk*

Special forms of construction, such as flameproof enclosures, shall be adopted where there is risk of fire or explosion.

6.5.5 *Connection to Ancillary Buildings*

Unless otherwise specified, electric connections to ancillary buildings, such as out-houses, garages, etc, adjacent to the main building and when no roadway intervenes shall be taken in an earthed GI pipe or heavy duty PVC or HDPE pipe of suitable size. This pipe can be taken either underground or over ground, however, in latter case, its height from the ground shall not be less than 5.8 m. This applies to both runs of mains or sub-mains or final sub-circuit wiring between the buildings.

6.5.6 *Expansion Joints*

Distribution boards shall be so located that the conduits shall not normally be required to cross expansion joints in a building. Where such crossing is found to be unavoidable, special care shall be taken to ensure that the conduit runs and wiring are not in any way put to strain or damaged due to expansion of building structure. Anyone of the standard methods of connection at a structural expansion joint shall be followed:

a) Flexible conduit shall be inserted at place of expansion joint.
b) Oversized conduit overlapping the conduit.
c) Expansion box.

Supports and flexible joints shall be of same requirement as the rising main/bus duct in so far as resistance to seismic forces is concerned. This is further important when rising mains and bus-ducts cross expansion joints.

6.5.7 *Low Voltage* (*Types of Wires/Cables)*

Low voltage services utilizes various categories of cables/wires, such as fibre optic cable, co-axial, category cable, etc. These shall be laid at least at a distance of 300 mm from any power wire or cable. The distance may be reduced only by using completely closed earthed metal trunking with metal separations for various kind of cable. Special care shall be taken to ensure that the conduit runs and wiring are laid properly for low voltage signal to flow through it.

The power cable and the signal or data cable may run together under floor and near the equipment. However, separation may be required from the insulation aspect, if the signal cable is running close to an un-insulated conductor carrying power at high voltage. All types of signal cables are required to have insulation level for withstanding 2 kV impulse voltage even if they are meant for service at low voltage.

6.6 Joints and Looping Back

6.6.1 Where looping back system of wiring is specified, the wiring shall be done without any junction or connector boxes on the line. Where joint box system is specified, all joints in conductors shall be made by means of suitable mechanical connectors in suitable joint boxes. Whenever practicable, only one system shall be adopted for a building, preferably a looping back system.

6.6.2 In any system of wiring, no bare or twist joints shall be made at intermediate points in the through run of cables unless the length of a final sub-circuit, sub-main or main is more than the length of the standard coil as given by the manufacturer of the cable. If any jointing becomes unavoidable such joint shall be made through proper cutouts or through proper junction boxes open to easy inspection, but in looping back system no such junction boxes shall be allowed.

6.6.3 Joints are a source of problems in reliability and are also vulnerable to fire. They should be avoided or at least minimized. They should under no circumstance exceed more than one to two in total length and distance between two shall not be less than 5 m. Joint should not be used as tap-off for multiple feeders. Where joints in cable conductors or bare conductors are necessary, they shall be mechanically and electrically sound. Joints in non-flexible cables shall be accessible for inspection; provided that this requirement shall not apply to joints in cables buried underground, or joints buried or enclosed in non-combustible building materials. Joints in non-flexible cables shall be made by soldering, brazing, welding or mechanical clamps, or be of the compression type; provided that mechanical clamps shall not be used for inaccessible joints buried or enclosed in the building structure. All mechanical clamps and compression type sockets shall securely retain all the wires of the conductors. Any joint in a flexible cable or flexible cord shall be effected by means of a cable coupler.

For flexible cables for small loads less than 1 kW, while it is desirable to avoid joints, if unavoidable, joints may be made either by splicing by a recognized method or by using a connector and protecting the joint by suitable insulating tape or sleeve or straight joint. For application of flexible cable for loads of 1 kW or more, if joint is unavoidable, crimped joint is preferred. Spliced joint should not be used for large loads.

There are different standard joints, such as epoxy resin based joint, heat shrinkable plastic sleeve joint, etc, and each one has its advantage and disadvantage. Selection has to be made on the basis of application, site conditions and availability of skilled licensed workmen trained in the application of the particular type of joint.

6.6.4 Every joint in a cable shall be provided with insulation not less effective than that of the cable cores and shall be protected against moisture and mechanical damage. Soldering fluxes which remain acidic or corrosive at the completion of the soldering operation shall not be used.

For joints in paper-insulated metal-sheathed cables, a wiped metal sleeve or joint box, filled with insulating compound, shall be provided.

Where an aluminum conductor and a copper conductor are joined together, precautions shall be taken against corrosion and mechanical damage to the conductors.

6.6.5 *Pull at Joints and Terminals*

Every connection at a cable termination shall be made by means of a terminal, soldering socket, or compression type socket and shall securely contain and anchor all the wires of the conductor, and shall not impose any appreciable mechanical strain on the terminal or socket.

Flexible cords shall be so connected to devices and to fittings that tension is not transmitted to joints or terminal screws. This shall be accomplished by a knot in the cord, by winding with tape, by a special fitting designed for that purpose, or by other approved means which can prevent a pull on the cord from being directly transmitted to joints or terminal screws.

6.7 Passing Through Walls and Floors

6.7.1 Where wires/cables are required to pass through walls, care shall be taken to see that wires/cables pass freely through protective pipe or box and that the wires pass through in a straight line without any twist or cross in wires.
One of the following methods shall be employed for laying wires/cables:

a) *Conduit wiring system* (*see* **6.10**) – The conductor shall be carried either in a rigid steel conduit or a rigid non-metallic conduit conforming to accepted standards [8-2(33)].

   The conduits shall be colour coded as per the purpose of wire carried in the same. The recommended colour coding may be in form of bands of colour (100 mm thick, with centre to centre distance of 300 mm) or coloured throughout. The colour scheme may be as follows:

Conduit Type	*Colour Scheme*

Power conduit	Black
Security conduit	Blue
Fire alarm conduit	Red
Low voltage conduit	Brown
UPS conduit	Green

Conduit wiring system shall comply with accepted standards [8-2(34)]. The number of insulated conductors that can be drawn into rigid conduit is given in Tables 1 (*see* Table 1A for rigid steel conduits and Table 1B for rigid non-metallic conduits).

b) *Cable trunking/ cable ways/ Race ways* (*see* **6.11**) – Cable trunking/ cable ways / race ways system should be used when number of wires/small cable sizes to be laid is more than the conduit capacity. Care should be taken to have space in the trunking system to minimize heating of wires and to provide identification of the different circuits. These can be laid in both floor and ceiling. Adequate junction boxes, access points shall be provided to pull in and out wires.

Cable trunking or ducting system shall comply with accepted standards [8-2(35)].

c) *Tray and ladder rack* – As tray provides continuous support, unless mounted on edge or in vertical runs (when adequate strapping or clipping is essential), the mechanical strength of supported cable is not as important as with ladder-racking or structural support methods. Consequently, tray is eminently suitable for the smaller unarmoured cabling while ladder racks call for armoured cables or larger unarmoured cables as they provide the necessary strength to avoid sagging between supports. Both tray and ladder racks are provided with accessories to facilitate changes of route, and they provide no difficulty in this respect on vertical runs.

Cable tray/ladder racks and support systems shall be installed in such a way that the deflection between the spans shall be less than 1 percent of the span.

Power cables running in cable ladders both horizontal and vertical shall be fixed with proper clamps which can withstand the mechanical force created on the cable in case of short circuit current. The complete installation consisting of cables, ladders, clamps, ladder supports and fixtures shall also withstand the mechanical force of short circuit current. Only one layer of power cable shall be laid in a ladder. The minimum space between two cables shall be equal to the diameter of the biggest cable.

Cable tray and ladder system shall comply with accepted standard [8-2(53)].

6.7.2 Insulated conductors while passing through floors shall be protected from mechanical injury by means of rigid steel/non-metal conduit or by mechanical protection up to a height not less than 1.5 m above the floor and flush with the ceiling below. These steel conduits shall be earthed and securely bushed.

Power outlets and wiring in the floor shall be generally avoided. If not avoidable, false floor trunking or metal floor trunking should be used. Power sockets of adequate IP/IK rating shall be used.

False floor shall be provided where density of equipment and interconnection between different pieces of equipment is high. Examples are, mainframe computer station, telecommunication switch rooms, etc. Floor trunking shall be used in large halls, convention centres, open plan offices, laboratory, etc.

In case of floor trunking, drain points/weep holes shall be provided within the trunking for installation for conventional centres, exhibition areas or any other place where water may spill into the trunking, as there might be possibility of water seepage in the case of wiring passing through the floors. Proper care should be taken for providing suitable means of draining of water. Possibility of water entry exists from floor washing, condensation in some particular weather and indoor temperature conditions. At the design stage, these aspects shall be assessed and an appropriate means of avoiding, or reducing, and draining method shall be built in. Floor trunking outlets shall be suitably IP rated for protection against dust and water. Floor trunking shall be adequste IK rating.

Floor outlet boxes are generally provided for the use of appliances, which require a signal, or communication connection. The floor box and trunking system should cater to serve both power distribution and the signal distribution, with appropriate safety and non-interference.

6.7.3 Where a wall tube passes 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.

6.8 Wiring of Distribution Boards

6.8.1 All connections between pieces of apparatus or between apparatus and terminals on a board shall be neatly arranged in a definite sequence, following the arrangements of the apparatus mounted thereon, avoiding unnecessary crossings.

6.8.2 Cables shall be connected to a terminal only by soldered or welded or crimped lugs using suitable sleeve, lugs or ferrules unless the terminal is of such a form that it is possible to securely clamp them without the cutting away of cables stands. Cables in each circuit shall be bunched together.

6.8.3 All bare conductors shall be rigidly fixed in such a manner that a clearance of at least 25 mm is maintained between conductors or opposite polarity or phase and between the conductors and any material other than insulation material.

6.8.4 If required, a pilot lamp shall be fixed and connected through an independent single pole switch and fuse to the bus-bars of the board. Leads connecting bus-bars to any instrument or indicating lamp or an outgoing connection switch or breaker face the same fault current that is applicable to the bus-bar and as such should be provided with a fuse capable of handling the prospective fault current.

6.8.5 In a hinged type board, the incoming and outgoing cables shall be fixed at one or more points according to the number of cables on the back of the board leaving suitable space in between cables, and shall also, if possible, be fixed at the corresponding points on the switchboard panel. The cables between these points shall be of such length as to allow the switchboard panel to swing through an angle of not less than 90° and cables arranged and clamped in such a manner that the cables do not face bending, but only face a twist, when the hinged door is opened. The circuit breakers in such cases shall be accessible without opening the door of distribution board. Also, circuit breakers or any other equipment (having cable size more than 1.5 mm^2 multi-strand wire) shall not be mounted on the door.

NOTE — Use of hinged type boards is discouraged, as these boards lead to deterioration of the cables in the hinged portion, leading to failures or even fire.

6.8.6 Wires terminating and originating from the protective devices shall be properly lugged and taped.

6.9 PVC-Sheathed Wiring System

6.9.1 *General*

Wiring with PVC-sheathed cables may be used for temporary installations for medium voltage installation and may be installed directly under exposed conditions of sun and rain or damp places.

6.9.2 *PVC Clamps/PVC Channel*

The clamps shall be used for temporary installations of 1-3 sheathed wires only. The clamps shall be fixed on wall at intervals of 100 mm in the case of horizontal runs and 150 mm in the case of vertical runs.

PVC channel shall be used for temporary installations in case more than 3 wires or wires or unsheathed wires. The channel shall be clamped on wall at intervals not exceeding 300 mm. PVC clamps/PVC channel shall conform to accepted standards.

6.9.3 *Protection of PVC-Sheathed Wiring from Mechanical Damage*

a) In cases where there are chances of any damage to the wirings, such wirings shall be covered with sheet metal protective covering, the base of which is made flush with the plaster or brickwork, as the case may be, or the wiring shall be drawn through a conduit complying with all requirements of conduit wiring system (*see* **6.10**).
b) Such protective coverings shall in all cases be fitted on all down-drops within 1.5 m from the floor.

6.9.4 *Bends in Wiring*

The wiring shall not in any circumstances be bent so as to form a right angle but shall be rounded off at the corners to a radius not less than six times the overall diameter of the cable.

6.9.5 *Passing Through Floors*

All cables taken through floors shall be enclosed in an insulated heavy gauge steel conduit extending 1.5 m above the floor and flush with the ceiling below, or by means of any other approved type of metallic covering. The ends of all conduits or pipes shall be neatly bushed with porcelain, wood or other approved material.

6.9.6 *Passing Through Walls*

The method to be adopted shall be according to good practice. There shall be one or more conduits of adequate size to carry the conductors [*see* **6.10.1**(a)]. The conduits shall be neatly arranged so that the cables enter them straight without bending.

6.9.7 *Stripping of Outer Covering*

While cutting and stripping of the outer covering of the cables, care shall be taken that the sharp edge of the cutting instrument does not touch the rubber or PVC-sheathed insulation of conductors. The protective outer covering of the cables shall be stripped off near connecting terminals, and this protective covering shall be maintained up to the close proximity of connecting terminals as far as practicable. Care shall be taken to avoid hammering on link clips with any metal instruments, after the cables are laid. Where junction boxes are provided, they shall be made moisture-proof with an approved plastic compound.

6.9.8 *Painting*

If so required, the tough rubber-sheathed wiring shall, after erection, be painted with one coat of oil-less paint or distemper of suitable colour over a coat of oil-less primer, and the PVC-sheathed wiring shall be painted with a synthetic enamel paint of quick drying type.

6.10 Conduit Wiring System

Conduit wiring system shall comply with accepted standards [8-2(34)]. Requirements relating to conduit wiring system with rigid steel and non-metallic conduits shall be as per **6.10.1** to **6.10.3**.

6.10.1 *Surface Conduit Wiring System with Rigid Steel Conduits*

a) *Type and size of conduit* – All conduit pipes shall conform to accepted standards [8-2(36)], finished with galvanized or stove 93 ewireab surface. All conduit accessories shall be of threaded type and under no circumstance pin grip type or clamp type accessories be used. No steel conduit less than 16 mm in diameter shall be used. The number of insulated conductors that can be drawn into rigid steel conduit is given in Tables 1A.

b) *Bunching of cables* – Unless otherwise specified, insulated conductors of a.c. supply and d.c. supply shall be bunched in separate conduits. For lighting and small power outlet circuits phase segregation in separate conduits is recommended.

Table 1A Maximum Permissible Number of Single-Core Cables up to and including 1 100 V that can be Drawn into Rigid Steel Conduits
[*Clauses* 6.7.1(a) *and* 6.10.1(a)]

Sl No.	Size of Cable		Size of Conduit mm													
	Nominal Cross-Sectional Area mm^2	Number and Diameter, in mm of Wires	16		20		25		32		40		50		63	
			Number of Cables, *Max*													
			S	B	S	B	S	B	S	B	S	B	S	B	S	B
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
i)	1.0	1/1.12 [1)]	5	4	7	5	13	10	20	14	-	-	-	-	-	-
ii)	1.5	1/1.40	4	3	7	5	12	10	20	14	-	-	-	-	-	-
iii)	2.5	1/1.80 3/1.06 [1)]	3	2	6	5	10	8	18	12	-	-	-	-	-	-
iv)	4	½.24 7/0.85 [1)]	3	2	4	3	7	5	12	10	-	-	-	-	-	-
v)	6	½.80 7/1.06 [1)]	2	-	3	2	6	5	10	8	-	-	-	-	-	-
vi)	10	1/3.55 [2)]	-	-	2	-	5	4	8	7	-	-	-	-	-	-
		7/1.40 [1)]	-	-	2	-	4	3	6	5	8	6	-	-	-	-
vii)	16	7/1.70	-	-	-	-	2	-	4	3	7	6	-	-	-	-
viii)	25	7/2.24	-	-	-	-	-	-	3	2	5	4	8	6	9	7
ix)	35	7/2.50	-	-	-	-	-	-	2	-	4	3	7	5	8	6
x)	50	19/1.80 7/3.007 [2)]	-	-	-	-	-	-	-	-	2	-	5	4	6	5

NOTES

1 The table shows the maximum capacity of conduits for the simultaneously drawing of cables. The columns headed S apply to runs of conduit which have distance not exceeding 4.25 m between draw-in boxes, and which do not deflect from the straight by an angle of more than 15°. The columns headed B apply to runs of conduit which deflect from the straight by an angle of more than 15°.

2 In case an inspection type draw-in box has been provided and if the cable is first drawn through one straight conduit, then through the draw-in box, and then through the second straight conduit, such systems may be considered as that of a straight conduit even if the conduit deflects through the straight by more than 15°.

3 Conductor sizes for cables and wires above and including 2.5 mm^2 core size shall be multi-stranded.

[1)] For copper conductors only.
[2)] For aluminium conductors only.

c) *Conduit joints* – Conduit pipes shall be joined by means of screwed couplers and screwed accessories only [*see* 8-2(37)]. In long distance straight runs of conduit, inspection type couplers at reasonable intervals shall be provided or running threads with couplers and jam-nuts (in the latter case the bare threaded portion shall be treated with anti-corrosive preservative) shall be provided.

Threaded on conduit pipes in all cases shall be between 11 mm and 27 mm long sufficient to accommodate pipes to full threaded portion of couplers or accessories. Cut ends of conduit pipes shall have no sharp edges or any burrs left to avoid damage to the insulation of conductors while pulling them through such pipes.

d) *Protection against dampness* – In order to minimize condensation or sweating inside the tube, all outlets of conduit system shall be properly drained and ventilated, but in such a manner as to prevent the entry of insects as far as possible.

e) *Protection of conduit against rust* – The outer surface of the conduit pipes, including all bends, unions, tees, conduit system shall be adequately protected against rust particularly when such system is exposed to weather. In all cases, no bare threaded portion of conduit pipe shall be allowed unless such bare threaded portion is treated with anti-corrosive preservative or covered with suitable plastic compound.

f) *Fixing of conduit* – Conduit pipes shall be fixed by heavy gauge saddles, secured to suitable wood plugs or other plugs with screws in an approved manner at an interval of not more than 1 m, but on either side of couplers or bends or similar fittings, saddles shall be fixed at a distance of 300 mm from the centre of such fittings. Conduit fittings shall be avoided as far as possible on conduit system exposed to weather; where necessary, solid type fittings shall be used.

g) *Bends in conduit* – All necessary bends in the system including diversion shall be done by bending pipes; or by inserting suitable solid or inspection type normal bends, elbows or similar fittings; or fixing cast iron, thermoplastic or thermosetting plastic material inspection boxes whichever is more suitable. Radius of such bends in conduit pipes shall be not less than 75 mm. No length of conduit shall have more than the equivalent of four quarter bends from outlet to outlet, the bends at the outlets not being counted.

h) *Outlets* – All outlets for fittings, switches, etc, shall be boxes of suitable metal or any other approved outlet boxes for either surface mounting or flush mounting system.

j) *Conductors* – All conductors used in conduit wiring shall preferably be stranded. No single-core cable of nominal cross-sectional area greater than 130 mm^2 enclosed along in a conduit and used for alternating current.

k) *Erection and earthing of conduit* – The conduit of each circuit or section shall be completed before conductors are drawn in. The entire system of conduit after erection shall be tested for mechanical and electrical continuity throughout and permanently connected to earth conforming to the requirements as already specified by means of suitable earthing clamp efficiently fastened to conduit pipe in a workman like manner for a perfect continuity between each wire and conduit. Gas or water pipes shall not be used as earth medium. If conduit pipes are liable to mechanical damage they shall be adequately protected.

m) Inspection type conduit fittings, such as inspection boxes, draw boxes, bends, elbows and tees shall be so installed that they can remain accessible for such purposes as to withdrawal of existing cables or the installing of traditional cables.

6.10.2 *Recessed Conduit Wiring System with Rigid Steel Conduit*

Recessed conduit wiring system shall comply with all the requirements for surface conduit wiring system specified in **6.10.1** (a) to **6.10.1** (k) and in addition, conform to the requirements specified below:

a) *Making of chase* – The chase in the wall shall be neatly made and be of ample dimensions to permit the conduit to be fixed in the manner desired. In the case of buildings under construction, chases shall be provided in the wall, ceiling, etc, at the time of their construction and shall be filled up neatly after erection of conduit and brought to the original finish of the wall. In case of exposed brick/rubble masonry work, special care shall be taken to fix the conduit and accessories in position along with the building work.
b) *Fixing of conduit in chase* – The conduit pipe shall be fixed by means of staples or by means of saddles not more than 600 mm apart. Fixing of standard bends or elbows shall be avoided as far as practicable and all curves maintained by bending the conduit pipe itself with a long radius which will permit easy drawing-in of conductors. All threaded joints of rigid steel conduit shall be treated with preservative compound to secure protection against rust.
c) *Inspection boxes* – Suitable inspection boxes shall be provided to permit periodical inspection and to facilitate removal of wires, if necessary. These shall be mounted flush with the wall. Suitable ventilating holes shall be provided in the inspection box covers. The minimum sizes of inspection boxes shall be 75 mm x 75 mm.
d) *Types of accessories to be used* – All outlet, such as switches and wall sockets, may be either of flush mounting type or of surface mounting type.

    1) *Flush mounting type* – All flush mounting outlets shall be of cast-iron or mild steel boxes with a cover of insulating material or shall be a box made of a suitable insulating material. The switches and other outlets shall be mounted on such boxes. The metal box shall be efficiently earthed with conduit by a suitable means of earth attachment.
    2) *Surface mounting type* – If surface mounting type outlet box is specified, it shall be of any suitable insulating material and outlets mounted in an approved manner.

The switches/socket outlets shall have adequate IP rating for various utilizations.

6.10.3 *Conduit Wiring System with Rigid Non-Metallic Conduits*

Rigid non-metallic conduits are used for concealed conduit wiring.

6.10.3.1 *Type and size*

All non-metallic conduits used shall conform to accepted standards [8-2(38)] and shall be used with the corresponding accessories {see accepted standards [8-2(39)]}. The conduits shall be circular or rectangular cross sections.

6.10.3.2 *Bunching of cables*

Conductors of a.c. supply and d.c. supply shall be bunched in separate conduits. For lighting and small power outlet circuits phase segregation in separate circuits is recommended. The number of insulated cables that may be drawn into the conduits are given in Table 1 B. In Table 1B, the space factor does not exceed 40 percent.

Table 1B Maximum Permissible Number of 250 V Grade Single-Core Cables that may be Drawn into Rigid Non-Metallic Conduits
[*Clauses* 6.7.1(a) *and* 6.10.3.2]

Sl No.	**Sizes of Cable**		**Size of Conduit** mm					
	Nominal Cross-Sectional Area mm^2	Number and Diameter (in mm) of Wires	16	20	25	32	40	50
			Number of Cables, *Max*					
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
i)	1.0	1/1.12[1)]	5	7	13	20	–	–
ii)	1.5	1/1.40	4	6	10	14	–	–
iii)	2.5	(1/1.80) [3/1.06[1)]]	3	5	10	14	–	–
iv)	4	(1/2.24) [7/0.85[1)]]	2	3	6	10	14	–
v)	6	(1/2.80) [7/1.40[1)]]	–	2	5	9	11	–
vi)	10	[1/3.55[2)]] [7/1.40[1)]]	–	–	4	7	9	–
vii)	16	7/1.70	–	–	2	4	5	12
viii)	25	7/2.24	–	–	–	2	2	6
ix)	35	7/2.50	–	–	–	–	2	5
x)	50	7/3.00[2)]	–	–	–	–	2	5
		19/1.80	–	–	–	–	2	3

1) For copper conductors only.
2) For aluminium conductors only.

6.10.3.3 *Conduit Joints*

Conduits shall be joined by means of couplers. Where there are long runs of straight conduit, inspection type couplers shall be provided at intervals. For conduit fittings and accessories reference may be made to the good practice [8-2(39)].

6.10.3.4 *Fixing of conduit in chase*

The conduit pipe shall be fixed by means of stapples or by means of non-metallic saddles placed at not more than 800 mm apart or by any other approved means of fixing. Fixing of standard bends or elbows shall be avoided as far as practicable and all curves shall be maintained by sending the conduit pipe itself with a long radius which will permit easy drawing in of conductors. At either side of bends, saddles/stapples shall be fixed at a distance of 150 mm from the centre of bends.

6.10.3.5 *Inspection boxes*

Suitable inspection boxes to the nearest minimum requirements shall be provided to permit periodical inspection and to facilitate replacement of wires, if necessary. The inspection/junction boxes shall be mounted flush with the wall or ceiling concrete. Where necessary deeper boxes of suitable dimensions shall be used. Suitable ventilating holes shall be provided in the inspection box covers, where required.

6.10.3.6 The outlet boxes such as switch boxes, regulator boxes and their phenolic laminated sheet covers shall be as per requirements of **6.10.1** (h). They shall be mounted flush with the wall.

6.10.3.7 *Types of accessories to be used*

All accessories such as switches, wall sockets, etc, may be either flush mounting type or of surface mounting type.

6.10.3.8 *Bends in conduits*

Wherever necessary, bends or diversions may be achieved by bending the conduits or by employing normal bends, inspection bends, inspection boxes, elbows or similar fittings. Heat may be used to soften the conduit for bending and forming joints in case of plain conduits.

6.10.3.9 *Outlets*

In order to minimize condensation or sweating inside the conduit, all outlets of conduit system shall be properly drained and ventilated, but in such a manner as to prevent the entry of insects.

6.11 Cable Trunking/Cable Ways

Cable trunking and ducting system of insulating material are used for surface wiring. The number of insulated conductors that can be drawn into cable trunking and ducting system are given in Table 2.

Table 2 Maximum Permissible Number of PVC Insulated 650/1 100 V Grade Aluminium/Copper Cable Conforming to Accepted Standard [8-2(3)] that can be Drawn into Cable Trunking/Cable Ways
(*Clause* 6.11)

Sl No.	**Nominal Cross-Sectional Area of Conductor** mm^2	**10/15 mm x 10 mm**	**20/15 mm x 10 mm**	**25/15 mm x 16 mm**	**32 mm x 16 mm**	**40 mm x 25 mm**	**40 mm x 40 mm**
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	1.5	3	5	6	8	12	18
ii)	2.5	2	4	5	6	9	15
iii)	4	2	3	4	5	8	12
iv)	6	-	2	3	4	6	9
v)	10	-	1	2	3	5	8
vi)	16	-	-	1	2	4	6
vii)	25	-	-	-	1	3	5
viii)	35	-	-	-	-	2	4
ix)	50	-	-	-	-	1	3
x)	70	-	-	-	-	1	2

7 FITTINGS AND ACCESSORIES

7.1 Ceiling Roses and Similar Attachments

7.1.1 A ceiling rose or any other similar attachment shall not be used on a circuit the voltage of which normally exceeds 250 V.

7.1.2 Normally, only one flexible cord shall be attached to a ceiling rose. Specially designed ceiling roses shall be used for multiple pendants.

7.1.3 A ceiling rose shall not embody fuse terminal as an integral part of it.

7.2 Socket-Outlets and Plugs

Each 16 A socket-outlet provided in buildings for the use of domestic appliances, such as, air conditioner and water cooler shall be provided with its own individual fuse, with suitable discrimination with back-up fuse or miniature circuit-breaker provided in the distribution/sub-distribution board. The socket-outlet shall not necessarily embody the fuse as an integral part of it.

7.2.1 Each socket-outlet shall also be controlled by a switch which shall preferably be located immediately adjacent thereto or combined therewith.

7.2.2 The switch controlling the socket-outlet shall be on the live side of the line.

7.2.3 Ordinary socket-outlet may be fixed at any convenient place at a height above 200 mm from the floor level and shall be away from danger of mechanical injury.

NOTE — In situations where a socket-outlet is accessible to children, it is necessary to install an interlocked plug and socket or alternatively a socket-outlet which automatically gets screened by the withdrawal of plug. In industrial premises socket-outlet of rating 20 A and above shall preferably be provided with interlocked type switch.

In case of public buildings, to facilitate operation of switches/socket-outlets by persons with disabilities and the elderly, these shall be installed at an accessible height for reaching and operating, between 800 mm and 1 100 mm above floor level and shall be located at a minimum of 600 mm with a preference of minimum 700 mm, from any internal corner (*see also* **B-7** of Part 3 'Development Control Rules and General Building Requirements' of the Code). They shall be so fixed so as to be away from danger of mechanical injury.

NOTE — As an exception, electrical wall socket outlets, telephone points and TV sockets can be located at a minimum height of 400 mm above floor level.

7.2.4 In an earthed system of supply, a socket-outlet with plug shall be of three-pin or five-pin type with the third or fifth terminal connected to the earth. When such socket-outlets with plugs are connected to any current consuming device of metal or any non-insulating material or both, conductors connecting such current-consuming devices shall be of flexible cord with an earthing core and the earthing core shall be secured by connecting between the earth terminal of plug and the body of current-consuming devices.

In industrial premises three-phase and neutral socket-outlets shall be provided with a earth terminal either of pin type or scrapping type in addition to the main pins required for the purpose.

7.2.5 In wiring installations for residential buildings, metal clad switch, socket-outlet and plugs shall be used for power wiring. For industrial and commercial application socket outlets conforming to accepted standards [8-2(25)] with suitable circuit breakers shall be used.

NOTE – A recommended schedule of socket-outlets in a residential building is given below:

Sl No. (1)	*Location* (2)	*Number of 6 A Socket-Outlets* (3)	*Number of 16 A Socket-Outlets* (4)
i)	Bed room	2 to 6	2
ii)	Living room	2 to 4	2
iii)	Kitchen	2 to 8	2
iv)	Dining room	2 to 4	2
v)	Garage	1	1
vi)	For refrigerator	-	1
vii)	For air conditioner	-	1 for each
viii)	Verandah	1 per 10 m^2	1
ix)	Bathroom	1	1

7.3 Lighting Fittings

7.3.1 A switch shall be provided for control of every lighting fitting or a group of lighting fittings. Where control at more than one point is necessary as many two way or intermediate switches may be provided as there are control points. *See also* **7.2.3**.

7.3.2 In industrial premises, lighting fittings shall be supported by suitable pipe/conduits, brackets fabricated from structural steel, steel chains or similar materials depending upon the type and weight of the fittings. Where a lighting fitting is supported by one or more flexible cords, the maximum weight to which the twin flexible cords may be subjected shall be as follows:

Sl No. (1)	*Nominal Cross-Sectional Area of Twin Cord* mm^2 (2)	Maximum Permissible Weight kg (3)
i)	0.5	2
ii)	0.75	3
iii)	1.0	5
iv)	1.5	5.3
v)	2.5	8.8
vi)	4	14.0

7.3.3 No flammable shade shall form a part of lighting fittings unless such shade is well protected against all risks of fire. Celluloid shade or lighting fittings shall not be used under any circumstances.

7.3.4 General and safety requirements for electrical lighting fittings shall be in accordance with good practice [8-2(40)].

7.3.5 The lighting fittings shall conform to accepted standards [8-2(26)].

7.4 Fitting-Wire

The use of fitting-wire shall be restricted to the internal wiring of the lighting fittings. Where fitting-wire is used for wiring fittings, the sub-circuit loads shall terminate in a ceiling rose or box with connectors from which they shall be carried into the fittings.

7.5 Lampholders

Lampholders for use on brackets and the like shall be in accordance with accepted standards [8-2(41)] and all those for use with flexible pendants shall be provided with cord grips. All lampholders shall be provided with shade carriers. Where centre-contact Edison screw lampholders are used, the outer or screw contacts shall be connected to the 'middle wire', the neutral, the earthed conductor of the circuit.

7.6 Outdoor Lamps

External and road lamps shall have weatherproof fittings of approved design so as to effectively prevent the ingress of moisture and dust. Flexible cord and cord grip lampholders shall not be used where exposed to weather. In verandahs and similar exposed situations where pendants are used, these shall be of fixed rod type.

7.7 Lamps

All lamps unless otherwise required and suitably protected, shall be hung at a height of not less than 2.5 m above the floor level. All electric lamps and accessories shall conform to accepted standards [8-2(42)]. Following shall also be ensured:

a) Portable lamps shall be wired with flexible cord. Hand lamps shall be equipped with a handle of moulded composition or other material approved for the purpose. Hand lamps shall be equipped with a substantial guard attached to the lampholder or handle. Metallic guards shall be earthed suitably.
b) A bushing or the equivalent shall be provided where flexible cord enters the base or stem of portable lamp. The bushing shall be of insulating material unless a 102 ewireab type of cord is used.
c) All wiring shall be free from short-circuits and shall be tested for these defects prior to being connected to the circuit.
d) Exposed live parts within porcelain fixtures shall be suitably recessed and so located as to make it improbable that wires will come in contact with them. There shall be a spacing of at least 125 mm between live parts and the mounting plane of the fixture.

7.8 Fans, Regulators and Clamps

7.8.1 *Ceiling Fans*

Ceiling fans including their suspension shall conform to accepted standards [8-2(43)] and to the following requirements:

a) Control of a ceiling fan shall be through its own regulator as well as a switch in series. *See also* **7.2.3**.
b) All ceiling fans shall be wired with normal wiring to ceiling roses or to special connector boxes to which fan rod wires shall be connected and suspended from hooks or shackles with insulators between hooks and suspension rods. There shall be no joint in the suspension rod, but if joints are unavoidable then such joints shall be screwed to special couplers of 50 mm minimum length and both ends of the pipes shall touch together within the couplers, and shall in addition be secured by means of split pins; alternatively, the two pipes may be welded. The suspension rod shall be of adequate strength to withstand the dead and impact forces imposed on it. Suspension rods should preferably be procured along with the fan.
c) Fan clamps shall be of suitable design according to the nature of construction of ceiling on which these clamps are to be fitted. In all cases fan clamps shall be fabricated from new metal of suitable sizes and they shall be as close fitting as possible. Fan clamps for reinforced concrete roofs shall be buried with the casting and due care shall be taken that they shall serve the purpose. Fan clamps for wooden beams, shall be of suitable flat iron fixed on two sides of the beam and according to the size and section of the beam one or two mild steel bolts passing through the beam shall hold both flat irons together. Fan clamps for steel joist shall be fabricated from flat iron to fit rigidly to the bottom flange of the beam. Care shall be taken during fabrication that the metal does not crack while hammer to shape. Other fan clamps shall be made to suit the position, but in all cases care shall be taken to see that they are rigid and safe.

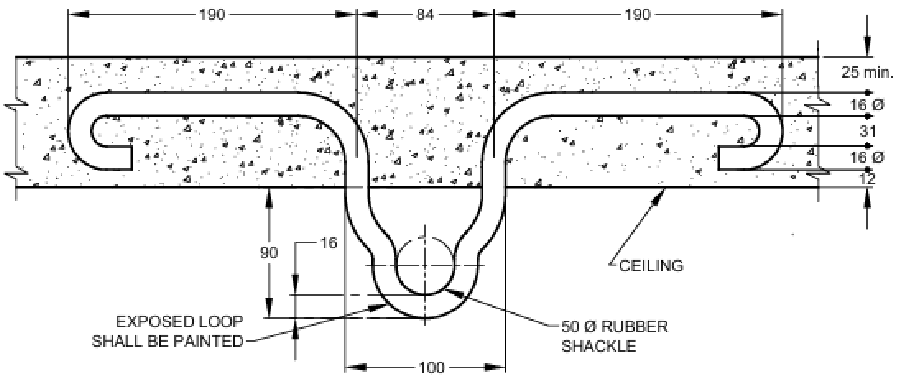
d) Canopies on top and bottom of suspension rods shall effectively conceal suspensions and connections to fan motors, respectively.

e) The lead-in-wire shall be of nominal cross-sectional area not less than 1.5 mm^2 copper and shall be protected from abrasion.

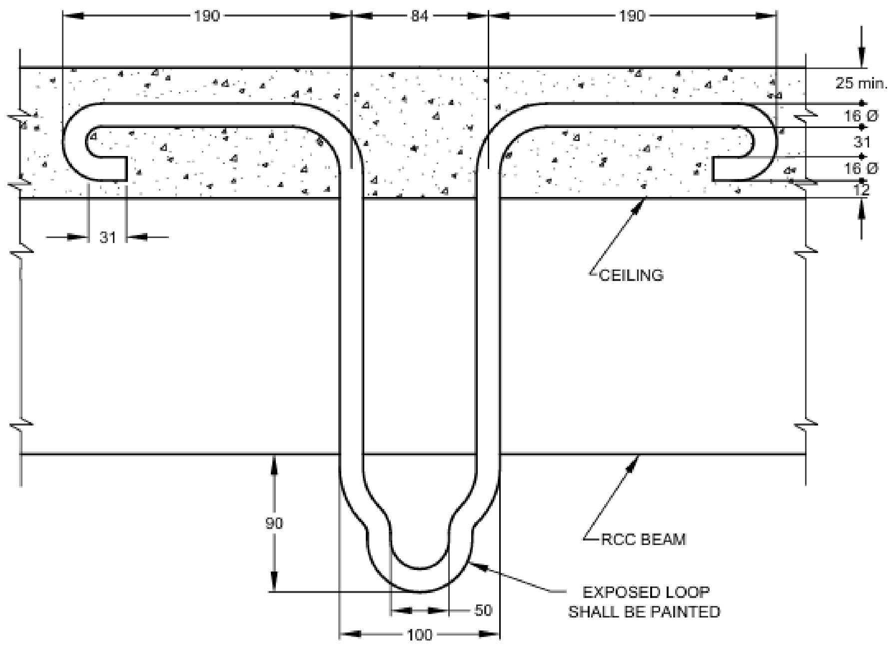
f) Unless otherwise specified, the clearance between the bottom most point of the ceiling fan and the floor shall be not less than 2.4 m. The minimum clearance between the ceiling and the plane of the blades shall be not less than 300 mm.

A typical arrangement of a fan clamp is given in Fig. 4.

NOTE – All fan clamps shall be so fabricated that fans revolve steadily.



2A SLAB



2B SLAB WITH BEAM

All dimensions in millimetres.

NOTES

1 RCC slab steel reinforcement not shown.

2 Fan clamp shall be placed in position such that its projecting arms are in the line of length of beam.

Fig. 4 TYPICAL DESIGN OF FAN CLAMPS

7.8.2 *Exhaust Fans*

For fixing of an 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 nearly plastered with cement and brought to the original finish of the wall. The exhaust fan shall be connected to exhaust fan point which shall be wired as near to the hole as possible by means of a flexible cord, care being taken that the blades rotate in the proper direction.

7.8.3 *Fannage*

7.8.3.1 Where ceiling fans are provided, the bay sizes of a building, which control fan point locations, play an important part. Fans of 1 200/1 400 mm sweep normally cover an area of 9 m^2 to 10 m^2 and therefore in general purpose office buildings, for every part of a bay to be served by the ceiling fans, it is necessary that the bays shall be so designed that full number of fans can be suitably located for the bay, otherwise it will result in ill-ventilated pockets. In general, fans in long halls may be spaced at 3 m in both the directions. If building modules do not lend themselves for proper positioning of the required number of ceiling fans, other fans such as, air circulators or bracket fans will have to be employed for the areas uncovered by the ceiling fans. For this, suitable electrical outlets shall be provided although result will be disproportionate to cost on account of fans.

7.8.3.2 Proper air circulation may be achieved either by larger number of smaller fans or smaller number of larger fans. The economics of the system as a whole should be a guiding factor in choosing the number and type of fans and their locations. For design guidelines in this regard, reference shall be made to Part 8 'Building Services, Section 1 Lighting and Natural Ventilation' of the Code.

7.8.3.3 Exhaust fans are necessary for spaces, such as community toilets, kitchens and canteens, and godowns to provide the required number of air changes (*see* Part 8 'Building Services, Section 3 Air Conditioning, Heating and Mechanical Ventilation' of the Code). Since the exhaust fans are located generally on the outer walls of a room, appropriate openings in such walls shall be provided for, in the planning stage.

NOTE — Exhaust fan requirement is based on the recommended air changes (*see* Part 8 'Building Services, Section 3 Air Conditioning, Heating and Mechanical Ventilation') of the Code. Reference shall also be made to Part 4 'Fire and Life Safety' of the Code for exhaust fan requirements for smoke extraction.

7.9 Attachment of Fittings and Accessories

7.9.1 In wiring other than conduit wiring, all ceiling roses, brackets, pendants and accessories attached to walls or ceilings shall be mounted on substantial teak wood blocks twice varnished after all fixing holes are made in them. Blocks shall not be less than 40 mm deep. Brass screws shall only be used for attaching fittings and accessories to their base blocks.

7.9.2 Where teak or hardwood boards are used for mounting switches, regulators, etc, these boards shall be well varnished with pure shellac on all four sides (both inside and outside), irrespective of being painted to match the surroundings. The size of such boards shall depend on the number of accessories that can be conveniently and neatly be arranged. Where there is danger of attack by white ants, the boards shall be treated with suitable anti-termite compound and painted on both sides.

7.10 Interchangeability

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

7.11 Equipment

Electrical equipment which form integral part of wiring intended for switching or control or protection of wiring installations shall conform to the relevant Indian Standards, wherever they exist.

7.12 Positioning of fans and light fittings shall be chosen to make these effective without causing shadows and stroboscopic effect on the working planes.

8 EARTHING

8.1 General

8.1.1 Earthing is an essential part of any electrical installation, essential for the safety from electrical shock, and fire and for operation of most of the protective systems of the electrical installation. The earthing provides the necessary reference of zero potential and helps in activating the operation of the circuit breaker provided for the safe disconnection of power in the event of an abnormality in the flow of current. Earthing systems, apart from addressing safety from shock and fire, help in limiting the interference between one appliance and the other. This is of particular importance in the case of voice and data communication devices. With the proliferation in electrical/electronic gadgets and greater dependency on voice and data communication systems, proper and effective earthing or grounding is very important. Earthing is also necessary for diverting the effects of lightning strikes from the buildings and its contents, including from sensitive equipment.

8.1.2 Different types of earth electrodes and different types of earthing systems available. For low voltage and medium voltage systems which apply to almost all electrical systems of buildings, the common earthing system followed is with the neutral solidly earthed at the source. This system requires that there is always a protective earth continuity conductor running all through the system and all metal parts of electrical appliances connected to an electrical system are connected to the earth continuity conductor. The exception to this system is the double insulated appliances which are connected to the line and neutral and operate on low voltage (single phase) and are also of low power consumption. All appliances (other than double insulated devices) use the earthing through the earth continuity conductor. Single phase appliances use a 3-wire connection with line (live wire), neutral (return path wire) and the earth-wire at zero potential. Three phase appliances use a connection with 4-wires for a load which does not require a neutral connection or use a 5-wire connection if the appliance requires a neutral connection. Care should be taken to ensure that the earthing system, the earth continuity conductor and in case of sockets plugs the earthing pin are not disconnected.

8.1.3 Different earthing systems have features which are suitable for different applications. Earthing system adopted should be so selected so as to match with the type of load, protection device, application, degree of reliability, etc. For classification of electrical systems based on the relationship of the source, and of exposed-conductive parts of the installation, to earth, *see* **2.1.75**.

8.2 Selection and Design of Earthing System

8.2.1 Earthing shall generally be carried out in accordance with the requirements of Regulation 18, 43 and 50 of *Central Electricity Authority (Measures relating to Safety and Electricity Supply) Regulations*, 2023 as amended from time-to-time (*see* Annex B) and good practice [8-2(44)] and the relevant regulations of the Electricity Supply Authority concerned.

8.2.2 Conductors and earth electrodes in an earthing system shall be so designed and constructed that in normal use their performance is reliable and without danger to persons and surrounding equipment. Earthing system shall be designed such as to have touch potential and step potential as specified in good practice [8-2(44)]. The choice of a material depends on its ability to match the particular application requirement. The requirements for earthing arrangements are intended to provide a connection to earth which,

a) is reliable and suitable for the protective requirements of the installation;
b) can carry earth fault currents and protective conductor currents to earth without danger from thermal, thermo-mechanical and electromechanical stresses and from electric shock arising from these currents;
c) if relevant, is also suitable for functional requirements; and
d) is suitable for the foreseeable external influences {*see* good practice [8-2(44)] and IEC 60364-5-51:2005 'Electrical installations of buildings – Part 5-51: Selection and erection of electrical equipment – Common rules'}, for example, mechanical stresses and corrosion.

8.2.3 The main earthing system of an electrical installation shall consist of,

a) an earth electrode, (electrode can be one vertical rod/pipe/buried plate or an earth mat with several vertical installations or a ring earthing with vertical installations.
b) a main earthing wire;
c) an earth bar (located on the main switchboard for small installation and installed in the wall/room in case of large industrial electronic installations) for

the connection of the main earthing wire, protective earthing wires and/or bonding wires within the installation; and

d) a removable link, which effectively disconnects the neutral bar from the earth bar.

NOTE — The requirements of (c) and (d) above shall be carried out by a licensed electrician as part of the switchboard installation.

8.2.4 The main earthing wire connection shall,

a) be mechanically and electrically sound;
b) be protected against damage, corrosion, and vibration;
c) not place any strain on various parts of the connection;
d) not damage the wire or fittings; and
e) be secured at the earth electrode.

8.2.4.1 The main earthing wire termination shall be readily accessible at the earth electrode except for **8.2.20**. As far as possible, all earth connections, except exothermically welded, shall be visible for inspection.

8.2.5 Consideration shall be given to the earthing arrangements where currents with high frequencies are expected to flow (*see* IEC 60364-4-44:2024 'Low-voltage electrical installations - Part 4-44: Protection for safety - Protection against voltage disturbances and electromagnetic disturbances').

8.2.6 Protection against electric shock (*see* IEC 60364-4-41:2005 'Low voltage electrical installations - Part 4-41: Protection for safety - Protection against electric shock'), shall not be adversely affected by any foreseeable change of the earth electrode resistance (for example, due to corrosion, drying or freezing).

8.2.7 Where the supply to an installation is at high or extra high voltage, requirements concerning the earthing arrangements of the high or extra high voltage supply and of the low-voltage installation shall also comply with IEC 60364-4-44:2024 'Low-voltage electrical installations - Part 4-44: Protection for safety - Protection against voltage disturbances and electromagnetic disturbances'.

8.2.8 A permanent fitting (like a screwed-down plastic label or copper label, or one that can be threaded onto the cable) shall be used at the connection point that is clearly marked with the words: 'EARTHING LEAD – DO NOT DISCONNECT' or 'EARTHING CONDUCTOR – DO NOT DISCONNECT'.

8.2.9 All medium voltage equipment shall be earthed by two separate and distinct connections with earth. The contact area of earth conductor/plate shall be determined in accordance with good practice [8-2(44)].

8.2.9.1 The 415/240 V, 4-wire, 3-phase systems are normally operated with the neutral solidly earthed at source. At medium voltage, Central Electricity Authority regulations require that the neutral be earthed by two separate and distinct connections with earth. Source in the case of a substation (such as 11 kV/400 V) will be the neutral(s) of the transformer(s). Neutral conductor shall be of the same size as the phase conductor.

NOTE — Neutral conductor of half the size of the phase conductor was permitted in earlier installations. But with the proliferation of equipment using non-linear devices and consequent increase in harmonics, the neutral will carry a current more than the notional out-of-balance current and therefore neutral conductor shall be of the same size as the phase conductor.

8.2.10 In the case of high and extra high voltages, the neutral points shall be earthed by not less than two separate and distinct connections to 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. The neutral may be earthed through suitable impedance. Neutral earthing conductor shall be sized as to have a current carrying capacity not less than the phase current.

8.2.11 For industrial/commercial installations having a transformer with in the facility, soil resistivity of the place of installation shall be measured as per good practice [8-2(44)] and recorded. For the adopted type of earth electrode configuration, earth resistance of each electrode configuration shall be calculated and recorded based on good practice [8-2(44)].

8.2.12 It is recommended that a drawing showing the main earth connection and earth electrodes be prepared for each installation.

8.2.14 Earth system shall be so devised that the testing of individual earth electrode is possible {except for installations according to **5.3.6** of [8-2(45)]}. It is recommended that the value of any earth system resistance shall be such as to conform to the degree of shock protection desired. For measuring purposes, the joint shall be capable of being opened with the aid of a tool. In normal use it shall remain closed.

8.2.17 All materials, fittings, etc, used in earthing shall conform to relevant Indian Standard specification, wherever these exist.

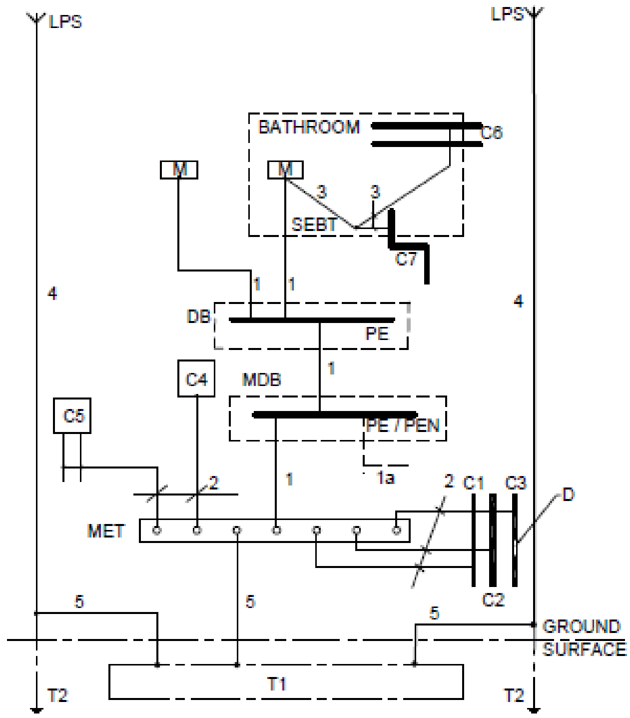
8.2.18 Earthing associated with current-carrying conductor is normally essential for the function of the system and is generally known as system earthing or functional earthing, while earthing of non-current carrying metal work and conductor is essential for the safety of human life, of animals and of property and it is generally known as equipment earthing or protective earthing. The requirements for protective purposes shall always take precedence.

8.2.19 For selection of electrodes for use in corrosive environments, reference shall be made to good practice [8-2(44)].

8.2.20 Test joints are not required in the case of natural down-conductors combined with foundation earth electrodes (*see* Fig. 5).

8.2.21 For computer and other sensitive electronic equipment system in industrial and commercial application, special bonding techniques with isolation transformer should be employed (*see* Fig. 6).

8.2.22 Isolated earthing is unsafe during a transient condition. In unavoidable conditions if isolated earthing is used, to reduce potential difference between isolated earthing, earth couplers or isolating spark gaps shall be installed. This will reduce potential difference during a transient condition such as lightning.

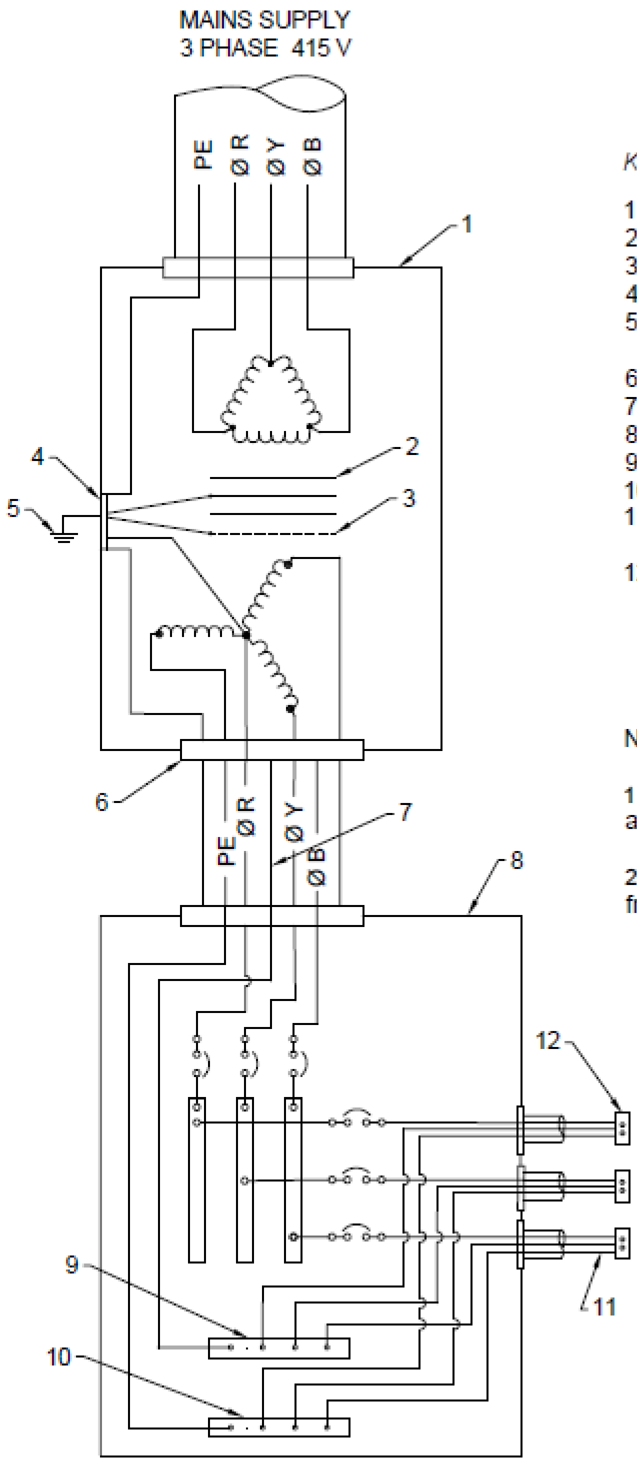


NOTES

1 Functional earthing conductors are not shown in figure.
2 Where a lightning protection system is installed, the additional requirements are given in 11.

Key	
C	Extraneous-conductive-part
C1	Water pipe, metal from outside
C2	Waste water pipe, metal from outside
C3	Gas pipe with insulating insert, metal from outside
C4	Air conditioning
C5	Heating system
C6	Water pipe, metal for example in a bathroom
C7	Waste water pipe, metal for example in a bathroom
D	Insulating insert
MDB	Main distribution board
DB	Distribution board
MET	Main earthing terminal
SEBT	Supplementary equipotential bonding terminal
T1	Concrete-embedded foundation earth electrode or soil-embedded foundation earth electrode
T2	Earth electrode for LPS, if necessary
LPS	Lightning protection system (if any)
PE	PE terminal(s) in the distribution board
PE/PEN	PE/PEN terminal(s) in the main distribution board
M	Exposed-conductive-part
1	Protective earthing conductor (PE)
1A	Protective conductor, or PEN conductor, if any, from supplying network
2	Protective bonding conductor for connection to the main earthing terminal
3	Protective bonding conductor for supplementary bonding
4	Down conductor of a lightning protection system (LPS), if any
5	Earthing conductor

FIG. 5 EXAMPLE OF AN EARTHING ARRANGEMENT FOR FOUNDATION EARTH ELECTRODE, PROTECTIVE CONDUCTORS AND PROTECTIVE BONDING CONDUCTORS



Key

1 Isolation transformer
2 Core
3 Shield
4 All earthing connections made at a point
5 Connection to building steel/earth Pits/ring earthing
6 Conduit earthing
7 Neutral
8 240/415 Volt power panel
9 Neutral bus[1)]
10 Earth bus[1)]
11 Earth connection for socket/work station/computers
12 3-pin sockets with isolated earth pin

[1)] Both busbars isolated from panel enclosure. No bonding connection between neutral and earth.

NOTES

1 Each branch circuit shall have a separate neutral and earth wire. No daisy chaining permitted.

2 Only computer or control system should be served from this panel.

FIG. 6 RECOMMENDED POWER DISTRIBUTION FOR A COMPUTER AND CONTROL SYSTEM WITH A DELTA/STAR ISOLATION TRANSFORMER

8.3 Earth Electrodes

The efficacy of any earth electrode depends on its configuration and upon local soil conditions. Number of earth electrodes suitable for the soil conditions and the value of resistance to earth required shall be considered. Examples of earth electrodes which may be used are,

a) concrete-embedded foundation earth electrode;
b) soil-embedded foundation earth electrode;
c) metallic electrode embedded directly in soil vertically or horizontally (for example rods, wires, tapes, pipes or plates);
d) metal sheath and other metal coverings of cables according to local conditions or requirements;
e) other suitable underground metalwork (for example, pipes) according to local conditions or requirements; and
f) welded metal reinforcement of concrete (except pre-stressed concrete) embedded in the earth.

The type, materials and dimensions of earth electrodes shall be selected to withstand corrosion and to have adequate mechanical strength for the intended lifetime. For materials commonly used for earth electrodes, the minimum sizes, from the point of view of corrosion and mechanical strength, when embedded in the soil or in concrete, shall be as specified in Table 3. If a lightning protection system is required, **11.5.3** applies {*see* **5.4** of good practice [8-2(45)]}.

NOTES

1 For corrosion, the parameters to be considered are: the soil pH at the site, soil resistivity, soil moisture, stray and leakage a.c. and d.c. current, chemical contamination, and proximity of dissimilar materials.

2 The minimum thickness of protective coating is greater for vertical earth electrodes than for horizontal earth electrodes because of their greater exposure to mechanical stresses while being embedded.

Table 3 Minimum Size of Commonly Used Earth Electrodes, Embedded in Soil or Concrete Used to Prevent Corrosion and Provide Mechanical Strength[1)]
(*Clause* 8.3)

Sl No.	Material and Surface	Shape	Diameter	Cross-Sectional Area	Thickness	Weight of Coating	Thickness of Coating/ Sheathing
			mm	mm^2	mm	g/m^2	μm
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	Steel embedded in concrete (bare, hot galvanized or stainless)	Round wire	10	–	–	–	–
		Solid tape or strip	–	75	3	–	–
ii)	Steel hot-dip galvanized[2)]	Strip[3)] or shaped strip/plate – solid plate – lattice plate	–	90	3	500	63
		Round rod installed vertically	16	–	–	350	45
		Round wire installed horizontally	10	–	–	350	45
		Pipe	25	–	2	350	45

Sl No.	Material and Surface	Shape	Diameter	Cross-Sectional Area	Thickness	Weight of Coating	Thickness of Coating/ Sheathing
			mm	mm^2	mm	g/m^2	µm
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
		Stranded (embedded in concrete)	–	70	–	–	–
		Cross profile installed vertically	–	(290)	3	–	–
iii)	Steel copper sheathed	Round rod installed vertically	(15)	–	–	–	2 000
iv)	Steel with electro-deposited copper coating	Round rod installed vertically	14	–	–	–	250[6)]
		Round wire installed horizontally	(8)	–	–	–	70
		Strip installed horizontally	–	90	3	–	70
v)	Stainless steel [4)]	Strip[3)] or shaped strip/plate	–	90	3	–	–
		Round rod installed vertically	16	–	–	–	–
		Round wire installed horizontally	10	–	–	–	–
		Pipe	25	–	2	–	–
vi)	Copper	Strip		50	2	–	–
		Round wire installed horizontally	–	(25)[5)] 50	–	–	–
		Round rod installed vertically	(12) 15	–	–	–	–
		Stranded wire	1.7 for individual strands of wire	(25)[5)] 50	–	–	–
		Pipe[6)]	20	–	2	–	–
		Solid plate	–	–	(1.5) 2	–	–
		Lattice plate	–	–	2	–	–

1) *See* IEC 60364-5-54:2011 'Low-voltage electrical installations – Part 5-54: Selection and erection of electrical equipment – Earthing arrangements and protective conductors'.
2) The coating shall be smooth, continuous and free from flux stains.
3) As rolled strip or slit strip with round edges.
4) Chromium ≥ 16 percent, Nickel ≥ 5 percent, Molybdenum ≥ 2 percent, carbon ≤ 0.08 percent.
5) Where experience shows that the risk of corrosion and mechanical damage is extremely low, 16 mm^2 can be used.
6) This thickness is provided to withstand mechanical damage of copper coating during the installation process. It may be reduced to not less than 100 µm where special precautions to avoid mechanical damage of copper during the installation process (for example, drilling holes or special protective tips) are taken according to the manufacturer's instruction.

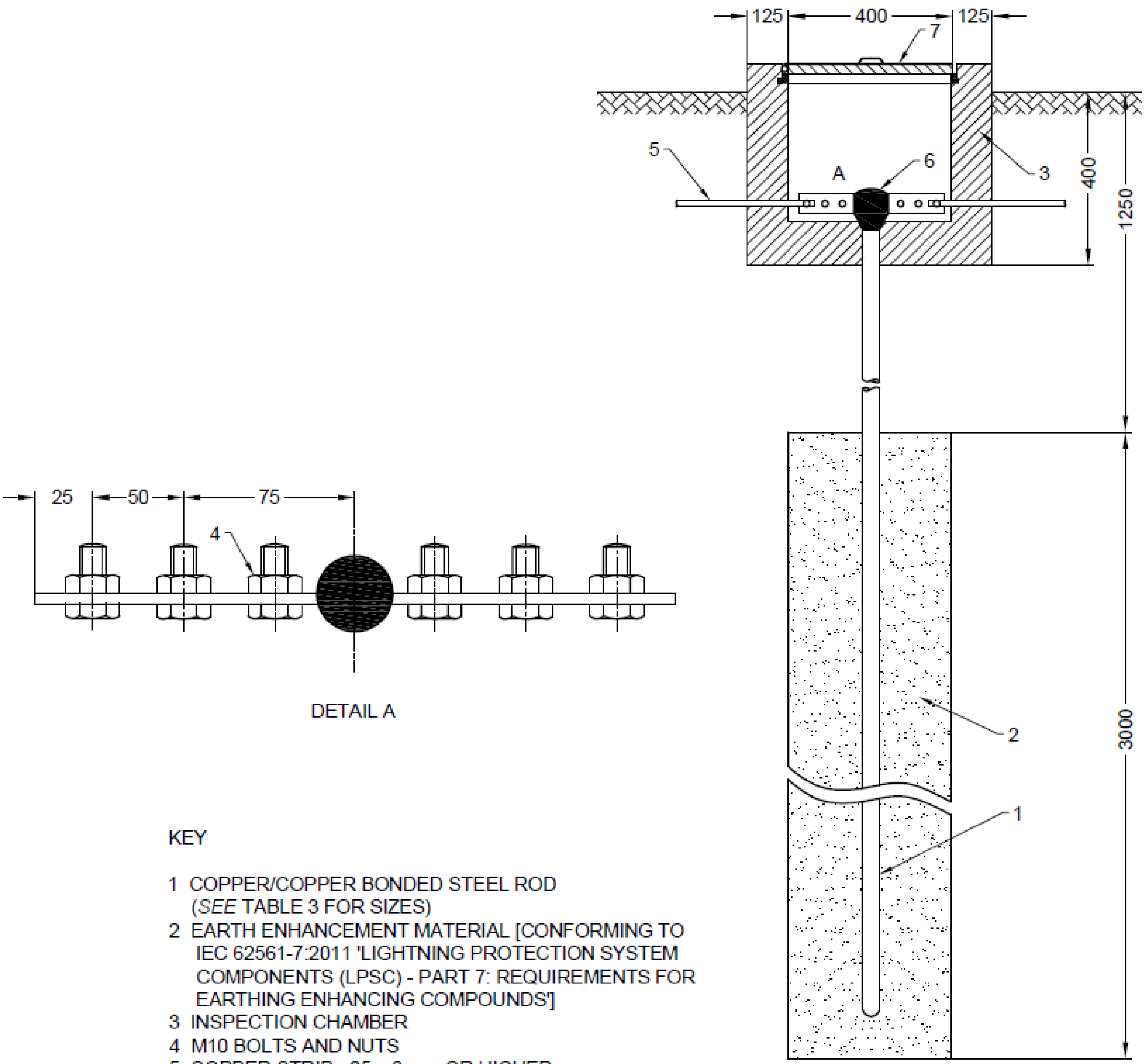
Sl No.	Material and Surface	Shape	Diameter	Cross-Sectional Area	Thickness	Weight of Coating	Thickness of Coating/ Sheathing
			mm	mm^2	mm	g/m^2	µm
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)

NOTES

1 Values in bracket are applicable for protection against electric shock only, while values not in brackets are applicable for lightning protection and for protection against electric shock.
2 Metals inserted inside pipe will not influence in the final earth resistance value.
3 Unprotected ferrous materials are not recommended due to high corrosion (*see* IEC 60364-4-43:2023 'Low-voltage electrical installations - Part 4-43: Protection for safety - Protection against overcurrent').

Earth electrode either in the form of solid rod, pipe, plate or earth grid should be provided at all premises for providing an earth system. Details of typical pipe, rod and plate earth electrodes are given in Fig. 7 and Fig. 8. Other electrode configurations can be as in Fig. 9 {*see also* **9.2** of good practice [8-2(44)]}.

Although electrode material does not affect initial earth resistance, care should be taken to select a material which is resistant to corrosion in the type of soil in which it is used. In case where soil condition leads to excessive corrosion of the electrode, and the connections, it is recommended to use either copper/ stainless steel or copper coated steel electrode and copper/stainless steel connections. Exothermic welding may also be adopted to have enhanced life and strength to the connection (*see* Fig. 7B and Fig. 8B). It is recommended to use similar material for earth electrodes and earth conductors or otherwise precautions should be taken to avoid corrosion.



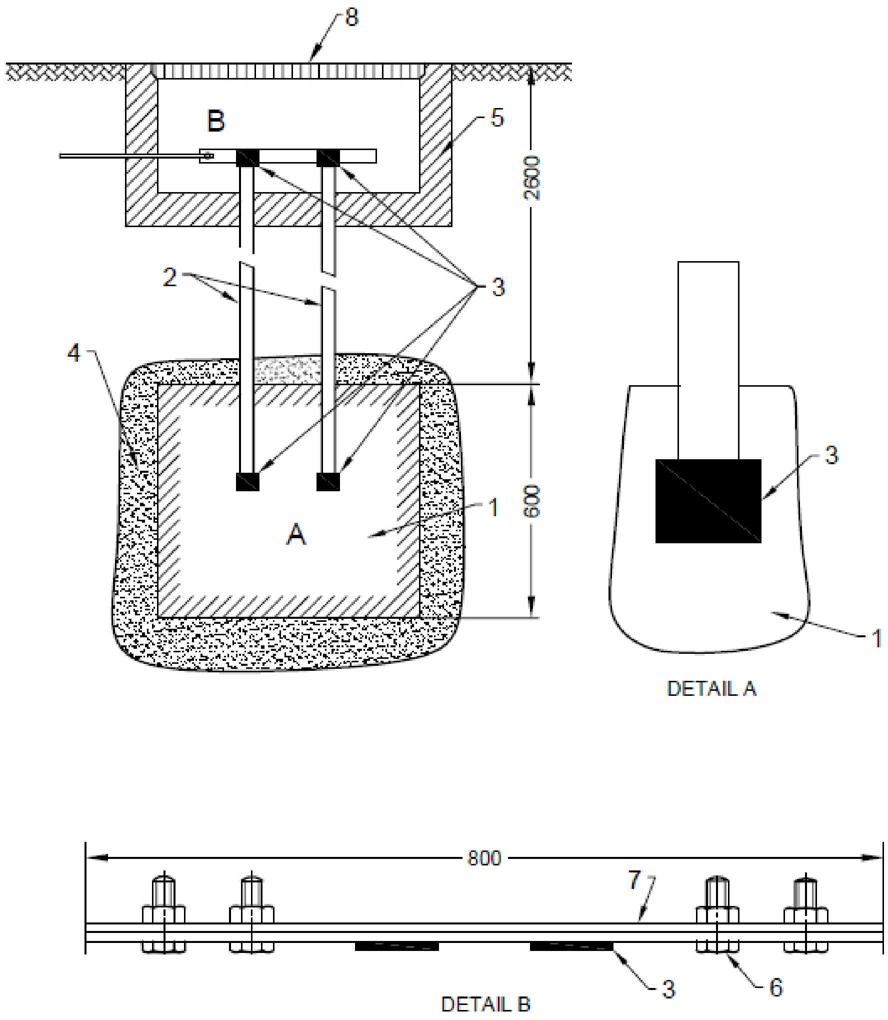
KEY

1 COPPER/COPPER BONDED STEEL ROD
(*SEE* TABLE 3 FOR SIZES)
2 EARTH ENHANCEMENT MATERIAL [CONFORMING TO IEC 62561-7:2011 'LIGHTNING PROTECTION SYSTEM COMPONENTS (LPSC) - PART 7: REQUIREMENTS FOR EARTHING ENHANCING COMPOUNDS']
3 INSPECTION CHAMBER
4 M10 BOLTS AND NUTS
5 COPPER STRIP - 25 x 6 mm OR HIGHER
6 EXOTHERMIC WELDING
7 CI LID/COVER

All dimensions are in mm

NOTE — Inspection housing can also be of FRP materials with CI cover tested according to accepted standard [8-2(54)].

FIG. 7 TYPICAL ARRANGEMENT OF EARTHING WITH COPPER/COPPER BONDED ELECTRODE WITH EXOTHERMIC WELDING (MAINTENANCE FREE ARRANGEMENT)



KEY

1 600 x 600 x 3 mm COPPER PLATE
2 30 x 6 mm COPPER STRIP
3 EXOTHERMIC WELDING
4 EARTH ENHANCEMENT MATERIAL [CONFORMING TO IEC 62561-7:2011 'LIGHTNING PROTECTION SYSTEM COMPONENTS (LPSC) - PART 7: REQUIREMENTS FOR EARTHING ENHANCING COMPOUNDS']
5 INSPECTION CHAMBER
6 M12 x 40 STAINLESS STEEL BOLTS AND NUTS
7 50 x 6 mm COPPER STRIP
8 CI LID/COVER

All Dimensions are in mm

NOTE — Inspection housing can also be of FRP materials with CI cover tested according to [8-2(54)].

FIG. 8 TYPICAL ARRANGEMENT OF COPPER ELECTRODE PLATE EARTHING WITH EXOTHERMIC WELDING (MAINTENANCE FREE ARRANGEMENT)

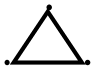
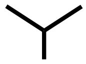
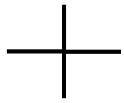
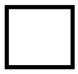
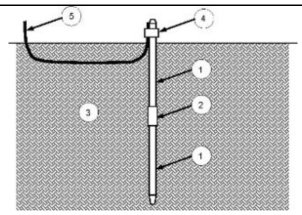
	Three rods at the vertices of an equilateral triangle		Three strips set at 120º meeting at the star point all of equal length
	Two strips set at right angles to each other meeting at one corner		Four strips set in a cruciform
	Vertical electrodes interconnected as a square		Vertical rod 1 extensible earth rod 2 rod coupling 3 soil 4 conductor to rod clamp 5 earthing conductor

Fig. 9 Miscellaneous Electrode Configurations

8.4 Earth Enhancing Compound

Multiple rods, even in large numbers, may sometime fail to produce an adequately low resistance to earth. This condition arises in installations involving soils of high resistivity. The alternative is to reduce the resistivity of the soil immediately surrounding the earth electrode. To reduce the soil resistivity, artificial soil treatment shall be adopted.

8.4.1 Earthing enhancing compound is a conductive compound producing low resistance of an earth-termination system. These compounds used for artificial treatment of soil {*see* good practice [8-2 (44)]} shall satisfy the requirements as per good practice [8-2(55)].

8.4.2 The material of the earthing enhancing compound shall be chemically inert to subsoil. It shall not pollute the environment. It shall provide a stable environment in terms of physical and chemical properties and exhibit low resistivity. The earthing enhancing compound shall not be corrosive to the earth electrodes being used.

8.4.3 The materials used for artificial treatment should also fulfil toxicity characteristic leaching procedure (TCLP) requirements.

8.4.4 Use of salt [sodium chloride (NaCl)] for artificial treatment of soil should be avoided as it accelerates corrosion of ferrous materials.

8.5 Earth Electrode Inspection Housings and Earth Electrode Seals

8.5.1 *Earth Electrode Inspection Housing*

Earth electrode inspection housing is the metallic or non-metallic enclosure that houses the down-conductor/earth-termination connection for inspection and testing purposes and consists of a housing and a removable lid. The design of the earth electrode inspection housing shall be such that it carries out its function of enclosing the down-conductor/earth rod termination in an acceptable and safe manner, and has sufficient internal dimensions to permit the assembly/disassembly of the earth rod clamp. The material of the earth electrode inspection housing shall be compatible with its surrounding environment and shall comply with the tests given in accepted standard [8-2(54)].

8.5.2 *Earth Electrode Seal*

Water pressure seal used in conjunction with an earth rod electrode that passes through the foundation of the building. The design of the earth electrode seal shall be such that it carries out its function of preventing ground water bypassing the earth rod and entering the basement of a building, in an acceptable and safe manner and shall be compatible with its surrounding environment and comply with the tests given in accepted standard [8-2(54)].

8.6 Bonding and Inter connection

All connections made in an earthing system above or below ground should meet electrical conductivity, corrosion resistance, current carrying capacity, and mechanical strength of the conductor. These connections should be strong enough to maintain a temperature rise below that of the conductor and to withstand the effect of heating and the mechanical forces caused by fault currents. Consideration shall be given to electrolytic corrosion when using different materials in an earthing arrangement. The complete connections shall be able to resist corrosion for the intended life of the installation

8.6.1 For external conductors (for example earthing conductor) connected to a concrete-embedded foundation earth electrode, the connection made from hot-dip galvanized steel shall not be embedded in the soil

8.6.2 Where an earth electrode consists of parts that must be connected together, the connection shall be by exothermic welding, pressure connectors, clamps or other suitable mechanical connectors.

8.6.3 All connection components shall meet the requirements according to accepted standard [8-2(56)].

8.7 Equipment and Portions of Installations which shall be Earthed

8.7.1 *Equipment to be Earthed*

Except for equipment provided with double insulation, all the non-current carrying metal parts of electrical installations are to be earthed properly. All metal conduits, trunking, cable sheaths, switchgear, distribution fuse boards, lighting fittings and all other parts made of metal shall be bonded together and connected by means of two separate and distinct conductors to an efficient earth electrode.

8.7.2 *Structural Metal Work*

Earthing of metallic parts of the structure shall be done according to good practices [8-2(44)] and [8-2(45)].

8.8 Neutral Earthing

To comply with relevant Central Electricity Authority regulations, no fuses or circuit breakers other than a linked circuit breaker shall inserted in an earthed neutral conductor, a linked switch or linked circuit breaker shall be arranged to break or the neutral either with or after breaking all the related phase conductors and. Shall positively make (or close) the neutral before making (or closing) the phases.

If this neutral point of the supply system is connected permanently to earth, then the above rule applies throughout the installation including 2-wire final circuits. This means that no fuses may be inserted in the neutral or common return wire. And the neutral should consist of a bolted solid link, or part of a linked switch, which completely disconnects the whole system from the supply. This linked switch shall be so arranged that the neutral makes before, and break after the phases.

8.9 System of Earthing

Equipment and portions of installations shall be deemed to be earthed only if earthed in accordance with either the direct earthing system, the multiple earthed neutral system or the earth leakage circuit-breaker system. In all cases, the relevant provisions of Central Electricity Authority regulation shall be complied with.

8.10 The earthing of electrical installations for non-industrial and industrial buildings shall be done in accordance with good practice [8-2(44)].

9 INSPECTION, TESTING AND VERIFICATION OF INSTALLATION

9.1 General Requirements

9.1.1 Before the completed installation, or an addition to the existing installation, is put into service, inspection and testing shall be carried out in accordance with the *Central Electricity Authority (Measures Relating to Safety and Electric Supply) Regulations,* 2023, as amended from time-to-time. In this connection, Regulation 4, 5, 6, 10, 32, 33, 34, 42 and 48 of the CEA regulation shall be complied with (*see* Annex B). In the event of defects being found, these shall be rectified, as soon as practicable and the installation retested.

9.1.2 Periodic inspection and testing shall be carried out in order to maintain the installation in a sound condition after putting into service.

9.1.3 Where an addition is to be made to the fixed wiring of an existing installation, the latter shall be examined for compliance with the recommendations of the Code.

9.1.4 The individual equipment and materials which form part of the installation shall generally conform to the relevant Indian Standard specification, wherever applicable.

If there is no relevant Indian Standard specification for any item, these shall be approved by the appropriate authority.

9.1.5 *Completion Drawings*

On completion of the electric work, a wiring diagram shall be prepared and submitted to the Engineer-in-Charge or the owner. All wiring diagrams shall indicate clearly, the main switch board, the runs of various mains and submains and the position of all points and their controls. All circuits shall be clearly indicated and numbered in the wiring diagram and all points shall be given the same number as the circuit in which they are electrically connected. Also the location and number of earth points and the run of each loads should be clearly shown in the completion drawings.

9.2 Inspection of the Installation

9.2.1 *General*

On completion of wiring a general inspection shall be carried out by competent personnel in order to verify that the provisions of this Code and that of *Central Electricity Authority (Measures Relating to Safety and Electric Supply) Regulations*, 2023, have been complied with. This, among other things, shall include checking whether all equipment, fittings, accessories, wires/cables, used in the installation are of adequate rating and quality to meet the requirement of the load. General workmanship of the electrical wiring with regard to the layout and finish shall be examined for neatness that would facilitate easy identification of circuits of the system, adequacy of clearances, soundness, contact pressure and contact area. A complete check shall also be made of all the protective devices, with respect to their ratings, range of settings and co-ordination between the various protective devices.

9.2.2 *Item to be Inspected*

All equipment in a substation including HV panel, transformer, LV panel, emergency DG sets, battery bank, cables, cable terminations, etc, need inspection. Healthiness of the main distribution boards, metering panels, distribution cables, rising mains, bus ducts, etc, need to be verified along with earthing system.

9.2.2.1 *Substation installations*

In substation installation, it shall be checked whether,

1) the installation has been carried out in accordance with the approved drawings;
2) phase to phase and phase to earth clearances are provided as required;
3) all equipment are efficiently earthed and properly connected to the required number of earth electrodes;
4) HV and MV/LV switchgears are all vermin and damp-proof and all unused openings or holes are blocked properly;
5) the required ground clearance to live-terminals is provided;
6) suitable fencing is provided with gate with lockable arrangements;
7) there is no vegetation in outdoor substation;

8) the required number of caution boards, fire-fighting equipment, operating rods, rubber mats, etc, are kept in the substation;
9) in case of indoor substation sufficient ventilation and draining arrangements are made;
10) all cable trenches are provided with non-inflammable covers;
11) free accessibility is provided for all equipment for normal operation;
12) all name plates are fixed and the equipment are fully painted;
13) all construction materials and temporary connections are removed;
14) oil-level, bus bar tightness, transformer tap position, etc, are in order;
15) earth pipe troughs and cover slabs are provided for earth electrodes/earth pits and the neutral and lightning arrestor earth pits are marked for easy identification;
16) earth electrodes are of GI pipes or CI pipes or copper plates or Cu bonded rods as per Table 3. For earth connections, brass bolts and nuts with lead washers are provided in the pipes/plates;
17) earth pipe troughs and oil sumps/pits are free from rubbish and dirt and stone jelly and the earth connections are visible and easily accessible;
18) earthing system designed are periodically checked for permissible limits of step and touch potential.
19) the earth bus bars have tight connections and corrosion-free joint surfaces;
20) operating handle of protective device are provided at an accessible height from ground, that is, 300 mm to 1 800 mm;
21) adequate headroom is available in the transformer room for easy topping-up of oil, maintenance, etc;
22) safety devices, horizontal and vertical barriers, bus bar covers/shrouds, automatic safety shutters/doors interlock, handle interlock are safe and in reliable operation in all panels and cubicles;
23) clearances in the front, rear and sides of the main HV and MV and sub-switch boards are adequate;
24) the switches operate freely; the 3 blades make contact at the same time, the arcing horns contact in advance; and the handles are provided with locking arrangements;
25) insulators are free from cracks, and are clean;
26) in transformers, there is any oil leak;
27) connections to bushing in transformers for tightness and good contact;
28) bushings are free from cracks and are clean;
29) accessories of transformers like breathers, vent pipe, buchholz relay, etc, are in order;
30) connections to gas relay in transformers are in order;
31) oil and winding temperature are set for specific requirements in transformers;
32) in case of cable cellars, adequate arrangements to pump out water that has entered due to seepage or other reasons;
33) all incoming and outgoing circuits of HV and MV panels are clearly and indelibly labelled for identifications;
34) no cable is damaged;
35) there is adequate clearance around the equipment installed; and
36) cable terminations are proper.

9.2.2.2 *Medium/low voltage installation*

In medium and low voltage installations, it shall be checked whether,

a) all blocking materials that are used for safe transportation in switchgears, contactors, relays, etc, are removed;
b) all connections to the earthing system are feasible for periodical inspection;
c) sharp cable bends are avoided and cables are taken in a smooth manner in the trenches or alongside the walls and ceilings using suitable support clamps at regular intervals;
d) suitable circuit breaker or lockable push button is provided near the motors/apparatus for controlling supply to the motor/apparatus in an easily accessible location;
e) two separate and distinct earth connections are provided for the motor/apparatus;
f) control switch-fuse is provided at an accessible height from ground for controlling supply to overhead travelling crane, hoists, overhead bus bar trunking;
g) the metal rails on which the crane travels are electrically continuous and earthed and bonding of rails and earthing at both ends are done;
h) four core cables are used for overhead travelling crane and portable equipment, the fourth core being used for earthing, and separate supply for lighting circuit is taken;
j) if flexible metallic hose is used for wiring to motors and other equipment, the wiring is enclosed to the full lengths, and the hose secured properly by approved means;
k) the cables are not taken through areas where they are likely to be damaged or chemically affected;
m) the screens and armours of the cables are earthed properly;
n) the belts of the belt driven equipment are properly guarded;
p) adequate precautions are taken to ensure that no live parts are so exposed as to cause danger;
q) ammeters and voltmeters are tested;
r) the relays are inspected visually by moving covers for deposits of dusts or other foreign matter;
s) wherever bus ducts/rising mains/overhead bus trucking are used, special care being taken for earthing the system. All tap off points are provided with adequately rated protective device like MCB, MCCB, fuses, RCCB/RCD, SPD (*see* 11), etc;
t) all equipment are weather, dust and vermin proof; and
u) any and all equipment having air insulation as media maintain proper distances between phases; phase to neutral; phase to earth and earth to neutral.

9.2.2.3 *Overhead lines*

For overhead lines, it shall be checked whether,

a) all conductors and apparatus including live parts thereof are inaccessible;
b) the types and size of supports are suitable for the overhead lines/conductors used and are in accordance with approved drawing and standards;
c) clearances from ground level to the lowest conductor of overhead lines, sag conditions, etc, are in accordance with **4.7**;

d) where overhead lines cross the roads or cross each other or are in proximity with one another, suitable guarding is provided at road crossings and also to protect against possibility of the lines coming in contact with one another;
e) every guard wire is properly earthed;
f) the type, size and suitability of the guarding arrangement provided is adequate;
g) stays are provided suitably on the overhead lines as required and are efficiently earthed or provided with suitably stay insulators of suitable voltages;
h) anti-climbing devices and danger board/caution board, notices are provided on all HV supports;
j) clearances along the route are checked and all obstructions, such as, trees/branches and shrubs are cleared on the route to the required distance on either side;
k) clearance between the live conductor and the earthed metal parts are adequate;
m) for the service connections tapped-off from the overhead lines, cut-outs of adequate capacity are provided;
n) all insulators are properly and securely mounted; also they are not damaged.
p) all poles are properly grouted/insulated so as to avoid bending of pole towards tension; and
q) steel poles, if used is properly earthed.

9.2.2.4 *Lighting and convenience power circuits*

For the lighting and convenience power circuits, it shall be checked whether,

a) wooden boxes and panels are avoided in factories for mounting the lighting boards and switch controls, etc;
b) neutral links are provided in double pole switch-fuses which are used for lighting control, and no protective device (such as MCB, MCCB, fuses, RCCB/RCD, etc) is provided in the neutral;
c) the plug points (6 A) in the lighting circuit are all of 3/5-pin type, the third pin being suitably earthed;
d) the plug points (16 A) in the lighting circuit are all of 3/6-pin type, the third pin being suitably earthed;
e) tamper-proof interlocked switch socket and plug are used for locations easily accessible;
f) lighting wiring in factory area is taken enclosed in conduit and conduit properly earthed, or alternatively, armoured cable wiring is used;
g) a separate earth wire is run in the lighting installation to provide earthing for plug points, fixtures and equipment;
h) proper connectors and junction boxes are used wherever joints are to be made in conductors or cross-over of conductors takes place;
j) cartridge fuse units are fitted with cartridge fuses only;
k) clear and permanent identification marks are painted in all distribution boards, switchboards, sub-main boards and switches as necessary;
m) the polarity has been checked and all protective devices (such as MCB, MCCB, fuses, RCCB/RCD, etc) and single pole switches are connected on the phase conductor only and wiring is correctly connected to socket-outlets;
n) spare knockouts provided in distribution boards and switch fuses are blocked;

p) the ends of conduits enclosing the wiring leads are provided with ebonite or other suitable bushes;
q) the fittings and fixtures used for outdoor use are all of weather-proof construction and of suitable IP and IK rating, and similarly, fixtures, fittings and switchgears used in the hazardous area, are of flame-proof application;
r) proper terminal connectors are used for termination of wires (conductors and earth leads) and all strands are inserted in the terminals;
s) flat ended screws are used for fixing conductor to the accessories;
t) use of flat washers backed up by spring washers for making end connections is desirable; and
u) all metallic parts of installation, such as conduits, distribution boards, metal boxes, etc, have been properly earthed.

9.3 Testing of Installation

9.3.1 *General*

After inspection, the following tests shall be carried out, before an installation or an addition to the existing installation is put into service. Any testing of the electrical installation in an already existing installation shall commence after obtaining permit to work from the Engineer-in-Charge and after ensuring the safety provisions.

Testing of the installations will cover the testing of equipment, connections, cables, switchgear, protective devices, circuit breakers and the associated relays, measuring instruments and earthing. Periodicity of testing should not exceed six months. More frequent testing may be prescribed for complex installations and installations feeding sensitive loads. Due date of next test cycle should be displayed on the equipment.

9.3.2 *Testing*

9.3.2.1 *Switchboards*

HV and MV switchboards shall be tested in the manner indicated below:

a) All high voltage switchboards shall be tested for dielectric test as per good practice [8-2(14)].
b) All earth connections shall be checked for continuity.
c) The operation of the protective devices shall be tested by means of secondary or primary injection tests.
d) The operation of the breakers shall be tested from all control stations.
e) Indication/Signalling lamps shall be checked for proper working.
f) The operation of the breakers shall be tested for all interlocks.
g) The closing and opening timings of the breakers shall be tested wherever required for auto-transfer schemes.
h) Contact resistance of main and isolator contacts shall be measured.
j) The specific gravity and the voltage of the control battery shall be measured.

9.3.2.2 *Transformers*

Transformers shall be tested in the manner indicated below:

a) All commissioning tests shall be in accordance with good practice [8-2(9)].
b) Insulation resistance on HV and MV windings shall be measured at the end of 1 min as also at the end of 10 min of measuring the polarization index. The absolute value of insulation resistance should not be the sole criterion for determining the state of dryness of the insulation. Polarization index values should form the basis for determining the state of dryness of insulation. For any class of insulation, the polarization index should be greater than 1.5.

9.3.2.3 *Cables*

Cable installations shall be checked as given below:

a) It shall be ensured that the cables conform to the relevant Indian Standards. Tests shall also be done in accordance with good practice [8-2(11)] and [8-2(15)]. The insulation resistance before and after the tests shall be checked.
b) The insulation resistance between each conductor and against earth shall be measured. The insulation resistance varies with the type of insulation used and with the length of cable. The following empirical rule gives reasonable guidance:

$$\text{Insulation resistance, in megaohms} = \frac{10 \times \text{Voltage, in kV}}{\text{Length, in km}}$$

c) Physical examination of cables shall be carried out.
d) Cable terminations shall be checked.
e) Continuity test shall be performed before charging the cable with current.

9.3.2.4 *Motors and other equipment*

The following tests shall be made on motor and other equipment.

The insulation resistance of each phase winding against the frame and between the windings shall be measured. Megger of 500 V or 1 000 V rating shall be used. Star points should be disconnected. Minimum acceptable value of the insulation resistance varies with the rated power and the rated voltage of the motor.

The following relation may serve as a reasonable guide:

$$R_\mathrm{I} = \frac{20 \times E_\mathrm{n}}{1\,000 + 2P}$$

where

R_i = insulation resistance in mega-ohms at 25 °C.
E_n = rated phase to phase voltage.
P = rated power, in kW.

If the resistance is measured at a temperature different from 25 °C, the value shall be corrected to 25 °C.

The insulation resistance as measured at ambient temperature does not always gives a reliable value, since moisture may have been absorbed during shipment and storage. When the temperature of such a motor is raised, the insulation resistance will initially drop considerably, even below the acceptable minimum. If any suspicion exists on this score, motor winding shall be dried out.

9.3.2.5 *Wiring installation*

The following tests shall be done:

a) The insulation resistance shall be measured by applying between earth and the whole system of conductor 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 installation otherwise electrically connected together, a d.c. voltage of not less than twice the working voltage, provided that it does not exceed 500 V for medium voltage circuits. Where the supply is derived from three-wire (a.c. or d.c.) or a poly-phase system, the neutral pole of which is connected to earth either direct or through added resistance the working voltage shall be deemed to be that which is maintained between the outer or phase conductor and the neutral.
b) The insulation resistance in mega-ohm of an installation measured as in (a) shall be not less than 50 divided by the number of points on the circuit, provided that the whole installation need not be required to have an insulation resistance greater than one mega-ohm.
c) Control rheostats, heating and power appliances and electric signs, may, if desired, be disconnected from the circuit during the test, but in that event the insulation resistance between the case of framework, and all live parts of each rheostat, appliance and sign shall be not less than that specified in the relevant Indian Standard specification or where there is no such specification, shall be not less than half a mega-ohm.
d) The insulation resistance shall also be measured between all conductors connected to one pole or phase conductor of the supply and all the conductors connected to the middle wire or to the neutral on to the other pole of phase conductors of the supply. Such a test shall be made after removing all metallic connections between the two poles of the installation and in these circumstances the insulation resistance between conductors of the installation shall be not less than that specified in (b).

9.3.2.6 *Completion certificate*

On completion of an electrical installation (or an extension to an installation) a certificate shall be furnished by the contractor, counter-signed by the certified supervisor under whose direct supervision the installation was carried out. This certificate shall be in a prescribed form as required by the local electric supply authority. One such recommended form is given in Annex G. This is a general form giving the minimum basic requirements and the items in the form have to be augmented keeping in view the features of the particular equipment, system or installation and environmental conditions of its operation.

9.3.2.7 *Earthing*

For checking the efficiency of earthing, the following tests shall be done:

a) The earth resistance of each electrode shall be measured.
b) Earth resistance of earthing grid shall be measured.
c) All electrodes shall be connected to the grid and the earth resistance of the entire earthing system shall be measured.

These tests shall preferably be done during the summer months.

9.4 Checklists covering basic minimum set of checks for installation, handing over and commissioning of typical equipment of a substation are given in Annex E for general reference and use. Checklist for handing over of earthing pits is given in Annex F for general reference and use. For any installation, the proper checklist should be developed keeping in view the type of loads, quality of service, environmental conditions and operating requirements of redundancy and reliability.

10 ALLIED/MISCELLANEOUS SERVICES

Requirements relating to various allied services shall be as per **10.1** to **10.9**.

10.1 Telecommunication and Information and Communication Technology Services

10.1.1 *Telephone Services*

10.1.1.1 House wiring of telephone subscribers in small buildings may be on the surface of walls or desirably, in a concealed manner through conduits. In large multi-storeyed buildings intended for commercial, business and office use as well as for residential purposes, wiring for telephone connections should be done in a concealed manner through conduits. The requirements of telecommunication facilities like telephone connections, private branch exchange and intercommunication facilities, should be planned well in advance so that suitable provisions are made in the building plan in such a way that the demand for telecommunication services in any part of the building at any floor are met at any time during the life of the building.

10.1.1.2 Layout arrangements, methods for internal block wiring and other requirements regarding provisions of space, etc, may be decided depending on the number of phone outlets and other details in consultation with engineer/architect and user. *See* also Part 8 'Building Services, Section 6 Information and Communication Enabled Installations' of the Code.

10.1.2 *Information and Communication Technology Services including Computer Networking* – *See* Part 8 'Building Services, Section 6 Information and Communication Enabled Installations' of the Code.

10.2 Public Address System – *See* Part 4 'Fire and Life Safety' of the Code.

10.3 Common Antenna System for TV Receivers

10.3.1 In multi-storeyed apartments, houses and hotels where many TV receivers are located, a common master antenna system may preferably be used to avoid mushrooming of individual antennas.

10.3.2 Master antenna is generally provided at the top most convenient point in any building and a suitable room on the top most floor or terrace for housing the amplifier unit, etc, may also be provided in consultation with the architect/engineer.

10.3.3 From the amplifier rooms, conduits should be laid in recess to facilitate drawing co-axial cable to individual flats. Suitable 'Tap Off' boxes may be provided in every room/flat, as required.

10.4 Emergency and Standby Power Supply Systems

10.4.1 *General*

Use of electricity has grown tremendously and for various activities the dependency on electricity has increased to such an extent as to cause serious problems even with loss of electrical power for a few moments. As a result, a wide variety of alternate sources of electricity are being in our built environment.

The different alternative sources of power are the Uninterrupted Power Supply (UPS) System, inverter, diesel (/CNG/LPG) generator sets, petrol/kerosene oil generator sets, bio-gas generator sets.

In addition to the above, there is a proliferation of power sources, such as solar photo-voltaic cells, wind generators, bio-mass and waste based power plants etc, primarily oriented towards reduction of the environmentally harmful CO_2 emissions.

These systems give electricity during the periods of the failure of the conventional grid based public energy system and keep our critical systems in continued operation. However, introduction of more than one source of electrical power introduces questions of safety. For safety from electrical shock to human beings or livestock, the hazard is not just dependent on the main high powered source such as the grid, but the hazard is the same from a low powered source also. Shock from a small 20 W inverter can be as dangerous as a shock from the grid with megawatts of power at the back. As such precautions from the angle of safety apply equally to all sources of power. Electric shock hazards are dependent on the system voltage and as such even a low capacity generator or an inverter (of capacity 100 VA) poses the same level of shock hazard as a multi-kilovolt ampere capacity generator and all protection provisions (such as safety earthing, earth leakage and overload breakers) shall be provided as done for a large capacity system.

Power devices contain fuel, batteries which are points of concentrated sources of energy constrained in a small place. Any unintended improper release of this bottled up energy can unleash devastating consequences, such as fire and as such care is required in location which houses any of these sources of electrical power and its associated components.

10.4.2 *Uninterrupted Power Supply (UPS) System*

UPS is an electrical device providing an interface between the mains power supply and sensitive loads (computer systems, instrumentation, etc). The UPS supplies sinusoidal a.c. power free of disturbances and within strict amplitude and frequency tolerances. It is generally made up of a rectifier/charger and an inverter together with a battery for backup power in the event of a mains failure with virtually no time lag.

In general UPS system shall be provided for sensitive electronic equipment like computers, printers, fire alarm panel, public address system equipment, access control panel, EPABX, etc, with the following provisions:

a) Isolation transformers may be provided in many UPS systems to provide higher grade of power supply quality to the loads fed by the UPS.
b) UPS shall have dedicated neutral earth pits. This earth pit shall be interconnected with other earth pits below soil for equipotential bonding.
c) Adequate rating of protective devices such as MCB, MCCB, fuses, RCCB/RCD, etc, shall be provided at both incoming and outgoing sides.
d) UPS room shall be provided with adequate ventilation and/or air conditioning as per requirement.
e) For all 3 phase UPS, 4 pole CB (circuit breaker) shall be used and for all 1 phase UPS, Double Pole CB shall be used.

10.4.3 *Inverter*

In general inverter system shall be provided for house lighting, shop lighting, etc.

NOTE — While a UPS system is provided to maintain power supply without any break even in the event of a failure of the incoming power supply, an inverter system is provided where a short break is acceptable.

Inverter systems also have a battery bank to supply power during the failure of the main power supply and the battery charged through a rectifier. The following provisions shall apply to inverter systems:

a) Adequate rating of protective devices such as MCB, MCCB, fuses, RCCB/RCD, etc, shall be provided at both incoming and outgoing sides.
b) Earthing shall be done properly.
c) Adequate ventilation space shall be provided around the battery section of the inverter.
d) Care shall be taken in circuit design to keep the connected load in such a manner that the demand at the time of mains failure is within the capability of the inverter.

NOTE — If the inverter fails to take over the load at the time of the mains failure, the purpose of providing the inverter and battery backup is defeated.

10.4.4 The following provisions shall apply to both inverter and UPS systems:

a) Circuits which are fed by the UPS or inverter systems should have suitable marking to ensure that a workman does not assume that the power is off, once he has switched off the mains from the DB for maintenance.

b) Electric shock hazards are dependent on the system voltage and as such even a low capacity generator or an inverter (of capacity 100 VA) poses the same level of shock hazard as a multi-kilovolt ampere capacity generator and all protection provisions (such as safety earthing, earth leakage and overload breakers) shall therefore be provided as done in case of a large capacity system.
c) UPS and inverter systems should be provided with protection to shut the output during abnormal conditions, such as overload or short circuit. Such systems may also have the choice of auto-restoration after a preset time delay and an ultimate lock-out after a number of restoration attempts. Warning should be displayed wherever the possibility of automatic restoration is possible.
d) Batteries that go with UPS and inverter systems are required to be placed in well-ventilated spaces as oxygen and hydrogen gasses are produced in the batteries, which unless ventilated, can cause explosive conditions.
e) The flooring for the battery room should be with acid (or alkali as the case may be) resistant tiles or coating.

10.4.5 *Standby Generating Set (less than 5 kVA)*

In general, small standby generating sets (using either diesel or petrol or kerosene or LPG or CNG) may be provided for small installations, such as offices, shops, small scale industry, hostels, etc, which shall comply the following requirements:

a) These shall be located outside in open areas.
b) There shall be no risk of fire due to presence of such equipment in the premise.
c) They shall be in reach of authorized persons only.
d) Adequate firefighting equipment shall be provided near such installations.
e) Exhaust from these shall be disposed in such a way so as not to cause health hazard.

NOTE — Installation of a set in a closed space poses the hazard of accumulation of the exhaust gasses which contains harmful gases such as carbon-monoxide, and also reduction of oxygen in the air in the enclosure.

f) These shall have acoustic enclosure, or shall be placed at a location so as not to cause noise pollution.
g) Adequate ventilation shall be provided around the installation.
h) Protective devices such as MCB, MCCB, fuses, RCCB/RCD, etc, with adequate rating shall be provided.
j) Separate and adequate body and neutral earthing shall be done.
k) Cumulative capacity shall not exceed 10 kVA.

10.5 Building Management System

A building management/automation system may be considered to be provided for controlling of some and monitoring of all parameters of heating, ventilation and air conditioning system (HVAC); electrical; plumbing; fire fighting; low voltage system, such as telephone, TV; etc. This not only leads to reduction of energy consumption, it also generates data leading to better operation practice and systematic maintenance scheduling. The total overview provided by a building automation system, with a capability to oversee a large number of operating and environmental parameters on real time basis leads to introduction of measures which further leads to reduction in energy consumption.

It also helps in reduction in skilled manpower requirement for operation and maintenance of large complexes. This system can further be linked to other systems such as fire alarm system, public address system, etc for more effective running of services. This system can be used for analysis and controlling of all services in a particular complex, leading to efficient and optimum utilization of available services.

NOTE — *See* Part 8 'Building Services, Section 3 Air Conditioning, Heating and Mechanical Ventilation' and Part 12 'Asset and Facility Management' of the Code for provisions relating to building management system.

10.6 Security System

Security system may comprise an integrated closed circuit television system, access control system, perimeter protection systems, movement sensors, etc. These have a central control panel, which has a defined history storage capacity. This main control panel may be located near to the fire detection and alarm system.

These may be considered for high security areas or large crowded areas or complexes. High security areas may consider uncorded, high-resolution, black and white cameras in place of coloured cameras. These cameras may be accompanied or automatically controlled with movement sensors. Cameras may be linked to access controls so that proper recording of the movement at the points of access to high security areas is maintained.

Access control may be provided for entry to high security areas. The systems may have proximity card readers, magnetic readers, etc.

NOTE — *See* Part 12 'Asset and Facility Management' of the Code for provisions relating to security system.

10.7 Car Parking Area

10.7.1 *Electrical Vehicle Charging*

Adequate electrical provisioning should be made for electric vehicle charging in designated spaces for electric car parks in enclosed/covered car parking. These electrical outlets should be fed from a separate distribution board located near such outlets for electric car parks. Distribution board and outlets should be protected and metered.

NOTE — Reference may be made to IEC 60364-7-722:2018 'Low-voltage electrical installations - Part 7-722: Requirements for special installations or locations - Supplies for electric vehicles'.

10.7.2 *Car Park Management System*

Wherever car park management system is provided in multi-level parking or other parking lots with features of boom barriers, pay and display machines (manned or unmanned type) and parking guidance system (for displaying number of car spaces vacant on various floors, direction of entry and exit, etc), the electrical provisions for the same shall be adequately backed with UPS for protection of vehicle and for efficient car park management.

10.8 Solar Photovoltaic Power Generating System

10.8.1 *General*

Solar energy, which is available in two forms, heat and light, is a renewable and inexhaustible natural resource and can supplement/augment the depleting fossil fuel resources. Greenhouse gases and pollutant emissions which result from fossil fuel generation can also be offset by solar photovoltaic power generation. Most parts of the country receive good solar radiation of 4 to 7 kWh/m^2 per day and almost 300 sunny days in a year making solar PV system one of the most preferred renewable energy source in the country.

10.8.2 Solar PV power generating system consists of components and subsystems that are used to convert incident solar radiation directly into electrical energy. The energy converter (namely, solar photovoltaic cells which convert solar energy directly into d.c. electric power) does not have moving parts and has a comparatively long lifetime. Also, it can be used in decentralized/distributed mode.

PV cells are made of light-sensitive semiconductor materials that use photons to dislodge electrons to drive an electric current. The available cell technology used in construction of solar PV is single crystal or mono-crystalline silicon/poly-crystalline or multi-crystalline silicon/amorphous thin film. Individual PV cells are interconnected to form a PV module. This takes the form of a panel for easy installation.

The electrical parameters of the input of a subsystem should be compatible with the output electrical parameters of a preceding subsystem(s).

Most solar PV systems can be mounted on a building or installed on ground. For buildings, they are either mounted on the roof or integrated into the building facade (BIPV). When installing on roof adequate distance between floor and frame on which solar panels are mounted should be kept to ensure human movement below for roof maintenance. Proper cleaning access provision should be kept to clean the solar plates.

10.8.3 *Types of Solar PV Generating System*

When photovoltaic modules are exposed to sunlight, they generate electricity in d.c. waveform. A d.c./a.c inverter then converts the d.c into a.c. or stabilizes d.c. for further distribution. The PV power generating systems can broadly be classified into two categories, namely, stand-alone (with a.c. output or with d.c. output) and grid connected system (*see* Fig. 10).

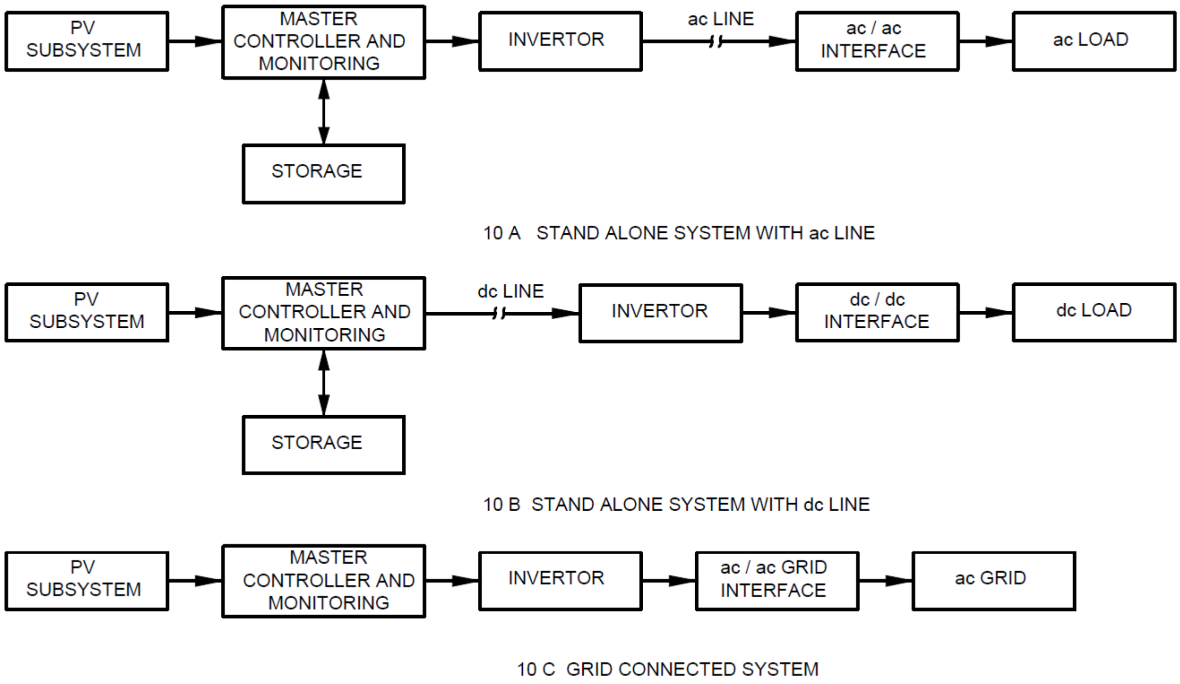


Fig. 10 PV Power Generating System and Major Subsystems

10.8.3.1 *Stand alone solar PV system* (*see* Fig. 11)

Stand alone solar PV generating system is an independent power production system that is not connected to the grid and can thus be designed free from grid code requirements. This system is also known as off-grid system. Off-grid solar PV systems are applicable for areas where there is no available power grid, such as remote villages, forests, off-shore islands, ships. But they may also be installed within the city in situations where it is inconvenient or too costly to tap electricity from the power grid.

An off-grid solar PV system needs deep cycle rechargeable batteries, such as lead-acid, nickel-cadmium or lithium-ion batteries to store electricity for use under conditions where there is little or no output from the solar PV system, such as during the night.

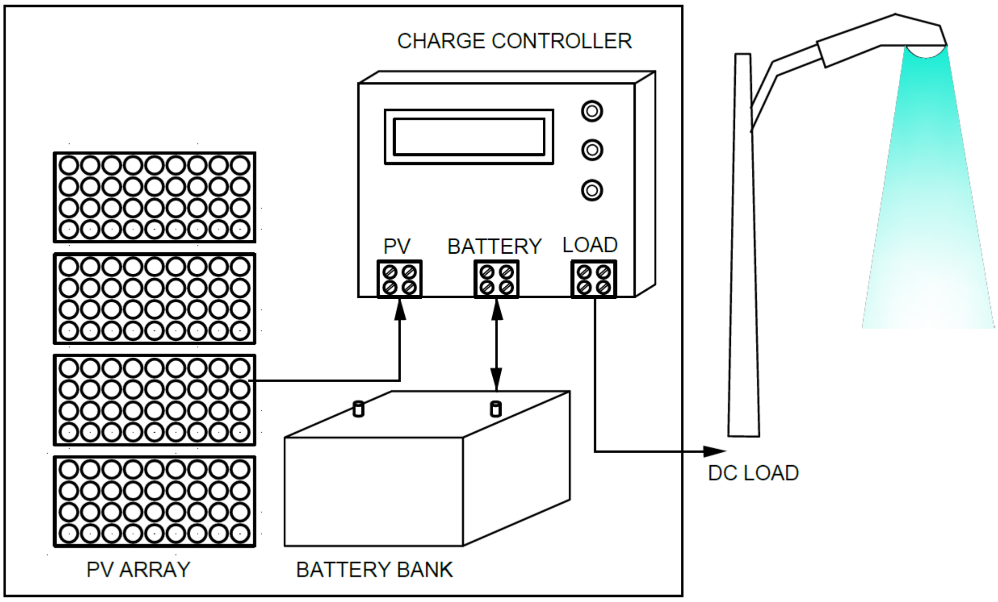


FIG. 11 STAND ALONE SOLAR PV SYSTEM

10.8.3.2 *Grid connected solar PV system* (*see* Fig. 12)

A grid connected solar PV generating system is interconnected with an existing electric power grid, subject to grid requirements. This system is also known as grid-tied system. A building has two parallel power supplies, one from the PV solar system and the other from the power grid. The combined power supply feeds all the loads connected to the main a.c. distribution board. The ratio of solar PV supply to power grid supply varies, depending on the size of the solar PV system. Whenever the solar PV supply exceeds the building's current demand, excess electricity is exported into the grid. When there is no sunlight to generate PV electricity at night, the power grid will feed all the building's demand. A grid-connected system can be an effective way to reduce dependence on utility power during the day, increase renewable energy production, and improve the environment.

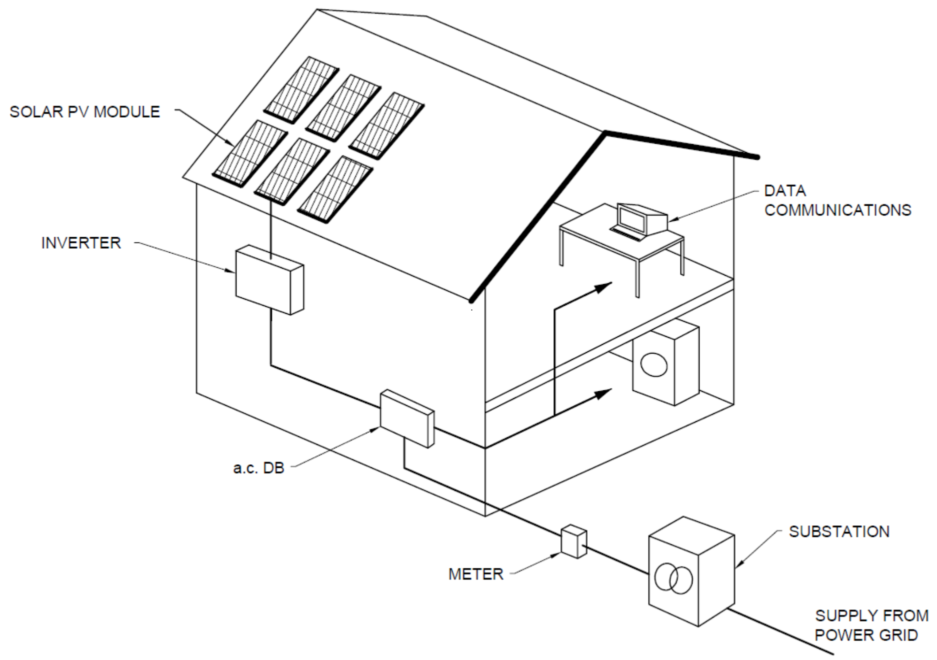


FIG. 12 GRID CONNECTED SOLAR PV SYSTEM

10.8.4 When designing solar PV system, care should be taken to address design aspects relating to earthing, short circuit protection, lightning protection and switching control. This shall be done in accordance with Part 8 'Solar Photovoltaic (PV) Power Supply Systems' of National Electrical Code 2023. Earthing and lightning protection of solar PV systems shall be done in accordance with the procedure laid down in **8** and **11**, respectively.

10.8.5 Building integrated photovoltaic cells (BIPV) When designing building façade using BIPV, special care shall be taken to maintain wiring and other integration with façade to ensure safety of occupants and building. Floor to floor sealing should be managed without disrupting the performance of the BIPV.

10.9 Aviation Obstacle Lights

High-rise buildings and structures such as chimneys and towers are potential hazards to aircraft. The provision of aviation obstacle lights (AOL) on tall buildings/structures is intended to reduce hazards to aircraft by indicating their presence. AOLs, low, medium or high intensity obstacle lights, or a combination of such lights, shall be provided on buildings of different heights as per the requirements of Annex 14 to the Convention on International Civil Aviation, Volume I Aerodrome Design and Operations, International Civil Aviation Organization (ICAO). A general arrangement of AOLs in case of group of buildings is given in Fig. 13.

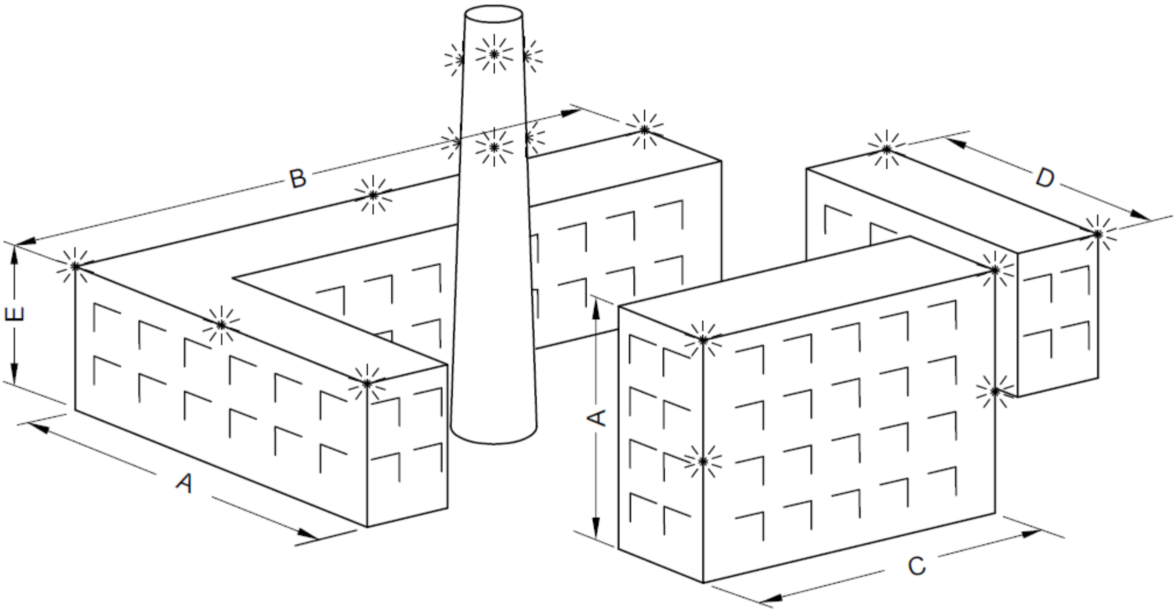


FIG. 13 TYPICAL ARRANGEMENT OF AVIATION OBSTACLE LIGHTS IN CASE OF GROUP OF BUILDINGS

11 LIGHTNING PROTECTION OF BUILDINGS

11.1 General

11.1.1 There are no devices or methods capable of modifying the natural weather phenomena to the extent that they can prevent lightning discharges. Lightning flashes to, or nearby, structures (or lines connected to the structures) are hazardous to people, to the structures themselves, their contents and installations. Lightning protection measures therefore becomes essential. Lightning protection systems are methods to divert the effects of lightning discharges away from the buildings, its occupants and sensitive equipment housed in the building, including from the necessary connections from public systems to the building. Lightning discharges are of very high energy and can have devastating effects depending on the path of its discharge. Lightning strike is not predictable and is a random phenomenon both from the aspect of its occurrence and intensity or the energy discharge.

Lightning protection systems installed to avoid accidents, severe injuries and loss of life deaths of humans and animals due to direct or indirect effects of lightning.

The following steps are to be followed to be carried out to ensure protection from lightning in a building:

a) In order to utilize the natural components such as concrete or foundation embedded earth termination system, the lightning protection system shall be considered before starting the construction of the building.

b) Find out the need for a lightning protection system based on risk assessment as per good practice [8-2(47)]. If LPS is required, the level of protection shall be identified (alternatively the recommendation in Table 1 may be used).
c) Decide on the type of external LPS including usage of natural components, corrosion problems, sizing of conductors, routing of conductors.
d) Calculate the separation distances, if isolated or electrically insulated LPS is used and find out the possibility of maintaining separation distance. Note that for high rise buildings, maintaining separation distance may not be practically possible. Hence alternate methods recommended in good practice [8-2(45)] are to be used.
e) Down conductors shall be placed around the building. Avoid bends and joints.
f) Decide on the type of earth termination system and the provisions for equipotential bonding at ground level. Note that Type A earth termination (vertical or horizontal earth electrodes) is not efficient for large buildings. Lightning protection system without equipotential boning to electrical installation is a safety hazard and shall be avoided.
g) Creating shielding measures for buildings with large amount of electronics are present, (for example datacenter, hospitals, telecommunication centers etc) the shielding measures.
h) Touch and step potential reduction measures outside the building for the safety of people.

In all cases the following measures shall be avoided.

1) Use of Multiple down conductors through one route and through shafts and inside facades.
2) No equipotential bonding with MET of the electrical installation and usage of SPD’s
3) Routing down conductors near metal installations such as facades, pipes etc without equipotential bonding.

11.2 Steps for deciding on Lightning Protection System

11.2.1 A risk assessment based on good practice [8-2(47)] shall be carried out to find out the need for Lightning protection and if necessary, the level of Lightning protection. In the absence of a risk assessment, recommendation in Table 4 may be followed.

11.2.2 Lightning protection is divided into four levels (LPL I to IV). LPL, I provide the maximum protection and is most expensive, whereas LPL IV provides the least protection and is less expensive.

Class of LPS denotes the classification of an LPS according to the lightning protection level for which it is designed. Four classes of LPS (I, II, III and IV) are defined as a set of construction rules, based on the corresponding LPL. Each set includes level-dependent (for example, rolling sphere radius, mesh width etc.) and level-independent (for example, cross-sections, materials etc) construction rules {see good practice [8-2(47)]}.

11.2.3 *Lightning Protection Level (LPL)*

Based on the risk assessment if protection is necessary, lightning protection is divided into four levels (LPL I to IV) which helps in designing and implementing protection measures for an economical implementation. LPL I provides the maximum protection and is expensive, whereas, LPL IV provides the least protection and is less expensive. Recommended lightning protection level (LPL) for typical buildings is given in Table 4 for guidance.

Table 4 Recommended LPL for Typical Buildings
(*Clause* 11.2.3)

Sl No.	**Application**	**LPL**
(1)	(2)	(3)
i)	Data centres, military applications, high rise hotels/ hospitals, nuclear power stations, airports, essential services such as telecom	I
ii)	Low rise hospitals/ hotels, ex-zones in the industry and chemical sector, fuel retail outlets/gas stations/compressor stations and similar installations	II/III
iii)	Schools, banks, residential buildings, temples, churches, mosques, community halls, etc	III/IV

NOTE — The table may be used as a recommendation for selection of LPS only in case details of the building to be protected are not precisely available however it is recommended to do a detailed risk assessment before implementation)

11.3 Planning of Lightning Protection System

Complete system for protection of structures against lightning, including their internal systems and contents, be installed to avoid damages to structures, accidents, severe injuries of humans due to direct or indirect lightning. Both protection measures should complement each other.

The LPS should be designed and installed by LPS designers and installers. Planning, implementation and testing of an LPS encompasses a number of technical fields and demands for coordination by all parties involved with the construction and maintenance of the structure to ensure an efficient Lightning Protection System. The management of the LPS should be efficient if the steps in Figure 1 are followed. Quality assurance measures are of great importance, in particular, for structures including extensive electrical and electronic installations. See good practice [8-2(45)] and [8-2(48)] for more information

During the planning various parties involved shall consult and agree on the subjects influencing Lightning protection system:

a) Decide whether or not the structure needs protection and, if so, what are the special requirements by making all calculations {*see* good practice [8-2(47)]}.

b) Special attention shall be provided by architects and civil engineers on routing of down conductors, separation distance, usage of natural components and foundation earthing (*see also* Note).
c) Electrical separation or equipotential bonding shall be carefully analysed. Equipotential bonding of electrical services by SPD is also mandatory to complete Lightning Protection.
d) Ensure a close liaison between the architect/engineer, the builder, the lightning protective system engineer, and the appropriate authorities throughout the design stages (*see also* Note).
e) Agree the procedures and define the period for testing and future maintenance {*see* good practice [8-2(47)]}.

NOTE — Modern buildings with electronic equipment need protection from radiated surges of lightning. To achieve this, structural steel of the building is also used as a part of lightning protection system {*see* good practice [8-2(47)]}. In such cases, lightning protection measures shall be included in the structural steel, particularly in column foundation.

11.4 Lightning Protection System (LPS)

The main and most effective measure for protection of structures against physical damage is considered to be the lightning protection system (LPS). It usually consists of both external and internal lightning protection systems.

An external LPS which consists of air-termination system, down-conductor system and earthing system {*see* good practice [8-2(45)] for details} is intended to,

a) intercept a lightning flash to the structure (with an air-termination system),
b) conduct the lightning current safely towards earth (using a down-conductor system), and
c) disperse the lightning current into the earth (using an earth-termination system).

An internal LPS comprises equipotential bonding or a separation distance (and hence electrical insulation) between the external LPS components and other electrically conducting elements internal to the structure.

Both external and internal protection systems should complement each other.

Access to the ground and the proper use of foundation steelwork for the purpose of forming an effective earth-termination may well be impossible once construction work on a site has commenced. Therefore, soil resistivity and the nature of the earth electrode should be considered at the earliest possible preferably during the design stage of a project. This information is fundamental to the design of an earth-termination system and may influence the foundation design work for the structure.

Regular consultation between LPS designers and installers, architects/civil engineer and builders is essential in order to achieve the best result at minimum cost. If lightning protection is to be added to an existing structure, every effort should be made to ensure that it conforms to the principles of this Code. The design of the type and location of an LPS should take into account the features of the existing structure.

11.4.1 *External Lightning Protection System*

11.4.1.1 Air-termination system is a part of an external LPS using metallic elements such as rods, mesh conductors or catenary wires intended to intercept lightning flashes. The probability of penetration by a lightning current on a structure is considerably decreased by the presence of a properly designed air-termination system. Air-termination systems can be composed of any combination of the following elements:

a) Vertical rods (offers certain angle of protection);
b) Catenary wires; and
c) Meshed/Grid conductors.

All types of air-termination systems shall be positioned in accordance with **11.4.1.2**. The individual air-terminations rods should be connected together at roof level to ensure current division. Radioactive air-terminals shall not be allowed. Any other kind of air-terminal like dissipation system/ESE air-terminal/CSE air-terminal shall not be acceptable.

11.4.1.2 *Positioning*

Air-termination components installed on a structure shall be located at corners, exposed points and edges (especially on the upper level of any facades) in accordance with one or more of the following methods {*see also* Figs. 14 to 18 in conjunction with [8-2(45)]}:

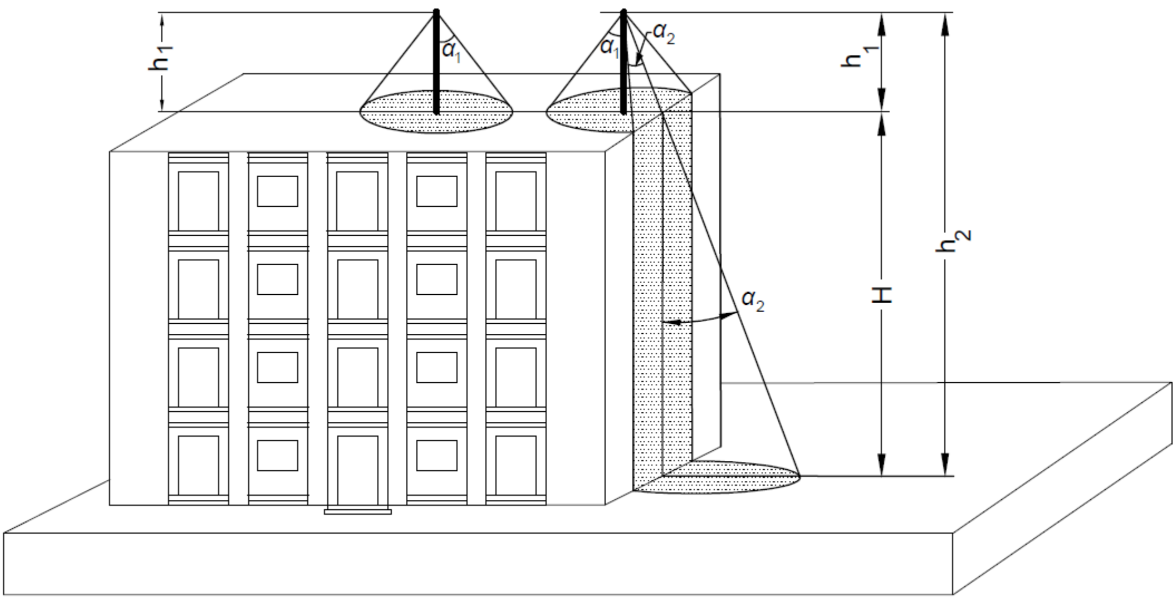
a) Protection angle method;
b) Rolling sphere method; and
c) Mesh method.

The protection angle method is suitable for simple shaped buildings but it is subject to limits of air-termination height indicated in Table 5. The mesh method is a suitable form of protection where plane/pitch roof surfaces are to be protected. The rolling sphere method is suitable in all cases. *See* good practice [8-2(45)] for details.

Table 5 Maximum Values of Mesh Size and Protection Angle Corresponding to the Class of LPS
(*Clause* 11.5.1.2)

Sl No.	**Class of LPS**	**Mesh Size**	**Rolling Sphere Radius** *r*	**Protection Angle with respect to Height**				
				10 m	20 m	30 m	45 m	60 m
		m	m					
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
i)	I	5 x 5	20	45	23	← Cannot be used →		

Sl No.	**Class of LPS**	**Mesh Size**	**Rolling Sphere Radius** *r*	**Protection Angle with respect to Height**				
				10 m	20 m	30 m	45 m	60 m
		m	m					
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
ii)	II	10 x 10	30	54	38	23	← Cannot be used →	
iii)	III	15 x 15	45	62	48	36	23	Cannot be used
iv)	IV	20 x 20	60	65	54	45	34	23



KEY

H HEIGHT OF THE BUILDING OVER THE GROUND REFERENCE PLANE

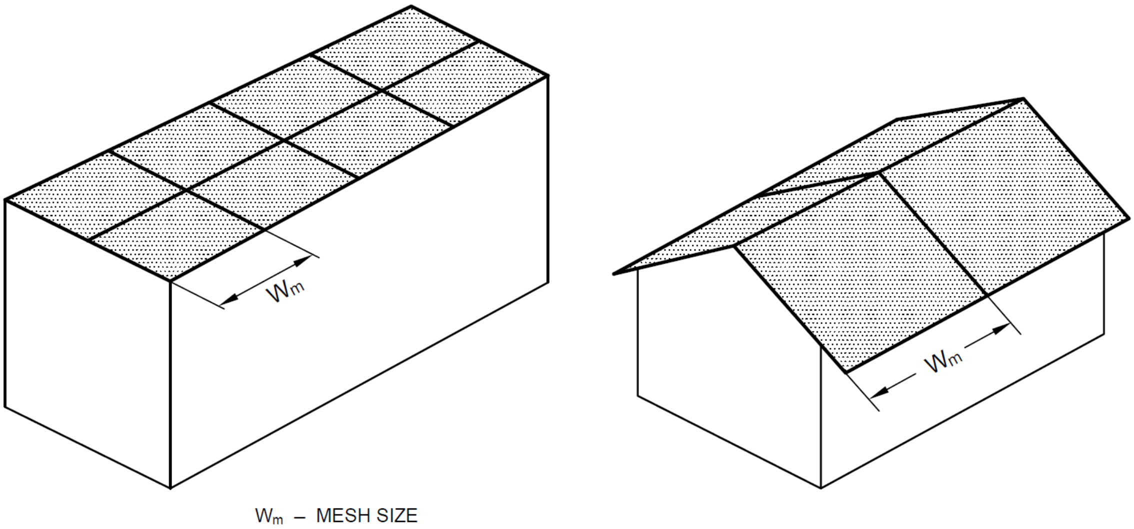
h_1 PHYSICAL HEIGHT OF AN AIR TERMINAL ROD

h_2 HEIGHT OF THE AIR TERMINATION ROD OVER THE GROUND = h_1 + H

α_1 THE PROTECTION ANGLE CORRESPONDING TO THE AIR TERMINATION HEIGHT, h = h_1, BEING THE HEIGHT ABOVE THE ROOF SURFACE TO BE MEASURED (REFERENCE PLANE)

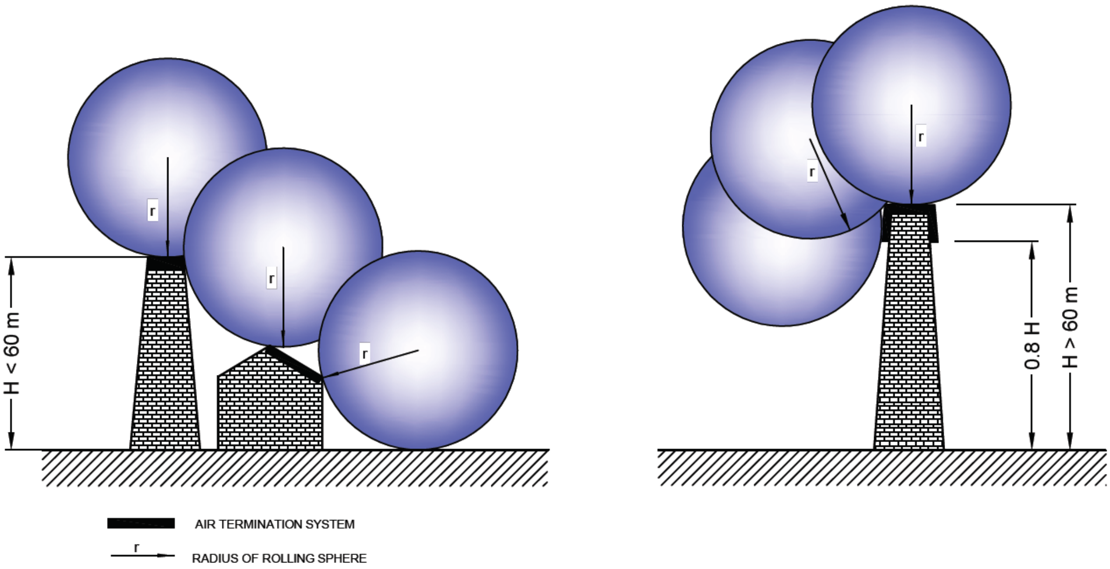
α_2 THE PROTECTION ANGLE CORRESPONDING TO THE HEIGHT, h_2 = H + h_1

FIG. 14 PROTECTION ANGLE METHOD OF AIR-TERMINATION DESIGN FOR DIFFERENT HEIGHTS ACCORDING TO TABLE 5



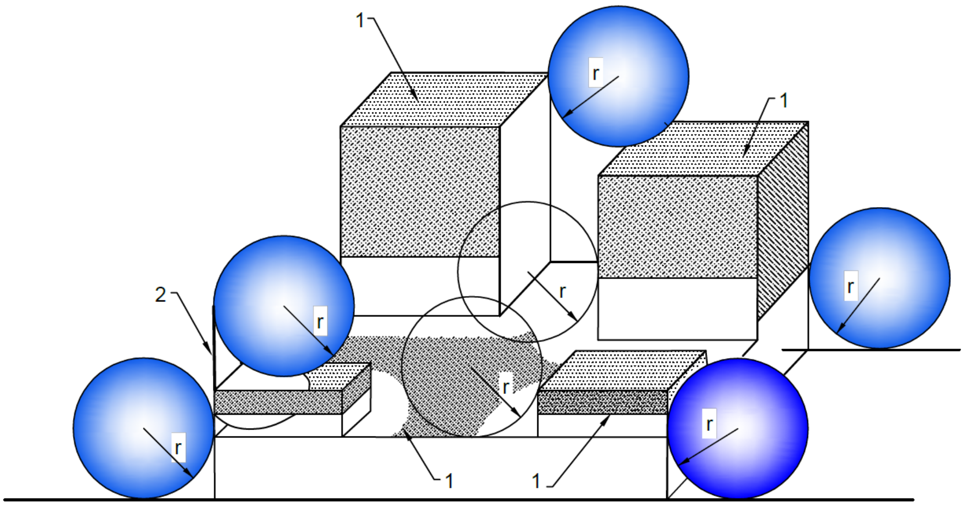
NOTE – THE MESH SIZE SHOULD COMPLY WITH TABLE 5.

FIG. 15 DESIGN OF AIR-TERMINATION SYSTEM ACCORDING TO MESH METHOD



NOTE - The rolling sphere, *r* should comply with the selected class of LPS (*see* Table 5)

FIG. 16 DESIGN OF AIR-TERMINATION SYSTEM ACCORDING TO THE ROLLING SPHERE METHOD

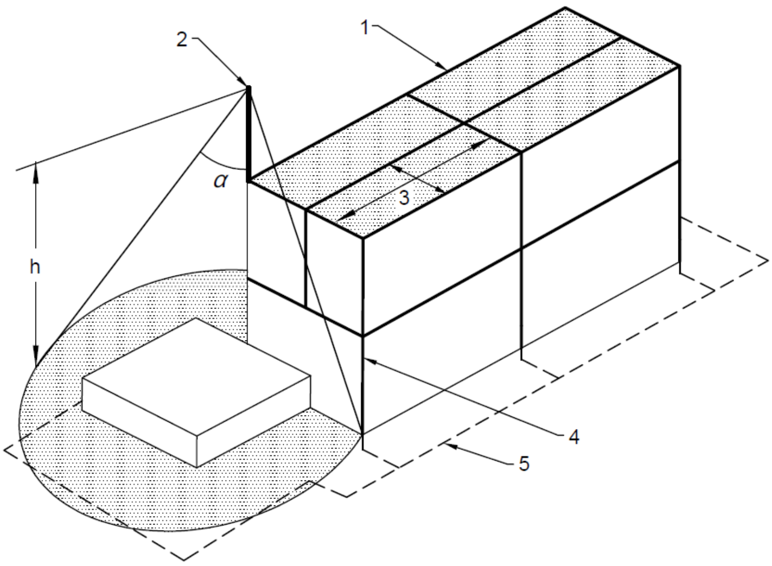


KEY

1 SHADED AREAS ARE EXPOSED TO LIGHTNING INTERCEPTION AND NEED PROTECTION ACCORDING TO TABLE 5
2 MAST ON THE STRUCTURE
r RADIUS OF ROLLING SPHERE ACCORDING TO TABLE 5

NOTE – Protection against side flashes is required { *see* good practice [8-2(45)] for details}.

FIG. 17 DESIGN OF AIR-TERMINATION CONDUCTOR NETWORK FOR A STRUCTURE WITH COMPLICATED SHAPE



KEY

1 AIR - TERMINATION CONDUCTOR (ALSO CALLED AS MESH / FARADAY CAGE). *See* TABLE 5 FOR MESH SIZE
2 AIR - TERMINATION ROD
3 MESH SIZE
4 DOWN CONDUCTOR
5 EARTHING SYSTEM WITH RING CONDUCTOR
h HEIGHT OF THE AIR TERMINAL ABOVE GROUND LEVEL
α PROTECTION ANGLE

FIG. 18 DESIGN OF AN LPS AIR-TERMINATION ACCORDING TO THE PROTECTION ANGLE METHOD, MESH METHOD AND GENERAL ARRANGEMENT OF AIR-TERMINATION ELEMENTS

11.4.1.3 Roof mounted electrical/electronic equipment (for example, chillers, antennas, cameras and bill boards) need vertical air-termination to avoid direct strike. Power and data connection to these equipment should have proper SPD's (*see* **11.5.5**) to avoid failures. Overhead cables such as cable TV lines from one building to the other should be avoided.

11.4.1.4 Unearthed metallic roofs should be avoided. Metallic roofs shall be connected either to steel reinforcement or to other earthed steel parts of the building satisfying the requirements of number of down-conductors (*see* **11.4.2**).

11.4.1.5 *Structures of height less than 60 m and more than 60 m*

Lateral impacts of flashes to the side of tall structures are considered as negligible for structures up to 60 m in height measured from ground level. However, elements significantly protruding the facade can be endangered (for example balconies, cameras, antennas).

On structures taller than 60 m, flashes to the side can occur, especially to protruding parts, and to corners and edges of facades.

> NOTE – In general, the risk due to these flashes is low because only a few per cent of all flashes to tall structures will be to the side and their parameters are significantly lower than those of flashes to the top of structures. However, electrical and electronic equipment on walls outside structures can be destroyed even by lightning flashes with low current peak values.

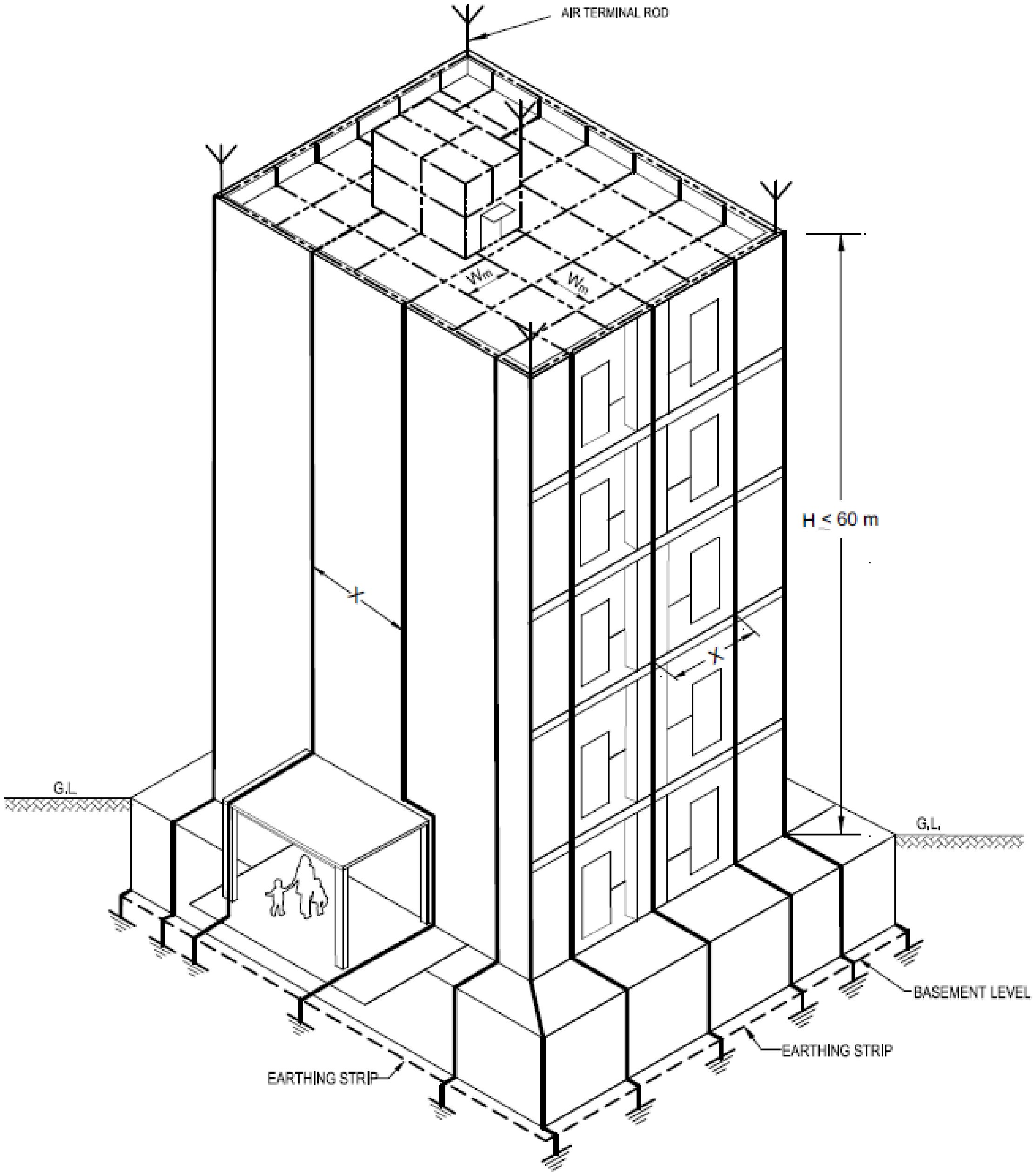
An air-termination system shall be installed to protect significant protrusions (such as balconies, viewing platforms) on vertical surfaces on the upper part of tall structures (that is typically the topmost 20 % of the height of the structure), as well as the equipment installed on them {*see* Annex D of good practice [8-2(45)]}. For parts of the upper 20 % that do not exceed 60 m above ground level, protection of the vertical surface is optional.

> NOTE – Elements protruding through the facade of structures up to 60 m in height are rarely endangered.

On structures lower than 60 m in height, generally flashes to the side may not occur, hence air-termination protection on sides will not be required (*see* Fig. 19A).

On structures taller than 60 m, flashes to the side may occur, especially to points, corners and edges of surfaces. In general, the risk due to these flashes is low, but electrical and electronic equipment on walls or outside structures may be destroyed even by lightning flashes with low current peak values.

An air-termination system shall be installed to protect the upper part of tall structures (that is, typically the topmost 20 percent of the height of the structure as far as this part exceeds 60 m in height) and the equipment installed on it. The rules for positioning the air-termination systems on these upper parts of a structure shall meet at least the requirements for LPL IV with emphasis on the location of air-termination devices on corners, edges, and significant protrusions (such as balconies, viewing platforms, etc). *See* Fig. 19B.



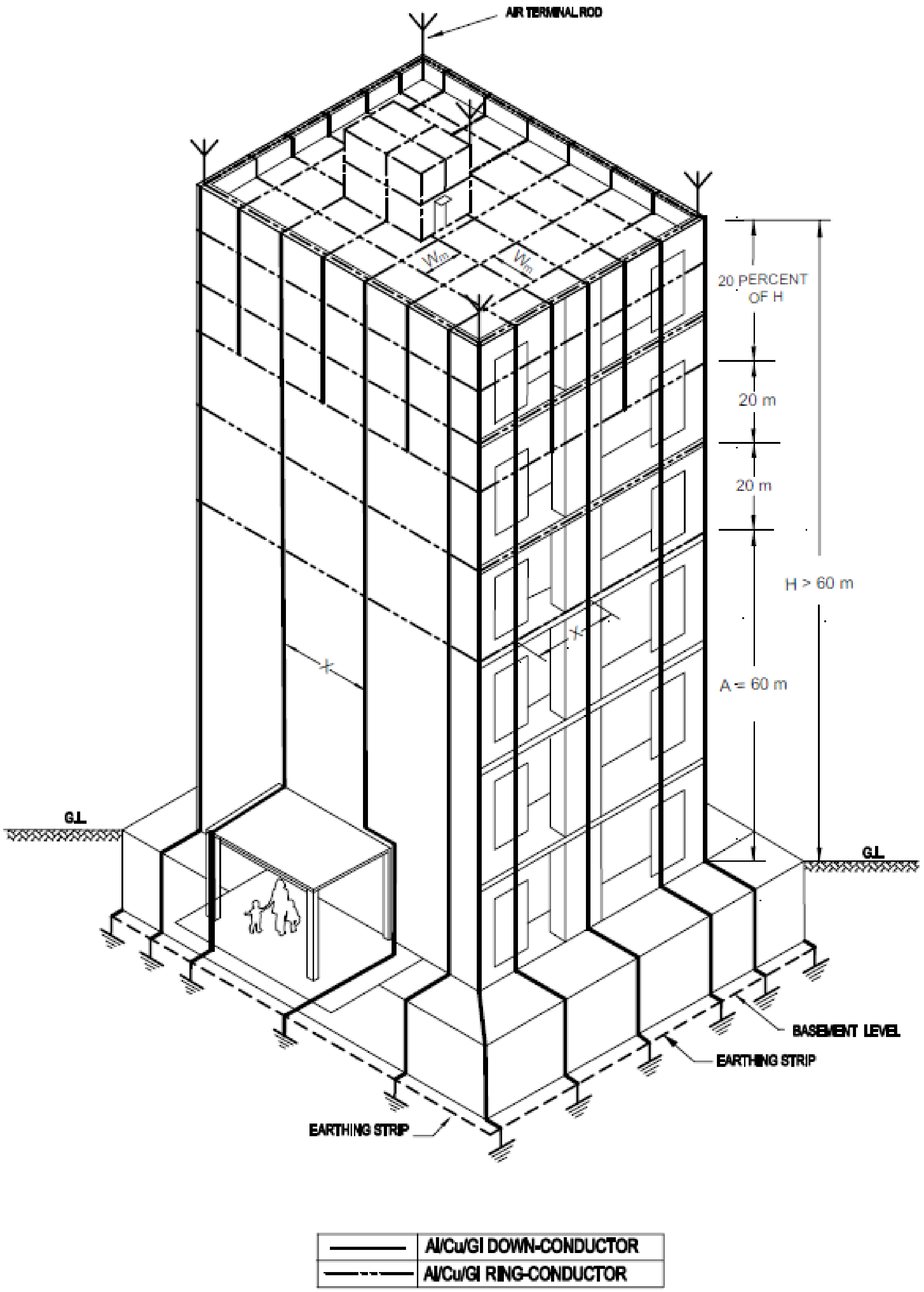
————	Al/Cu/GI DOWN-CONDUCTOR
—·—·—	Al/Cu/GI RING-CONDUCTOR

NOTES

1 Mesh size, W_m shall be as per Table 5

2 Down-conductor spacing, X, shall be as per Table 6

19A TYPICAL LIGHTNING PROTECTION SYSTEM FOR BUILDINGS OF HEIGHT, H ≤ 60 M



NOTES

1 Mesh size, W_m shall be as per Table 5

2 Down-conductor spacing, X, shall be as per Table 6

19B TYPICAL LIGHTNING PROTECTION SYSTEM FOR BUILDINGS OF HEIGHT, H > 60 M

FIG. 19 TYPICAL LIGHTNING PROTECTION SYSTEM FOR BUILDINGS

11.4.1.6 *Buildings with roof top solar PV and water heaters*

Vertical air-terminals are required for protecting roof mounted installations such as solar PV, water heaters, chillers as well as water tanks. Protection angle should be considered as per Table 5. Vertical air-terminals need to be connected to the air-termination mesh/down-conductors. Metal support structure of these installations shall be bonded to the air-termination mesh/down-conductors. Class I/Class II surge protection devices (SPDs) (*see* **11.5.5**) should be installed in the electrical lines to protect the installations inside the building (typically d.c. SPD for solar PV output at inverter or junction box level and a.c. SPD for inverter output and mains input). The roof top PV system or 230 V a.c. water heaters or any other equipment should not pose any safety risk related to lightning protection and protection of overall building may be reviewed by the expert after installation of roof top PV system. Necessary measures may then be required to complete the lightning protection arrangement (*see* Fig. 20).

11.4.1.7 *Large solar PV power plants/farms*

Vertical air-terminals for PV modules based on LPL III/IV connected directly to the frame shall protect against direct lightning impact in case of large solar PV power plants/farms. A design according to rolling sphere method should be done for zone of protection (for example, 1 m rod at 0.5 m height from panel at four corners provides protection to approximately 12 m x 9 m area). Maximum height of the air-termination rod above the panel should be restricted to less than 0.5 m considering the influence of shadow of air-terminal in current generation. To reduce step potential, structures should be interconnected with underground earth mats/isolating spark gaps, wherever necessary. (*see* Fig. 21)

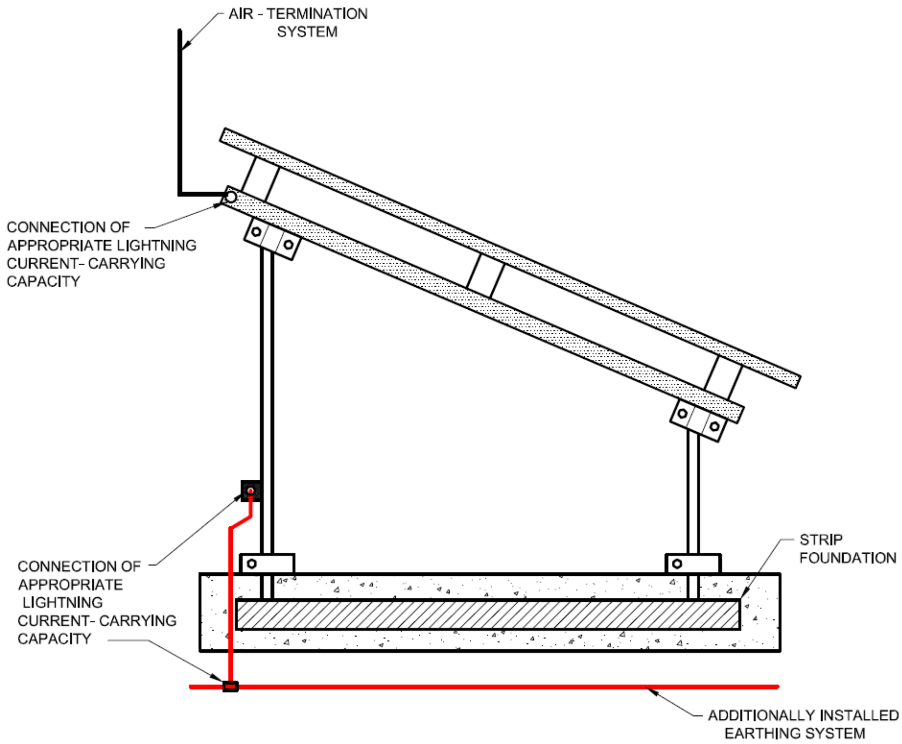


FIG. 20 TYPICAL INSTALLATION OF LIGHTNING PROTECTION SYSTEM IN SOLAR PV INSTALLATION

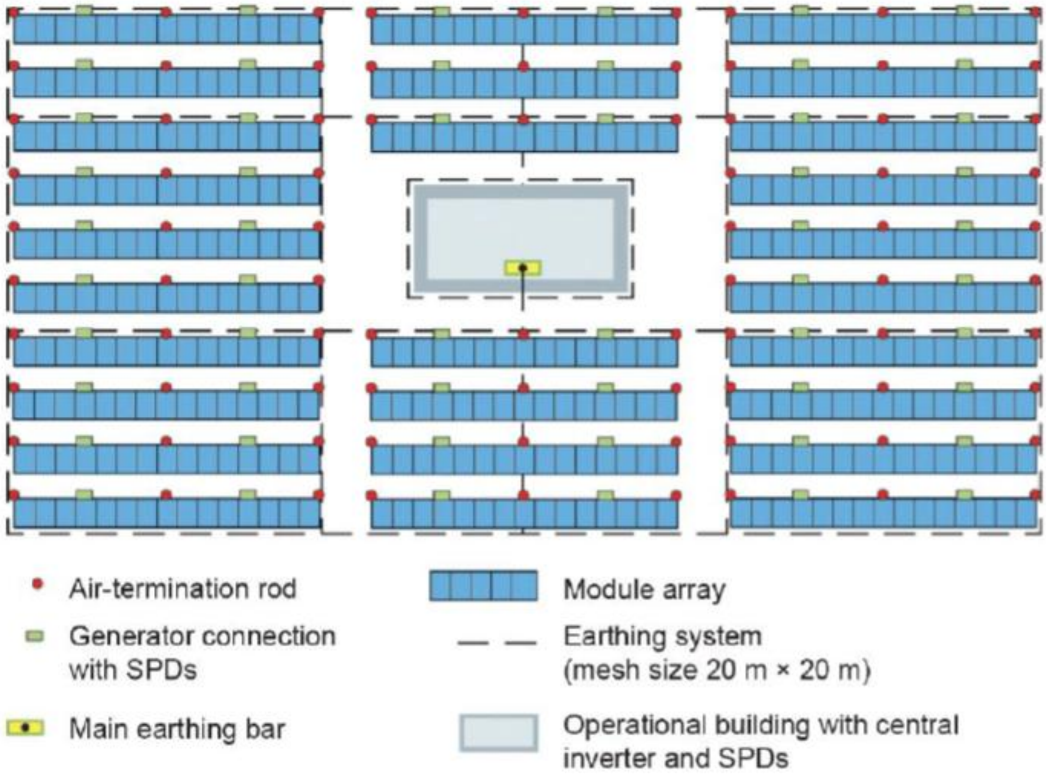


FIG. 21 TYPICAL ARRANGEMENT OF EARTHING AND SURGE PROTECTION DEVICES IN SOLAR PV INSTALLATION

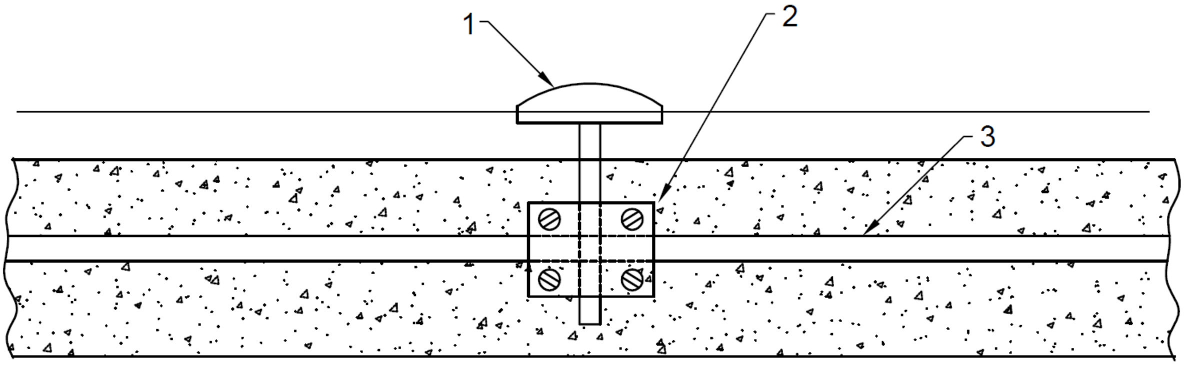
11.4.1.8 *Buildings with roof top telecom towers*

The metallic tower itself will act as air-termination. Antennas mounted above these towers need air-terminals connected to the main structure. The main structure shall be connected to the air-termination conductors for the balance of the building if available. Two separate down-conductors with a size of minimum 150 mm^2 should be used in addition to regular down-conductors to make the bonding between tower and ring earthing. In order to avoid uncontrolled flash overs and also to protect equipment, which may be mounted on the tower itself, special cable with increased dielectric strength as down-conductor should be used in order to avoid separation distance. The area of cross section will be significantly lower than 50 mm^2 but not less than 25 mm^2, which is sufficient enough to discharge the lightning current.

Every power, coaxial, data and other metallic lines connected between the telecom installation and the other parts of the building shall be protected with suitable SPD. It should be ensured that SPDs during their operation do not impede fire safety.

11.4.1.9 *Lightning protection for multi-storeyed car park roofs/helipads*

Air-termination studs (*see* Fig. 22) may be used for lightning protection for multi-storeyed car park roofs/helipads. Air-termination studs used can be connected to the reinforcement steel of a concrete roof. In the case of roofs where a connection to the reinforcement cannot be made, the roof conductors can be laid in the seams of the carriageway slabs and air-termination studs can be located at the mesh joints. The mesh width shall not exceed the value corresponding to the protection class given in Table 5. The persons and vehicles on this parking area are not protected against direct lightning.



KEY

1 AIR - TERMINATION STUD
2 STEEL CONDUCTOR CONNECTING TO SEVERAL BARS OF THE REINFORCEMENT STEEL
3 STEEL REINFORCEMENT TO CONCRETE

FIG. 22 TYPICAL AIR-TERMINATION STUDS USED ON CAR PARK ROOFS

11.4.2 *Down-conductor System*

Down-conductor system is a part of an external LPS intended to conduct lightning current from the air-termination system to the earth-termination system. The down conductor system shall confirm to **5.3** of good practice [8-2(45)]. In order to reduce the probability of damage due to lightning current flowing in the air-termination system, the down-conductors shall be arranged in such a way that from the point of strike to earth,

a) several parallel current paths exist;
b) the length of the current paths is kept to a minimum; and
c) equipotential bonding to conducting parts of the structure is performed.

11.4.2.1 Typical values of the distance between down-conductors are given in Table 6. These values can be used for horizontal ring conductors installed for a tall building more than 60 m height. The minimum number of down-conductors shall be 2 (diagonally opposite to each other) for building with an area less than 100 m^2.

Table 6 Minimum Distance between Down-conductors
(*Clause* 11.4.2.1)

Sl No.	**Class of LPS**	**Distance**
		m

(1)	(2)	(3)
i)	I	10
ii)	II	10
iii)	III	15
iv)	IV	20

11.4.2.2 Down-conductors shall be installed so that, as far as practicable, they form a direct continuation of the air-termination conductors. It shall be installed straight and vertical such that they provide the shortest and most direct path to earth. The formation of sharp bends and loops shall be avoided. Every down-conductor should be connected to a type B ring/foundation earthing. Connection of down-conductor to a type A earthing is allowed only in case of space constraints or existing buildings, where installation is difficult.

11.4.2.3 While routing the down-conductors, separation distance need to be calculated based on good practice [8-2(45)] and maintained from live parts/ services.

11.4.2.4 Lateral connection of down-conductors at ground level and every 10 m to 20 m of height as a ring conductor as per below table is considered to be good practice. The installation of as many down-conductors as possible, at equal spacing around the perimeter interconnected by ring conductors, reduces the probability of dangerous sparking and facilitates the protection of internal installations {*see* good practice [8-2(45)]}. This condition is fulfilled in metal framework structures and in reinforced concrete structures in which the interconnected steel is electrically continuous.

11.4.2.5 Routing of down-conductors (insulated or uninsulated) through electrical and other service shafts are not allowed as it can create fire and explosion during lightning.

11.4.2.6 Separation distance is the distance required between air-terminals/lightning down-conductor and any conductive/metallic/electrical/ electronic part of a building to avoid uncontrolled flashover.

11.4.2.6.1 While calculating the separation distance, the parameter l (length, in m along the air-terminal and the down-conductor from the point where the separation distance is to be considered, to the nearest equipotential bonding point or earth termination system is not bonded to equipotential bonding point or the earth termination) is a major influencing factor. If the down conductors or the earth terminal system is not bonded to equipotential bonding system of the electrical installation in the building. Lightning protection system will be ineffective.

Cable with increased dielectric strength and tested for lightning current discharge may be used to avoid specific separation distance to live parts of the building {*see* good practice [8-2(45)]}.

11.4.2.7 The down-conductor shall be supported using suitable clamps or connectors or exothermic welding. The clamps or connectors or exothermic welding shall be tested for the lightning current as per selected LPL. Reference may be made to table given below and good practice [8-2(45)] for supporting details.

Sl. No.	*Arrangement*	*Fixing Centres for Tape, Stranded and Soft Drawn Round Conductors* mm	*Fixing Centres for Round Solid Conductors* mm
(1)	(2)	(3)	(4)
i)	Horizontal conductors on horizontal surfaces	1 000	1 000
ii)	Horizontal conductors on vertical surfaces	500	1 000
iii)	Vertical conductors from the ground to 20 m	1 000	1 000
iv)	Vertical conductors from 20 m and thereafter	500	1 000

NOTES

1 This table does not apply to built-in type fixings, which may require special considerations.
2 Assessment of environmental conditions (that is, expected wind load) should be undertaken and fixing centres different from those recommended may be found to be necessary.

11.4.2.9 The wind speed shall be taken into account while mounting the air-termination and down-conductor system {*see* good practice [8-2(45)]}.

11.4.3 *Earth-termination System*

Earth-termination system is a part of an external LPS which is intended to conduct and disperse lightning current into the earth. When dealing with the dispersion of the lightning current (high frequency behaviour) into the ground, whilst minimizing any potentially dangerous over voltages, the shape and dimensions of the earth-termination system are the important criteria. In general, a low earthing resistance (if possible lower than 10 ohm when measured at low frequency) is recommended. From the viewpoint of lightning protection, a single integrated structure earth-termination system is preferable and is suitable for all purposes (that is, lightning protection, power systems and telecommunication systems).

Type A earth-termination comprising of vertical/horizontal conductor or Type B earth-termination comprising of ring earthing/foundation earthing shall be used satisfying the requirements of this Code as well as good practice [8-2(45)]. In structures where only electrical systems are provided, a Type A earthing arrangement may be used, but a Type B earthing arrangement is preferable. In structures with electronic systems, a Type B earthing arrangement is recommended.

11.4.3.1 *Type A Earthing*

Length of the earth electrode depends on the soil resistivity and class of LPS {*see* [8-2(45)] for details and Table 7 for vertical earth electrode}.

Table 7 Minimum Length of Vertical Earth Electrode
(*Clause* 11.4.3.1)

Sl No.	Class of LPS	Typical Length of Each Vertical Earth Electrode Based on Soil Resistivity m			
		Up to 500 Ω-m	1 000 Ω-m	2 000 Ω-m	3 000 Ω-m
(1)	(2)	(3)	(4)	(5)	(6)
i)	I	2.5	10	25	40
ii)	II	2.5	5	15	25
iii)	III	2.5	2.5	2.5	2.5
iv)	IV	2.5	2.5	2.5	2.5

11.4.3.2 *Type B Earthing*

This type of arrangement comprises either a ring conductor external to the structure to be protected, in contact with the soil for at least 80 percent of its total length, or a foundation earth electrode. Such earth electrodes may also be meshed. For the ring earth electrode (or foundation earth electrode), the area enclosed by the ring earth electrode (or foundation earth electrode) shall be not less than the value of Type A earthing as given in Table 7 {see *also* [8-2(45)]}.

11.4.3.4 In industrial and commercial structures, the ring earth electrode around the structure or the ring earth electrode in the concrete at the perimeter of the foundation, should be integrated with a meshed network under and around the structure, having a mesh width of typically 5 m. This greatly improves the performance of the earth-termination system. If the basement's reinforced concrete floor forms a well-defined interconnected mesh and is connected to the earth-termination system, typically at every 5 m, the same will also be suitable {*see* good practice [8-2(45)]}.

11.4.3.6 Where large numbers of people frequently assemble in an area adjacent to the structure to be protected, further potential control for such areas should be provided. More ring earth electrodes should be installed at distances of approximately 3 m from the first and subsequent ring conductors. Ring electrodes further from the structure should be installed more deeply below the surface, that is, those at 4 m from the structure at a depth of 1 m, those at 7 m from the structure at a depth of 1.5 m and those at 10 m from the structure at a depth of 2 m. These ring earth electrodes should be connected to the first ring conductor by means of radial conductors.

11.4.3.7 For large buildings integrating structural steel as down-conductor and earth-termination, earth resistivity measurements are not required. Proper drawings should be made based on the actual installation and submitted to authorities if necessary. *See also* good practice [8-2(45)]. However provisions shall be provided for continuity resistance measurement.

11.4.3.8 Touch and step voltage safety measures outside structure shall be installed and maintained as per good practice [8-2(45)].

11.4.4 *Use of Natural Components*

Natural components are conductive component installed in a building not specifically for lightning protection which can be used to provide the function of one or more parts of the LPS.

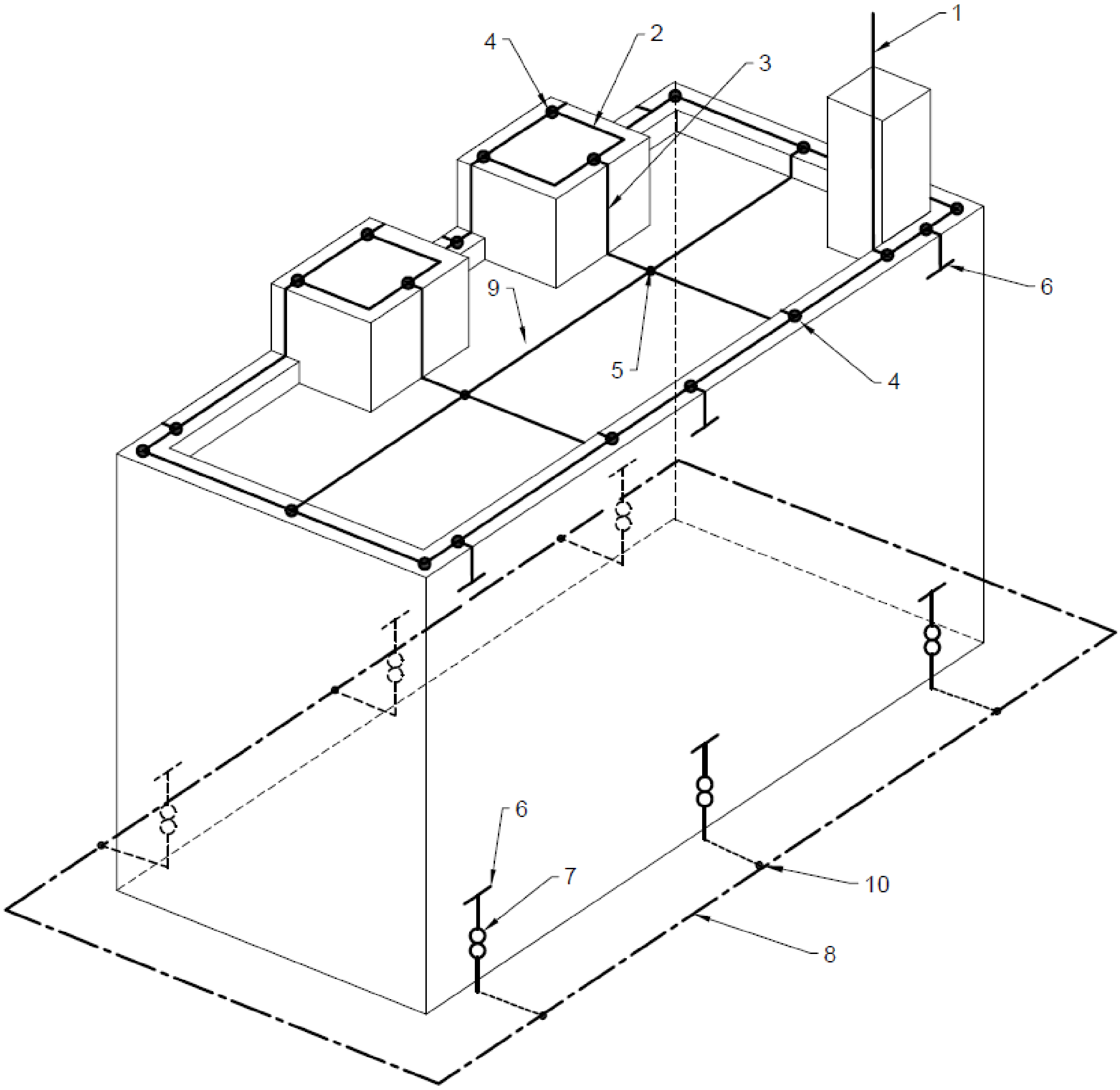
Natural components made of conductive materials, which will always remain in/on the structure (for example, interconnected steel-reinforcement, metal framework of the structure, steel roof, metal façade, handrails, etc) should be used as parts of an LPS such as air-termination, down-conductor and earthing, if it satisfies the requirement according to good practices [8-5(44)] and [8-5(45)]. Bonding of different metallic installations in the building should be done to avoid dangerous potential differences which results in flashover. This integrated method is not only economical but does not influence or spoil the aesthetics of the building. It also reduces the failure of electronic equipment inside the building from radiated lightning effects.

In case of natural down-conductors combined with foundation earth electrodes, test joints are not required and earth resistance measurements are not necessary (*see also* **11.4.3.7**)

11.4.4.1 *Continuity of steelwork in reinforced concrete structures*

Steelwork within reinforced concrete structures is considered to be electrically continuous provided that the major part of interconnections of vertical and horizontal bars are welded or otherwise securely connected. Connections of vertical bars shall be welded, clamped or overlapped a minimum of 20 times their diameters and bound or otherwise securely connected. For new structures, the connections between reinforcement elements shall be specified by the designer or installer, in cooperation with the builder and the civil engineer. *See* [8-2(45)] for details.

For structures utilizing steel reinforced concrete (including pre-cast, pre-stressed reinforced units), the electrical continuity of the reinforcing bars shall be determined by electrical testing between the uppermost part and ground level (*see* Fig. 23). The overall electrical resistance should not be greater than 0.2 Ω, measured using test equipment suitable for this purpose. If this value is not achieved, or it is not practical to conduct such testing, the reinforcing steel shall not be used as a natural down-conductor. In this case it is recommended that an external down-conductor be installed. In the case of structures of pre-cast reinforced concrete, the electrical continuity of the reinforcing steel shall be established between individual adjacent pre-cast concrete units. *See* [8-2(45)] for details.



KEY
1 AIR TERMINATION ROD
2 HORIZONTAL AIR TERMINATION CONDUCTOR
3 DOWN CONDUCTOR
4 T - TYPE JOINT
5 CROSS TYPE JOINT
6 CONNECTION TO STEEL REINFORCING RODS {*see* **E-4.3.3** AND **E-4.3.6** OF GOOD PRACTICE [8-2(45)]}
7 TEST JOINT
8 TYPE B EARTHING ARRANGEMENT, RING ELECTRODE
9 FLAT ROOF WITH ROOF FIXTURES
10 T - TYPE JOINT - CORROSION RESISTANT

NOTE – The steel reinforcement of the structure should comply with available Indian Standards. All dimensions of the LPS should comply with the selected protection level.

FIG. 23 CONSTRUCTION OF EXTERNAL LPS ON A STRUCTURE OF STEEL-REINFORCED CONCRETE USING THE REINFORCEMENT OF THE OUTER WALLS AS NATURAL COMPONENTS

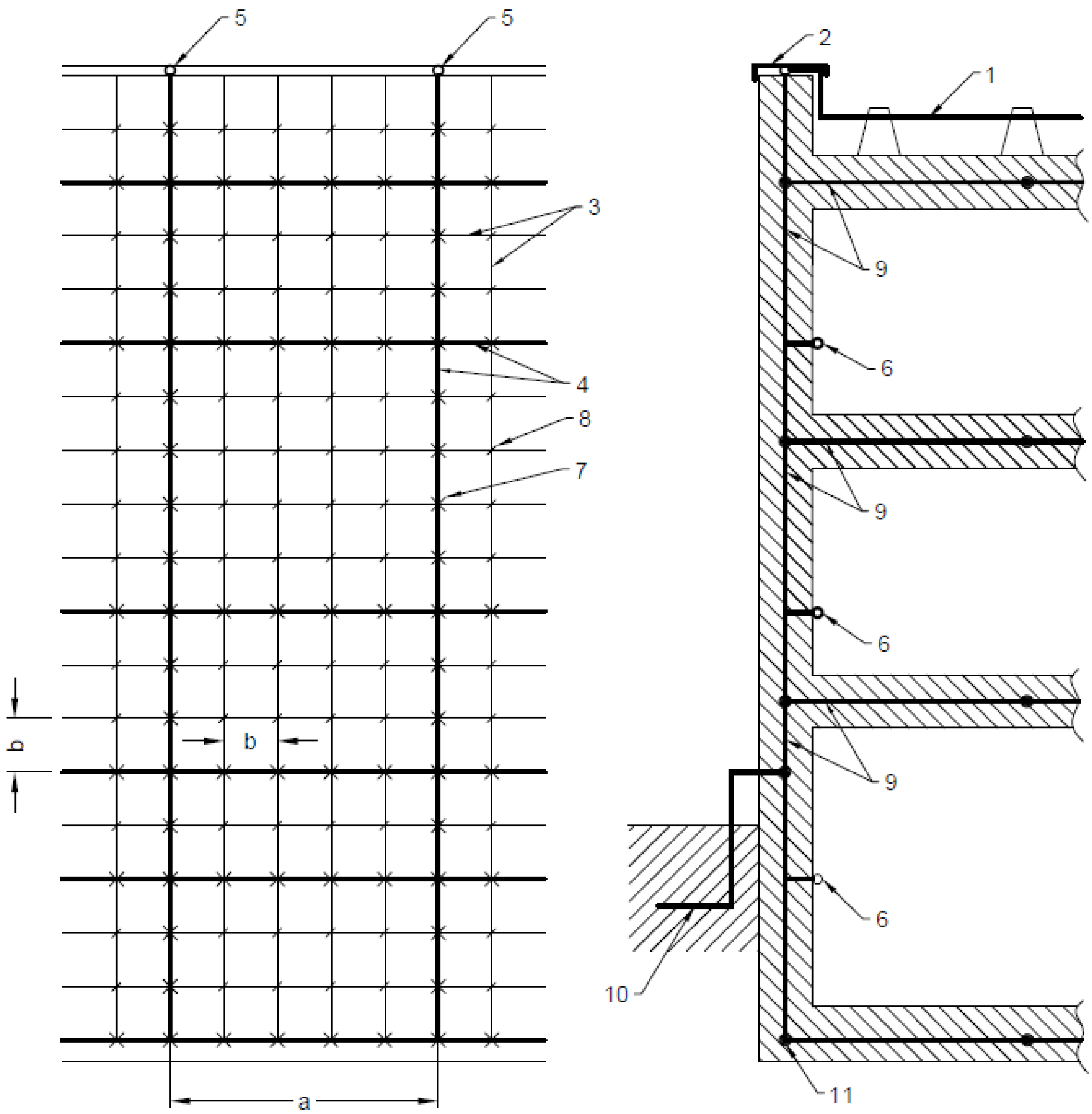
11.4.4.2 *Bonding network*

A low impedance bonding network is needed to avoid dangerous potential differences between all equipment inside the building. Moreover, such a bonding network also reduces the magnetic field, thereby reduces the radiated surges inside the building and provides more protection for electrical electronic equipment {*see* good practice [8-5(48)]}.

This can be realized by a meshed bonding network integrating conductive parts of the structure, or parts of the internal systems, and by bonding metal parts or conductive services at the boundary of each LPZ directly or by using suitable SPDs.

The bonding network can be arranged as a three-dimensional meshed structure with a typical mesh width of 5 m (*see* Fig. 24 and Fig. 25). This requires multiple interconnections of metal components in and on the structure (such as concrete reinforcement, elevator rails, cranes, metal roofs, metal facades, metal frames of windows and doors, metal floor frames, service pipes and cable trays). Bonding bars (for example, ring bonding bars, several bonding bars at different levels of the structure) and magnetic shields of the LPZ shall be integrated in the same way.

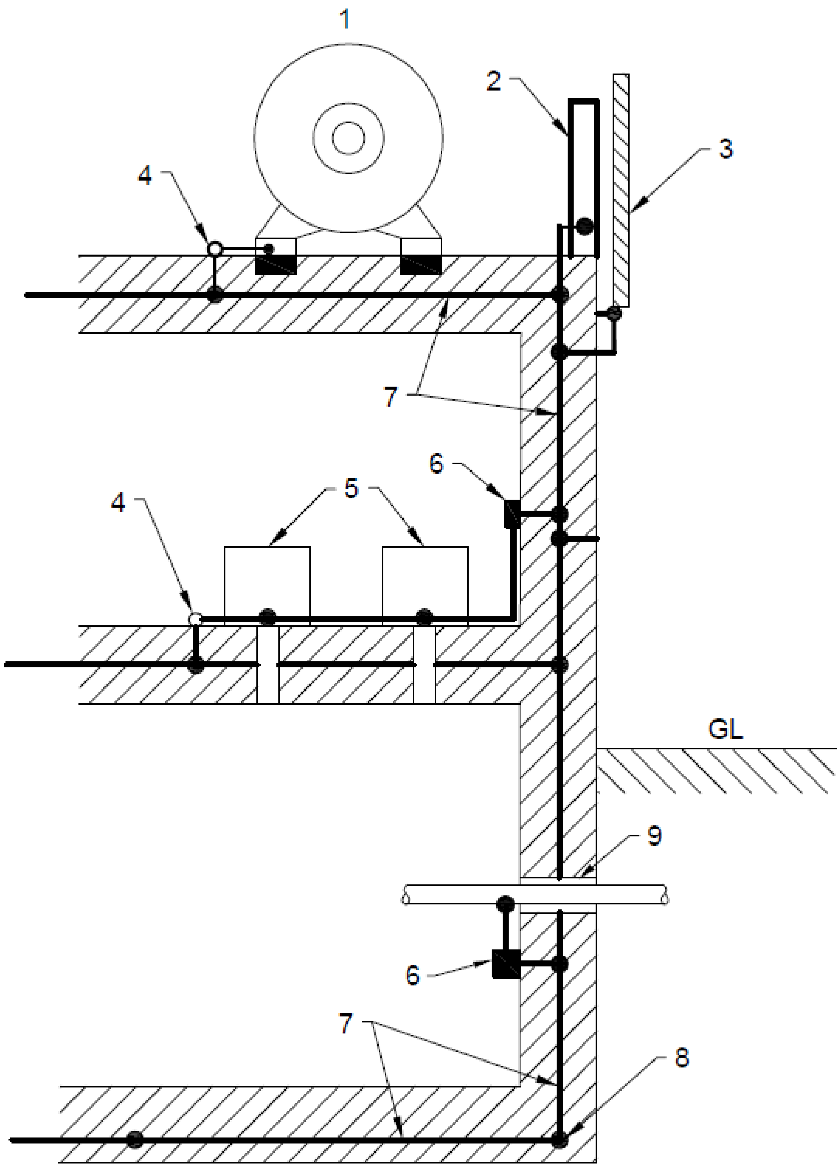
Conductive parts (for example, cabinets, enclosures, racks) and the protective earth conductor (PE) of the internal systems shall be connected to the bonding network {*see* good practice [8-5(48)]}.



KEY

1 AIR-TERMINATION CONDUCTOR
2 METAL COVERING OF THE ROOF PARAPET
3 STEEL REINFORCING RODS
4 MESH CONDUCTORS SUPERIMPOSED ON THE REINFORCEMENT
5 JOINT OF THE MESH CONDUCTOR
6 JOINT OF THE INTERNAL BONDING BAR
7 CONNECTION MADE BY WELDING OR CLAMPING
8 ARBITARY CONNECTION
9 STEEL REINFORCEMENT IN CONCRETE (WITH SUPERIMPOSED MESH CONDUCTORS)
10 RING EARTHING ELECTRODE (IF ANY)
11 FOUNDATION EARTHING ELECTRODE
a TYPICAL DISTANCE OF 5 m FOR SUPERIMPOSED MESH CONDUCTOR
b TYPICAL DISTANCE OF 1 m FOR CONNECTING THIS MESH WITH THE REINFORCEMENT

FIG. 24 UTILIZATION OF REINFORCING RODS OF A STRUCTURE FOR EQUIPOTENTIAL BONDING



KEY

1 ELECTRIC POWER EQUIPMENT
2 STEEL GIRDER
3 METAL COVERING OF THE FACADE
4 BONDING JOINT
5 ELECTRICAL OR ELECTRONIC EQUIPMENT
6 BONDING BAR
7 STEEL REINFORCEMENT IN CONCRETE (WITH SUPERIMPOSED MESH CONDUCTORS)
8 FOUNDATION EARTHING ELECTRODE
9 COMMON INLET FOR DIFFERENT SERVICES

FIG. 25 EQUIPOTENTIAL BONDING IN A STRUCTURE WITH STEEL REINFORCEMENT

11.4.5 *Materials and Dimensions*

Copper and aluminium are recommended for exposed areas on installations required to have a long life. Galvanized steel may be preferred for temporary installations such as exhibition centres. Although it is a common practice to use material in the form of strip for horizontal air-terminations, down-conductors and bonds, it is more convenient to use round material, particularly as it facilitates the making of bends in any plane. *See* Tables 8 to 10 for details for different materials and conditions of use, refer good practice [8-2(45)] for minimum dimension of materials used in LPS.

Table 8 LPS Materials and Conditions of Use[1)]

(*Clause* 11.4.5)

Sl No.	**Material**	**Use**			**Corrosion**		
		In Open Air	In Earth	In Concrete	Resistance	Increased by	May be destroyed by galvanic coupling with
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	Copper	Solid Stranded –	Solid Stranded As coating	Solid Stranded As coating	Good in many environments	Sulphur compounds Organic materials	–
ii)	Hot galvanized steel [2), 3) and 4)]	Solid Stranded[5)]	Solid	Solid Stranded[5)]	Acceptable in air, in concrete and in benign soil	High chlorides content	Copper
iii)	Steel with electro deposited copper	Solid	Solid	Solid	Good in many environments	Sulphur compounds	
iv)	Stainless steel	Solid Stranded	Solid Stranded	Solid Stranded	Good in many environments	High chlorides content	–
v)	Aluminium	Solid Stranded	Unsuitable	Unsuitable	Good in atmospheres containing low concentrations of sulphur and chloride	Alkaline solutions	Copper

1) This table gives general guidance only. In special circumstances more careful corrosion immunity considerations are required.

2) Galvanized steel may be corroded in clay soil or moist soil.

3) Galvanized steel in concrete should not extend into the soil due to possible corrosion of the steel just outside the concrete.

4) Galvanized steel in contact with reinforcement steel in concrete may, under certain circumstances, cause damage to the concrete.

5) Stranded conductors are more vulnerable to corrosion than solid conductors. Stranded conductors are also vulnerable where they enter or exit earth/concrete positions. This is the reason why stranded galvanized steel is not recommended in earth.

Table 9 Material, Configuration and Minimum Cross-Sectional Area of Air-Termination Conductors and Rods, Earth Lead-in Rods and Down-Conductors[1)]

(*Clause* 11.4.5)

Sl No.	Material	Configuration	Minimum Cross-Sectional Area mm^2
(1)	(2)	(3)	(4)
i)	Copper, Tin plated Copper	Solid tape	50
		Solid round[2)]	50
		Stranded[2)]	50
		Solid round[3)]	176
ii)	Aluminium	Solid tape	70
		Solid round	50
		Stranded	50
iii)	Aluminium alloy	Solid tape	50
		Solid round	50
		Stranded	50
		Solid round[3)]	176
iv)	Copper coated aluminium alloy	Solid round	50
v)	Hot dipped galvanized steel	Solid tape	50
		Solid round	50
		Stranded	50
		Solid round[3)]	176
vi)	Copper coated steel	Solid round	50
		Solid tape	50
vii)	Stainless steel	Solid tape[4)]	50
		Solid round[4)]	50
		Stranded	50
		Solid round[3)]	176

[1)] Mechanical and electrical characteristics as well as corrosion resistance properties shall meet the requirements of the IS 18925 series.

[2)] 50 mm^2 (8 mm diameter) may be reduced to 25 mm^2 in certain application where mechanical strength is not an essential requirement. Consideration should in this case, given to reducing the space between fasteners.

[3)] Applicable for air-termination rods and earth lead-in rods. For air-termination rods where mechanical stress such as wind loading is not critical, a 9.5 mm diameter, 1 m long rod may be used.

[4)] If the thermal and mechanical considerations are important, then these values should be increased to 75 mm^2.

Table 10 Material Configuration and Minimum Dimensions of Earth Electrodes[1) and 2)]
(*Clause* 11.4.5)

Sl No.	Material	Configuration	Minimum Dimensions		
			Earth Rod Diameter mm	Earth Conductor mm^2	Earth Plate mm
(1)	(2)	(3)	(4)	(5)	(6)
i)	Copper, Tin plated Copper	Stranded		50	
		Solid round	15	50	
		Solid Tape		50	
		Pipe	20		
		Solid plate			500 x 500
		Lattice plate[3)]			600 x 600
ii)	Hot dipped galvanized steel	Solid round	14	78	
		Pipe	25		
		Solid tape		90	
		Solid plate			500 x 500
		Lattice plate			600 x 600
		Profile	[4)]		
iii)	Bare steel [5)]	Stranded		70	
		Sold round		78	
		Solid tape		75	
iv)	Copper Coated Steel	Solid round	14[6)]	50	
		Solid tape		90	
v)	Stainless steel[7)]	Solid round	15	78	
		Solid tape		100	

1) Mechanical and electrical characteristics as well as corrosion resistance properties shall meet the requirements of IS 18925 series.

2) In case of a type B arrangement foundation earthing system, the earth electrode shall be correctly connected at least every 5 m with the reinforcement steel.

3) Lattice plate constructed with a minimum total length of conductor of 4.8 m.

4) Different profiles are permitted with a cross-section of 290 mm^2 and a minimum thickness of 3 mm, for example, cross profile.

5) Shall be embedded in concrete for a minimum depth of 50 mm.

6) 250µm minimum radial copper coating, with 99.9 percent copper content

7) Chromium ≥ 16 percent, nickel ≥ 5 percent, molybdenum ≥ 2 percent, carbon ≤ 0.08 percent.

11.4.6 Protection measures against injury to living beings due to touch voltage and step voltage shall be provided in accordance with good practice [8-2(45)].

11.4.7 Inspection of the LPS shall be done as per the good practice [8-2(45)].

11.5 Protection of Electrical/Electronic Systems within Structures

11.5.1 The internal LPS shall avoid the occurrence of dangerous sparking within the structure to be protected due to lightning current flowing in the external LPS or in other conductive parts of the structure. Dangerous sparking between different parts can be avoided by means of equipotential bonding or electrical insulation between the parts.

Permanent failure of electrical and electronic systems can be caused by the lightning electromagnetic impulse (LEMP) *via*:

a) Conducted and induced surges transmitted to equipment *via* connecting wiring; and
b) The effects of radiated electromagnetic fields directly into equipment itself.

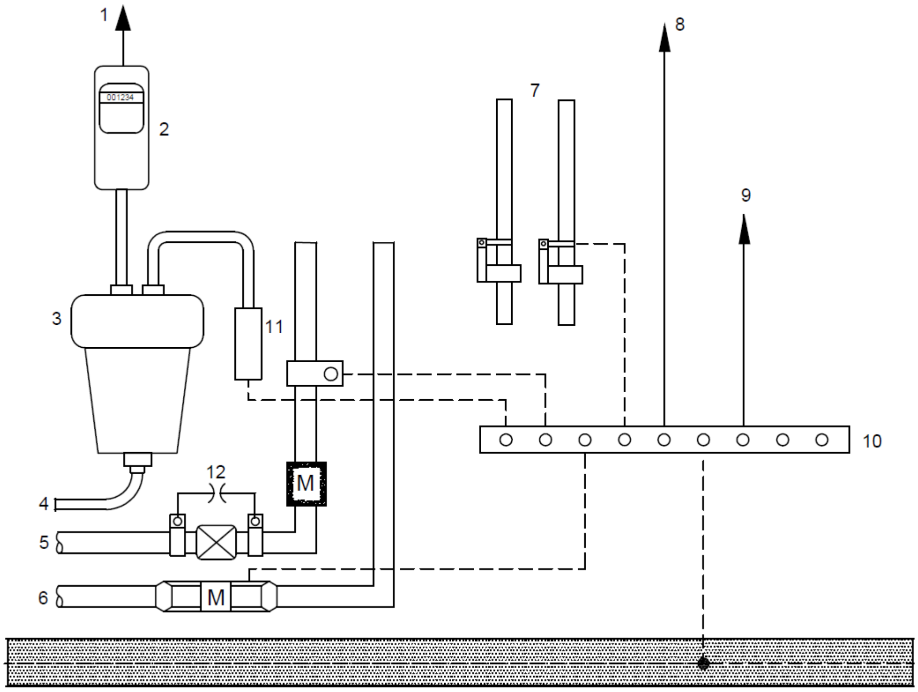
11.5.3 *Equipment Protection Principles*

11.5.3.1 For protection against the effects of radiated electromagnetic fields impinging directly onto the equipment, SPM consisting of spatial shields and/or shielded lines, combined with shielded equipment enclosures should be used.

11.5.3.2 For protection against the effects of conducted and induced surges being transmitted to the equipment *via* connection wiring, SPM consisting of a coordinated SPD system should be used. SPD to be used according to their installation position.

11.5.4 *Equipotentialization of Services to LPS*

Equipotentialization is achieved by interconnecting the LPS with structural metal parts, metal installations, internal systems, external conductive parts and lines connected to the structure. *See* Fig. 26.



KEY

1 POWER TO USER	7 CENTRAL HEATING SYSTEM
2 POWER METER	8 ELECTRONIC APPLIANCES
3 HOUSE CONNECTION BOX	9 SCREEN OF ANTENNA CABLE
4 POWER FROM UTILITY	10 EQUIPOTENTIAL BONDING BAR
5 GAS	11 SURGE PROTECTION DEVICE
6 WATER	12 ISOLATING SPARK PLUG
	M METER

FIG. 26 EXAMPLE OF AN EQUIPOTENTIAL BONDING ARRANGEMENT

Interconnection can be done with bonding conductors, where the electrical continuity is not provided by natural bonding or by using surge protective devices (SPD's), where direct connections with bonding conductors is not feasible (for example, installation of SPD's for power, data, telecom lines, etc). It contains at least one non-linear component to ensure perfect equipotential bonding. All SPD's at the service entrance to an installation should be able to divert 10/350 μS impulse current depending upon selected level of protection. A three phase four wire system should be designed for 50 percent of the I_{imp} of selected LPS and single phase two wire system should be designed for 25 percent of the I_{imp} of selected LPS. The lightning current distribution for three phase four wire system is given in Fig. 27 {*see also* good practice [8-2(46)]}.

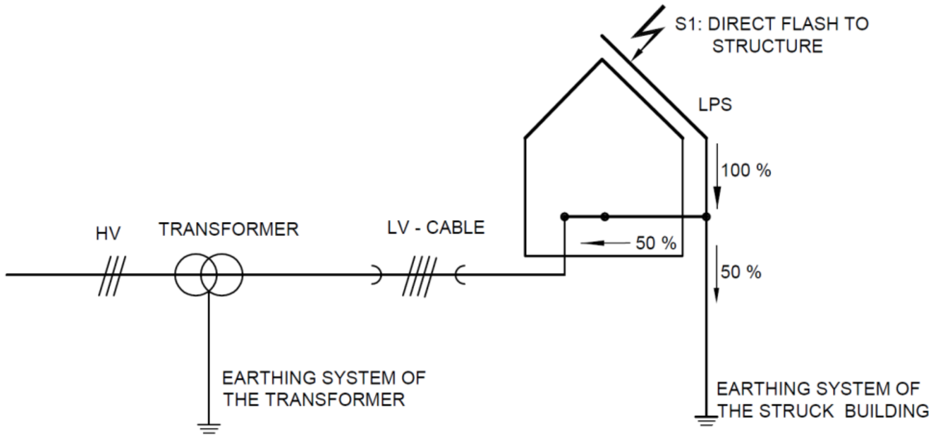


FIG. 27 BASIC EXAMPLE OF BALANCED CURRENT DISTRIBUTION

11.5.5 *Protection Measures with Surge Protection devices (SPD's)*

11.5.5.1 Lightning surges frequently cause failure of electrical and electronic systems due to insulation breakdown or when over voltages exceed the equipment's common mode insulation level. Power line protection is fundamental, however equal importance should be given to data, communication and instrumentation lines of the equipment that need protection. Equipment is protected if its rated impulse withstand voltage U_W at its terminals is greater than the surge overvoltage between the live conductors and earth. If not, an SPD shall be installed.

Implementing coordinated SPDs will provide protection against radiated surges for equipment {*see* good practice [8-2(48)]}. Shielding and routing of power and data lines, bonding of services and various lightning protection zones (LPZ) {*see* good practice [8-2(48)]} and earthing also plays major role in protecting electrical and electronic equipment.

SPDs are used to protect under specified conditions, electrical systems and equipment against various over voltages and impulse currents such as lightning and switching surges. SPD shall be selected according to their environmental conditions and the acceptable failure rates of the equipment and the SPD's.

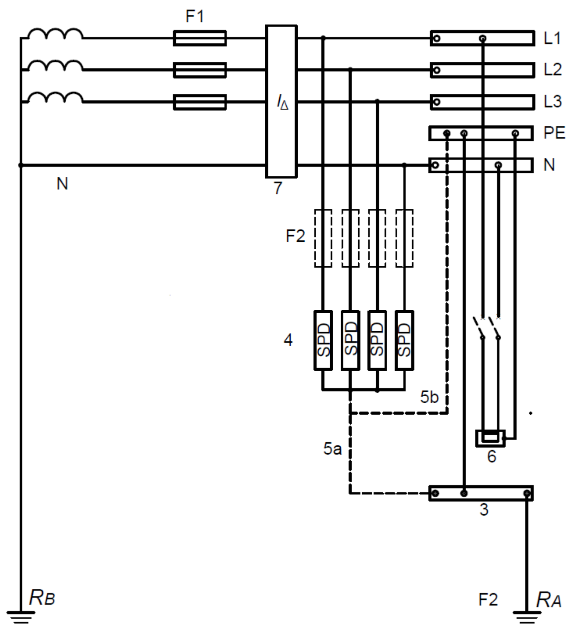
11.5.5.2 *Failure of SPDs*

Possibility of failure of any line to neutral or neutral to earth connected SPDs should not be ruled out, hence measures should be taken within the SPD for safe failure or withstand in worst conditions. SPD can fail in open or short modes. SPD should not create a fire hazard during failure. Safe failure mode is expected from the SPD.

11.5.5.3 *Status indicators*

Each SPD should have inbuilt health indicator so as to show if protection is available. SPD should be installed in a way that visual inspection is easily possible. Failed SPD shall be replaced.

11.5.5.4 SPD's for power line need to be installed according to the type of service such as TN, TT, IT, etc. In general, the SPDs connected as per connection diagram given in Fig. 28 (informative) is suitable for TT connections. Reference may be made to relevant Indian Standard for such installations.

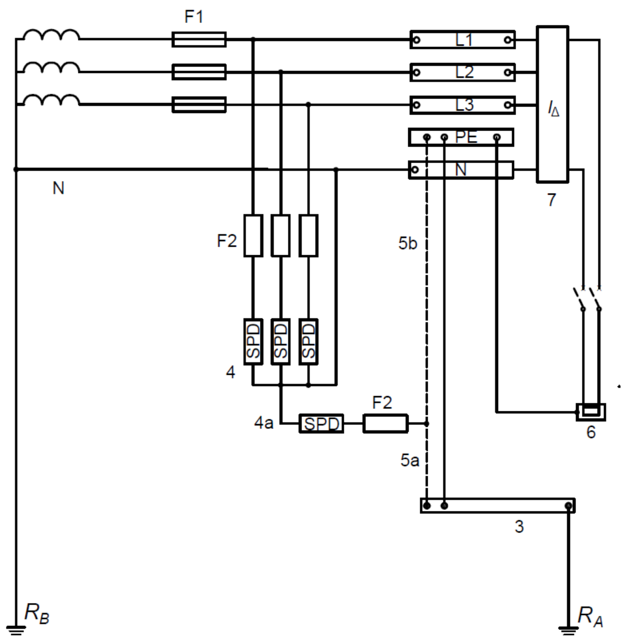


KEY

3 MAIN EARTHING TERMINAL OR BAR
4 SURGE PROTECTION DEVICES PROVIDING PROTECTION AGAINST OVERVOLTAGES OF CATEGORY II (EITHER 5a AND/OR 5b)
5 EARTHING CONNECTION OF SPDs
6 EQUIPMENT TO BE PROTECTED
7 RESIDUAL CURRENT PROTECTIVE DEVICE (RCD)

F1 PROTECTIVE DEVICE AT THE ORIGIN OF INSTALLATION
F2 PROTECTIVE DEVICE REQUIRED BY THE MANUFACTURER OF THE SPD
R_A EARTHING ELECTRODE (EARTHING RESISTANCE) OF THE INSTALLATION
R_B EARTHING ELECTRODE(EARTHING RESISTANCE) OF THE SUPPLY SYSTEM

28A SPDs ON THE LOAD SIDE OF RCD



KEY

3 MAIN EARTHING TERMINAL OR BAR
4 SURGE PROTECTION DEVICES
4a SURGE PROTECTION DEVICES
(A COMBINATION OF 4-4a PROVIDING PROTECTION AGAINST OVERVOLTAGES OF CATEGORY II (EITHER 5a AND/OR 5b)
5 EARTHING CONNECTION OF SPDs
6 EQUIPMENT TO BE PROTECTED
7 RESIDUAL CURRENT PROTECTIVE DEVICE (RCD) , PLACED EITHER UPSTREAM OR DOWN STREAM OF THE BUS BAR

F1 PROTECTIVE DEVICE AT THE ORIGIN OF THE INSTALLATION
F2 PROTECTIVE DEVICE REQUIRED BY THE MANUFACTURER OF THE SPDs
R_A EARTHING ELECTRODE (EARTHING RESISTANCE) OF THE INSTALLATION
R_B EARTHING ELECTRODE (EARTHING RESISTANCE) OF THE SUPPLY SYSTEM
F2 IS REQUIRED IF F1 IS MORE THAN SPECIFIED VALUE OF BACK UP FUSE BY MANUFACTURER (OPTIONAL FOR N-PE CONNECTED SPD)

28B SPDs ON THE SUPPLY SIDE OF RCD

FIG. 28 TYPICAL INSTALLATION OF SPDS IN TT SYSTEM

11.5.5.5 *Selection of SPDs*

SPD(s) need to be selected based on the place of installation as well the impulse voltage withstanding capacity of the equipment. I_{imp}, and I_n, are test parameters used to categorize Class I and Class II SPD(s). They are related to the maximum values of discharge currents, which are expected to occur at the LPL probability level at the location of installation (LPZ) of the SPD in the system. I_n is associated with Class II tests and I_{imp} is associated with Class I tests.

11.5.5.5.1 If no risk analysis according to good practice [8-2(47)] has been carried out or if the current value of SPD cannot be established, Class I SPDs should be installed with an I_{imp} not less than 12.5 kA (10/350μS) for connection according to Fig. 28A or between L to N or PE. For connection according to Fig. 28B, I_{imp} shall not be less than 50 kA (10/350μS) between N and PE for three-phase systems and 25 kA (10/350 μS) between N and PE for single-phase systems. Otherwise the currents shall be considered as per level of protection.

11.5.5.5.2 *Follow current extinguishing capability of the SPD*

Follow current is the short circuit current (rms value) which flows through the SPD when it gets switched on due to lightning strike or surges. The SPD has to restore to normal condition by breaking this short circuit current before back fuse/switchgears are stressed, in order to retain the availability of the services by the load or to retain the availability of protection in the network. Follow current extinguishing capability and short circuit withstand capacity of SPD shall be as per good practice [8-2(48)].

11.5.5.5.3 Where Class II tested SPD {*see* good practice [8-2(48)]} are required at or near the origin of installation, the value of I_n shall be not less than 5 kA for connections according to Fig. 28A or between L to N or PE. For Class II tested SPDs connected between neutral and PE for connection in Fig. 28B, I_n shall not be less than 20 kA for three-phase systems and 10 kA for single-phase systems.

11.5.5.5.4 *Voltage protection level of SPD*

The voltage protection level of SPD is the voltage that is finally exposed to the equipment. The voltage protection level (U_p) should be less than the withstand voltage of the equipment. The voltage protection level of the SPD shall be as less as possible to have better protection but it should be ensured that it should not get switched on due to normal voltage variations or during low spark over voltages {*see* good practice [8-5(48)]}. The values of the withstand voltages of the equipment at various supply voltages is given in Table 11.

Table 11 Rated Impulse Voltage for the Equipment Energized Directly from the Low Voltages Mains

(*Clause* 11.5.5.5.4)

Sl No.	Nominal Voltage of the Supply System[1] Based on IEC 60038:2009 'IEC standard voltages'[2]		Voltage Line to Neutral Derived from Nominal Voltages a.c. or d.c. up to and Including	Rated Impulse Voltage[3]			
	Three Phase	Single Phase		Overvoltage Category [4]			
			V	I	II	III	IV
	V	V		V	V	V	V
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)			50	330	500	800	1 500
ii)			100	500	800	1 500	2 500
iii)		120-240	150	800	1 500	2 500	4 000
iv)	230/400 277/480		300	1 500	2 500	4 000	6 000
v)	400/690		600	2 500	4 000	6 000	8 000
vi)	1 000		1 000	4 000	6 000	8 000	12 000

[1] *See* Annex B of accepted standard [8-2(57)].

[2] The '/' mark indicates a four-wire three-phase distribution system. The lower value is the voltage line-to-neutral, while the higher value is the voltage line-to-line. Where only one value is indicated, it refers to three-wire, while the higher value is the voltage line-to-line. Where only one value is indicated, it refers to three-wire, three-phase systems and specifies the value line-to-line.

[3] Equipment with these rated impulse voltage can be used in installations in accordance with IEC 60364-4-44:2024 'Low-voltage electrical installations - Part 4-44: Protection for safety - Protection against voltage disturbances and electromagnetic disturbances'.

[4] *See* accepted standard [8-2(57)].

11.5.5.5.5 The preferred values of voltage protection level of SPDs, U_p is given below {*see* accepted standard [8-2(49)]}:

> 0.08, 0.09, 0.10, 0.12, 0.15, 0.22, 0.33, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0, 1.2, 1.5, 1.8, 2.0, 2.5, 3.0, 4.0, 5.0, 6.0, 8.0 and 10 kV

Hence for protecting a 240 V/415 V connected equipment, selecting a $U_p \leq 1.5$ kV will be a safer choice. The U_p may be tested and certified by a third party as per the laid down test procedures. *See* Fig. 29 on connection diagram for SPD.

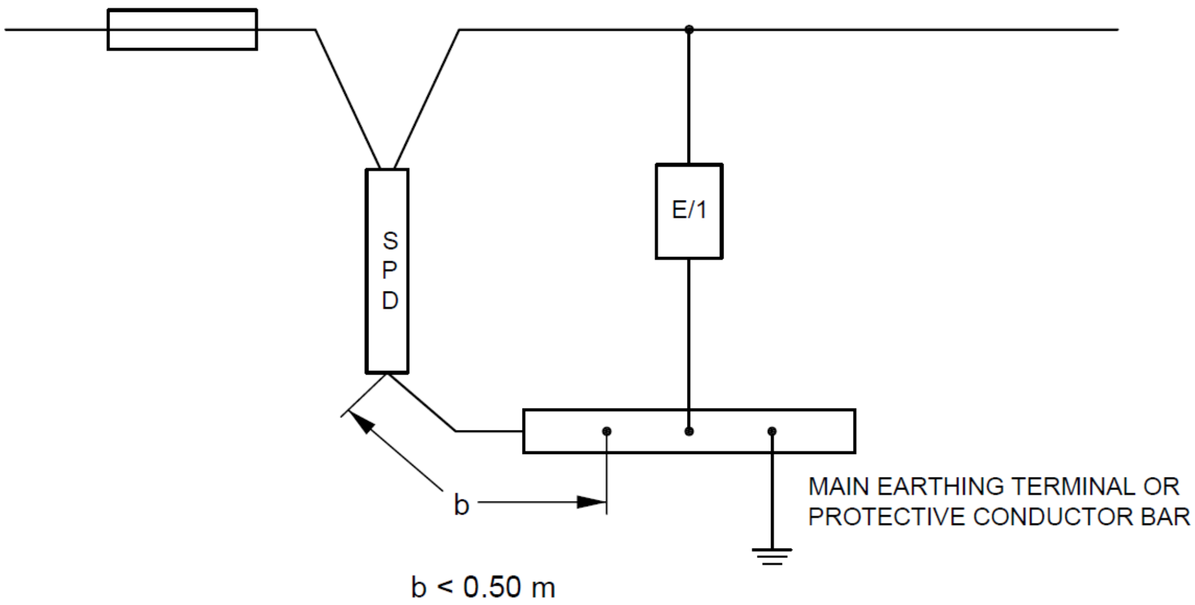


FIG. 29 EXAMPLE OF INSTALLATION OF SPDS AT OR NEAR ORIGIN OF INSTALLATION

11.5.5.6 For small residential buildings, power line SPD at the mains incoming panel will enhance the life of electronic equipment, such as TV, music system, refrigerators, LED lights, etc.

11.5.5.7 For large buildings, power line SPD is required at incoming panel as well as for sub distribution panels based on the LPZ principle {*see* good practice [8-5(48)]}.

11.5.5.8 For industrial and commercial buildings, critical and sensitive loads such as drives, PLC's, automation panels, etc require protection with SPD in addition to SPD at incoming power panels and sub distribution boards. SPDs shall be selected to meet the requirements of relevant LPZs.

11.5.5.9 Lifts, escalators, moving walks and fire panels shall be protected with SPD in control panels. All electrical and control panels related to safety and security of building shall be protected with appropriate SPDs.

11.5.5.10 SPDs should be installed for outdoor equipment such as CCTV cameras, LED street lights, weighbridges, fire fighting systems, roof top solar PV installations, etc. This will ensure availability of the vital services provided by these equipment as and when required.

11.6.5.11 Failure of equipment and chance of fire in electrical installations are more for buildings near tall structures (for example, telecom tower). These buildings should be protected with SPD at power incoming and ring earthing to avoid fire and equipment failure.

11.5.5.12 All SPDs should have status indication to show their healthy state for discharging the lightning current. The possibility of failure of L-N as well as N-PE connected SPD cannot be ignored.

11.5.5.13 The SPD shall be installed at the entrance to ensure perfect bonding to the ground at the time of lightning {*see* good practice [8-2(44)] and [8-2(48)]}. The let through energy of the protection system shall be less than the energy that equipment can withstand. As per good practice [8-5(48)], the energy coordination method is the best method to ensure the protection of the equipment. The let through energy details of the SPD shall be provided by manufacturer.

11.5.5.14 Maximum continuous operating voltage of the SPD (U_c) should not be less than 1.1 x $U_{nominal}$ = 1.1 x 230 = 253 V; however, neutral disconnect tests are done at much higher voltages (above 440 V) to simulate this condition.

The Class I SPD shall be tested to withstand sustained high voltage of minimum 460 V (L-N) under neutral disconnect condition.

11.5.5.15 Low-voltage SPDs for connection to low-voltage power systems shall be conforming to the accepted standard [8-2(49)].

11.5.5.16 SPDs for data/telecommunication line shall be selected considering following parameters:

a) Place of installation {*see* good practice [8-2(48)] for lightning protection zone concept};
b) Immunity of terminal equipment;
c) Earthing of the system to be protected (balanced/unbalanced);
d) Requirement on interface (transmission parameters: voltage, frequency, current); and
e) Mounting interface.

These SPDs shall be tested as per Table 12.

NOTE — Reference may be made to IEC 61643-21:2000 'Low voltage surge protective devices - Part 21: Surge protective devices connected to telecommunications and signalling networks - Performance requirements and testing methods' for requirements and test methods for SPDs for data/telecommunication line.

Table 12 Voltage and Current Waveforms for Impulse-Limiting Voltage
(*Clause* 11.5.5.16)

Sl No. (1)	**Category** (2)	**Type of Test** (3)	**Open-Circuit Voltage** [1)] (4)	**Short-Circuit Current** (5)	**Minimum Number of Applications** (6)	**Terminals to be Tested** (7)
i)	A1	Very slow rate of rise	≥ 1 kV Rate of rise from 0.1 kV/µs to 100 kV/s	10 A, 0.1 A/µs, 2A/ µs ≥ 1 000 µs (duration)	Not applicable (NA)	X1-C X2-C X1-X2[2)]
	A2	AC	Select a test from Table 5[1)]		Single cycle	

Sl No.	Category	Type of Test	Open-Circuit Voltage [1)]	Short-Circuit Current	Minimum Number of Applications	Terminals to be Tested
(1)	(2)	(3)	(4)	(5)	(6)	(7)
ii)	B1	Slow rate of rise	1 kV 10/1 000	100 A, 10/1 000	300	
	B2		1 kV to 4 kV 10/700	25 A to 100 A 5/300	300	
	B3		≥1 kV 100 V/µs	10 A to 100 A 10/1 000	300	
iii)	C1	Fast rate of rise	0.5 kV to <2 kV 1.2/50	0.25 kA to < 1 kA 8/20	300	
	C2		2 kV to 10 kV 1.2/50	1 kA to 5 kA 8/20	10	
	C3		≥1 kV 1 kV/µs	10 A to 100 A 10/1 000	300	
iv)	D1	High energy	≥1 kV	0.5 kA to 2.5 kA 10/350	2	
	D2		≥1 kV	0.6 kA to 2.0 kA 10/250	5	

1) An open-circuit voltage different from 1 kV may be used. However, it shall be sufficient to operate the SPD under test.

2) X1-X2 terminals shall be tested only if it is required.

NOTES

1 For the verification of *U*p, one of the above impulse waveform of Category C is mandatory and A, B and D are optional. Unless otherwise specified, apply 5 positive and 5 negative pulses.

2 For impulse reset, select test from Category B, C and D. Unless otherwise specified, apply 3 positive and 3 negative pulses.

3 For impulse durability measurement, one impulse waveform of Category C is mandatory and A1, B and D are optional.

4 Values listed in this table are minimum requirements; other surge current ratings are possible and can also be found in other standards, for example, ITU-T K series – Recommendations.

11.7 Implementation of Lightning Protection Measures for Typical Buildings

Sl No.	*Type of Building*	*Place*	*Implementation*
(1)	(2)	(3)	(4)
i)	Buildings with no steel reinforced foundation with electricity connection (one or two family private dwellings)	Close to tall structures/ trees [1)]	SPD and ring earthing connected to the power incoming switchboard earth terminal
		Isolated	Class IV external LPS, SPD[2)] and ring earthing
ii)	Buildings with steel reinforced foundation with electricity connection (one or two family private dwellings)	Close to tall structures/ trees [1)]	SPD[2)] and bonding of steel reinforcement to earthing bonding bar[3)]
		Isolated	Class IV external LPS connected to reinforcement and down-conductor[5)] (max every 20 m). SPD[2)] and bonding[3)] of steel reinforcement to earthing bonding bar

Sl No.	*Type of Building*	*Place*	*Implementation*
(1)	(2)	(3)	(4)
iii)	Buildings with steel reinforced foundation with electricity connection (less than 20 m height) [other than those covered in (ii)]	Urban/suburban/ rural	Class IV External LPS connected to reinforcement and down-conductor[5)] (max every 20 m). SPD[2)] and bonding[3)] of steel reinforcement to earthing bonding bar
iv)	Residential high rise buildings (more than 20 m height) with steel reinforced columns/ pillars	Urban/suburban/ rural	
v)	Educational buildings (school/ college/training) for education or recreation for not less than 20 students	Urban/suburban/ rural	Recommended [6)] LPS as per **11.3**. SPD[2)] and bonding of steel reinforcement to earthing bonding bar[3)]. Additional step/touch potential reduction measures in pathways/play grounds
vi)	Institutional buildings (Hospitals/Jails)	Urban/suburban/ rural	
vii)	Assembly buildings (theatres/ passenger stations (rail/bus/air)/exhibition halls/religious buildings	Urban/suburban/ rural	
	Assembly buildings (more than 5 000 people) Railway stations/airport/hill stations/mines	Urban/suburban/ rural	In addition to LPS as per good practice [8-5(45)], [8-5(46)], [8-5(47)] and [8-5(48)], lightning safety areas shall be declared for the assembly of people during thunderstorm
viii)	Offices, banks, data centers, telephone exchanges, broadcasting stations	Urban/suburban/ rural	Recommended[6)] LPS as per good practice **11.3**. SPD[2)] and bonding of steel reinforcement to earthing bonding bar[3)]. Ring earthing as per **11.5.1** for the safe assembly area.
ix)	Industrial buildings/ Storage buildings (without the risk of combustible materials)	Urban/suburban/ rural	
x)	Hazardous Buildings (storage and handling of highly flammable or explosive materials, liquids or gases [7)]	Urban/suburban/ rural	

Sl No.	*Type of Building*	*Place*	*Implementation*
(1)	(2)	(3)	(4)

[1] Side flashes from trees/tall structures are expected if the building is within 5 m. To reduce the impact of side flash, metal conductors (down-conductors) connected to ring earthing need to be installed near the tall structure.

[2] SPD shall be installed in all the incoming services like power, telephone, data etc.

[3] May not be possible for an existing building. Ring earthing is recommended as an alternate. Provision to bond the steel reinforcement to the earthing bus bar shall be provided during the construction of the building using a corrosion resistant metal (such as stainless steel).

[4] Direction boards towards lightning safe area shall be shown.

[5] Down-conductor can be avoided, if reinforcement steel is interconnected according to good practice [8-5(44)].

[6] *Recommended LPS* – Class of LPS as derived in a risk assessment calculation as per **11.3**.

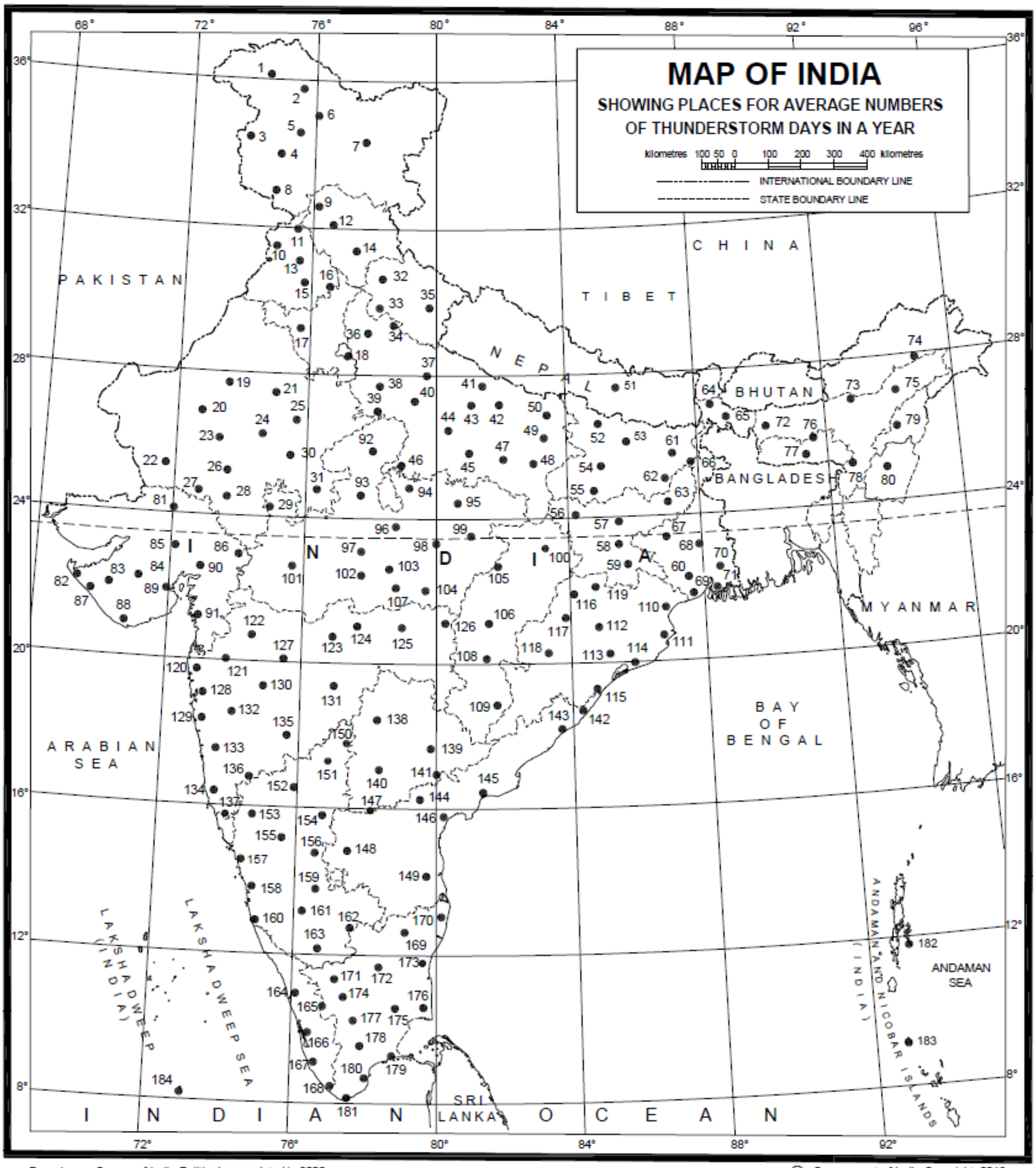
[7] Lightning protection with insulated materials can avoid safety distance of LPS from these installations.

[8] The quality of the connectors and other components of the LPS shall be ensured by following tests:

a) Salt mist test;
b) Humid sulphurous atmosphere treatment tests;
c) Electrical tests for lightning current and resistance;
d) *Mechanical strength tests* – tensile strength, minimum elongation test; and
e) Metal compatibility tests.

11.8 Average Number of Thunderstorm Days

For the purpose of risk assessment, annual thunderstorm days in various places are provided in the table below read with Fig. 30.



Based upon Survey of India Political map printed in 2002.

The territorial waters of India extend into the sea to a distance of twelve nautical miles measured from the appropriate baseline.

The interstate boundaries between Arunachal Pradesh, Assam and Meghalaya shown on this map are as interpreted from the North-Eastern Areas (Reorganization) Act, 1971, but have yet to be verified.

The external boundaries and coastlines of India agree with the Record/Master Copy certified by Survey of India.

The responsibility for the correctness of internal details rest with the publisher.

FIG. 30 MAP OF INDIA SHOWING PLACES FOR AVERAGE NUMBER OF THUNDERSTORM DAYS IN A YEAR

Sl No.	Name of Place	Annual Thunder-storm Days	Sl No.	Name of Place	Annual Thunder-storm Days	Sl No.	Name of Place	Annual Thunder-storm Days
1	Gilgit	7	62	Sabour	76	123	Akola	20
2	Skardu	5	63	Dumka	63	124	Amraoti	32
3	Gulmarg	53	64	Darjeeling	28	125	Nagpur	45
4	Srinagar	54	65	Jalpaiguri	68	126	Gondia	10
5	Dras	3	66	Malda	59	127	Aurangabad	34
6	Kargil	2	67	Asansol	71	128	Mumbai	16
7	Leh	3	68	Burdwan	39	129	Alibag	12
8	Jammu	26	69	Kharagpur	76	130	Ahmadnagar	10
9	Dharmsala	13	70	Kolkata	70	131	Parbhani	32
10	Amritsar	49	71	Sagar Island	41	132	Pune	22
11	Pathankot	4	72	Dhubri	8	133	Mahabaleshwar	14
12	Mandi	46	73	Tezpur	27	134	Ratnagiri	6
13	Ludhiana	12	74	Dibrugarh	98	135	Sholapur	23
14	Simla	40	75	Sibsagar	103	136	Miraj	25
15	Patiala	26	76	Shillong	75	137	Vengurla	39
16	Ambala	9	77	Cherrapunji	49	138	Nizambad	36
17	Hissar	27	78	Silchar	33	139	Hnamkonda	43
18	Delhi	30	79	Kohima	34	140	Hyderabad	28
19	Bikaner	10	80	Imphal	49	141	Khammam	26
20	Phalodi	14	81	Deesa	7	142	Kalingapatam	20
21	Sikar	17	82	Dwarka	5	143	Vishakapatnam	46
22	Barmer	12	83	Jamnagar	8	144	Rentichintala	42
23	Jodhpur	23	84	Rajkot	12	145	Masulipatam	20
24	Ajmer	26	85	Ahmedabad	11	146	Ongole	25
25	Jaipur	39	86	Dohad	17	147	Kurnool	29
26	Kankroli	36	87	Porbandar	3	148	Anantpur	22
27	Mount Abu	5	88	Veraval	3	149	Nellore	18
28	Udaipur	38	89	Bhavnagar	11	150	Bidar	15
29	Neemuch	28	90	Vadodara	8	151	Gulbarga	34
30	Kota	27	91	Surat	4	152	Bijapur	9
31	Jhalawar	40	92	Gwalior	53	153	Belgaum	31
32	Mussorie	61	93	Guna	33	154	Raichur	17
33	Roorkee	74	94	Nowgong	59	155	Gadag	21
34	Najibabad	36	95	Satna	41	156	Bellary	22
35	Mukteswar	53	96	Sagar	36	157	Karwar	27
36	Meerut	–	97	Bhopal	44	158	Honavar	5
37	Bareilly	34	98	Jabalpur	50	159	Chikalthana	24
38	Aligarh	30	99	Umaria	37	160	Mangaluru	36
39	Agra	24	100	Ambikapur	29	161	Hassan	26
40	Mainpuri	23	101	Indore	34	162	Bengaluru	46
41	Bahraich	31	102	Hoshangabad	37	163	Mysuru	44
42	Gonda	22	103	Panchmarhi	30	164	Kozhikode	39
43	Lucknow	18	104	Seoni	51	165	Palghat	35
44	Kanpur	26	105	Pendadah	56	166	Kochi	69
45	Fatehpur	24	106	Raipur	34	167	Alleppey	51
46	Jhansi	20	107	Chhindwara	27	168	Thiruvananthapuram	68
47	Allahabad	51	108	Kanker	37	169	Vellore	25
48	Varanasi	51	109	Jagdalpur	35	170	Chennai	47
49	Azamgarh	1	110	Balasore	81	171	Udhagamandalam	24
50	Gorakhpur	11	111	Chandbali	75	172	Salem	69
51	Katmandu	74	112	Angul	81	173	Cuddalore	37
52	Motihari	38	113	Bhubaneswar	46	175	Trichchirapalli	41
53	Darbhanga	10	114	Puri	33	176	Nagappattinam	15
54	Patna	33	115	Gopalpur	34	177	Kodaikanal	82
55	Gaya	38	116	Jharsuguda	85	178	Madurai	39
56	Daltonganj	73	117	Sambalpur	67	179	Pamban	5
57	Hazaribagh	73	118	Titlagarh	24	180	Tuticorin	14

58	Ranchi	34	119	Rajgangpur	1	181	Cape Comorin	68
59	Chaibasa	70	120	Dahanu	1	182	Port Blair	62
60	Jamshedpur	66	121	Nasik	17	183	Car Nicobar 1	18
61	Purnea	52	122	Malegaon	13	184	Minicoy 1	20

12 ELECTRICAL INSTALLATIONS FOR CONSTRUCTION AND DEMOLITION SITES

12.1 General

12.1.1 Electrical hazards are a major cause of serious injury and even death in construction sites. Accidents also cause loss of productivity and destroy the morale of workers. The need to use electricity and electrical/electronic equipment has been constantly increasing. Without these gadgets productivity and quality of work will suffer. Therefore, the use of electricity and the use of gadgets has to increase. Such increase requires a proper electrical distribution system in the work site.

12.1.2 To ensure continuous supply of power during the construction activity and maintain productivity, site security, etc, the city power supply may required to be supplemented by on-site standby power generation. Some gadgets require continuity of power supply without interruption, thereby requiring UPS systems. In a typical large construction site there may be a large temporary distribution network combined with more than one source of electricity, which can make the system quite complex from the safety point of view.

12.1.3 Problem may also arise in case of lack of required training to workers in the safe use of the tools and equipment that they are required to handle in a system with multiple sources of power supply. In case of use of imported equipment which may be manufactured to their own standards, problems may arise, such as, during connection and inter-connection of equipment and tools and mismatch of plugs and sockets.

12.1.4 Practical guidance to employers, designers, manufacturers, importers, suppliers (including hirers), electrical contractors and electricians on eliminating or reducing the risk of electrocution and electric shock to any person is necessary.

12.1.5 Even though awareness exist about good practices, the same may be compromised at times in the name of speed or economy or due to ignorance and neglect. The materials, equipment, tools, cables, switchgear used in the temporary installation face far more severe environmental working conditions. Use of discarded switchgear, cables, etc, at the construction sites compounds the risk to workmen from shock and fire. The laid down standard need to be followed during construction and demolition meticulously as in the case of permanent installations during building use.

12.2 Installation and Removal of Construction Wiring

All construction wiring work shall be installed by an appropriately registered electrical worker as required by *The Indian Electricity Act*, 2003 and only by electrical workmen holding licence of the appropriate level of competency depending on the voltage, local generation, etc, The installation should be inspected prior to commissioning and at regular intervals by the Engineer-in-Charge (if he is qualified to inspect electrical installations) or by his representative, who should be competent to inspect an installation.

12.3 Provision of Indicating and Recording Instruments and Meters

Measurement is a prerequisite to analyze the performance. Construction site switchboards should have adequate instrumentation (such as, ammeters, PF meters, voltmeters, energy meters) on different branches of the distribution system so that any abnormal condition or overload is noticed. Considering the nature of varying activity in a construction site, frequent visual and instrument based inspections are necessary keeping record of the same.

12.4 RCCB/RCD

Following shall be ensured in construction and demolition sites:

a) Every electric supply to which electrical plant can be connected should incorporate an RCCB/RCD so as to protect persons who may come into contact with the electrical plant against electric shock.
b) The RCCB/RCD(s) should have a rated tripping current not exceeding 30 mA and should have the capacity to carry the load current required by the appliances permitted to be connected in that branch circuit or feeder.
c) Where construction work supply can only be obtained from a permanent wiring socket outlet, RCCB/RCD should be connected at the socket outlet.
d) Sub-mains supplying site sheds should incorporate an RCCB/RCD having a rated tripping current not exceeding 100 mA.
e) Every non-portable RCCB/RCD device on the worksite shall be trip tested by the built-in push button test monthly, and performance tested for operation before being put into service and thereafter at least once every 12 months. It shall also be subjected to an imbalance of current not less than the rated residual current and shall trip in a time not exceeding 6 s.
f) Every portable RCCB/RCD device on the worksite shall be trip tested by the built-in push button test. The test shall be done prior to use and each day while in use; and it shall be performance tested for operation before being put into service and thereafter at least once every 3 months. It shall also be subjected to an imbalance of current not less than the rated residual current and shall trip in a time not exceeding 6 s.
g) Results of RCCB/RCD tests shall be recorded and kept on site or made available for audit and kept for a minimum period of 5 years [excluding the daily push button test for portable RCCB/RCD(s)].
h) Portable RCCB/RCD(s) when tested shall be fitted with a durable, non-reusable, non-metallic tag. The tag shall include the following information:

    1) the name of the person or company who performed the tests; and
    2) the test or retest date.

    The recommended colour coding for tags on tested RCCB/RCD, which is prescribed below should be indicated by its colour representing the period when the test was performed:

January – March	:	Red
April – June	:	Green
July – September	:	Blue
October – December	:	Yellow

j) Portable generators should be fitted with RCDs and the RCDs should be fitted with core balance earth leakage protection having a rated tripping current not exceeding 30 mA.

k) Personal hoists used on construction sites shall be supplied from a separate final sub-circuit originating from the main switchboard; and be suitably identified by marking this supply, the RCD/MCB feeding it.

12.5 Temporary Supply Switchboards

All temporary supply switchboards used on building, construction and demolition sites shall be of robust construction and either securely attached to a pole, post wall or other structure which may be of stable freestanding design and,

a) where installed in outdoor locations, should be constructed and maintained to IP23 (or higher) rating so that safe operation is not affected by the weather;

b) switchboards should incorporate the support and elevation of cables and flexible extension cords;

c) switchboard enclosures shall be provided with an insulated or covered tie-bar or similar arrangement for the anchorage of the cables or flexible cords in order to prevent strain and mechanical damage at the termination of the cables or cords;

d) switchboards should be provided with a door and locking facility. The doors should be designed and attached in a manner that will not damage any flexible cord connected to the board and should protect the switches from mechanical damage;

e) the door should be provided with signs (in English, Hindi and at least one local language) stating, 'KEEP CLOSED – LEADS THROUGH BOTTOM';

f) switchboards should have an insulated slot (with edges suitably shaped or covered with plastic or rubber trims to avoid damaging the cable insulation/sheath) at the bottom for the passage of leads;

g) switchboards should be attached to a permanent wall or suitable portable or temporary structure in an elevated position suitable for easy access and least interference with the activity in the area.

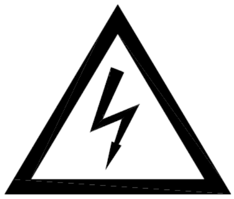
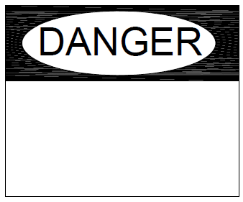
h) if the floor in that area is likely to be wet, additional precautions are necessary and an insulated platform should preferably be provided for access to operation of switches. Personal protective equipment such as gloves should be available, placed near the switchboard, as an alternative.

j) a clearance of at least 1.2 m should be maintained in front of all switchboards;

k) the contractor or nominated persons should ensure that all power circuits are isolated or made inaccessible so as to eliminate the risk of fire, electric shock or other injury to persons after completion of the daily work;

m) switchboards shall be legibly and indelibly marked with a set of numbers or letters or both which uniquely identify the switchboard from others on a site;

n) switchboards shall be marked to indicate the presence of live parts in accordance with symbols such as the following drawing:

---

p) chart indicating first aid measures for electric shock management should be placed near the switchboard;
q) ‘Lock Out and Tag Out’ procedures as adopted should be displayed;
r) the switchboard should be lighted properly to ensure its identification and safe working; and
s) all switchboards should have their identification names (or/and numbers) so that and communication/instructions about them are unambiguous.

12.6 Cables Used in Worksite Installations

12.6.1 Worksite poses a number of hazards to the cables. The conditions are severe compared to those in permanent installations. Cables face dust, moisture, abrasives and even impact unlike those in permanent installations. Extra care should be taken to frequently inspect the cables and discard cables which show signs of damage as a damaged insulation combined with moisture can be dangerous.

12.6.2 Cables are likely to be run over by vehicles. Suitable protection by a steel pipe or hume pipe or steel plate, whichever is appropriate, is required. Dragging of cables damages their sheath/insulation and may also cut a few strands of the conductor due to stretching, effectively reducing the current carrying capacity.

12.6.3 Overhead installation of cables is a common practice. Such installations should use a GI wire to carry the weight of the cable without causing the stretching of the cable. The carrier GI wire should be earthed. Unarmoured cables shall not be installed on metallic roofs or similar structures unless suitably protected against mechanical damage.

Overhead wiring should be positioned to avoid crossing roadways or accessways where cranes, high loads, or heavy machinery may travel. Where it is not possible to avoid accessways an effective means shall be provided to minimize the risk of the vehicular contact with the aerial wiring system. This condition may be satisfied by the placement of flagged catenary wires or cables of suitable material across the accessway 6 m on either side of the overhead wiring and 0.6 m below the lowest point of the overhead electrical cables or lower.

All aerial conductors installed on construction and demolition sites shall be insulated. Cables supported by means of a catenary shall be stranded or shall be flexible cables affording double insulation or the equivalent of double insulation. Construction wiring (including switchboards) shall be visually inspected at intervals not exceeding 6 weeks.

12.7 Extension Cords and Fittings

12.7.1 It shall be ensured that 3-pin plugs and cord extension sockets used on flexible extension cords and portable power tools are either of non-rewirable (moulded) or transparent type. Cables that are normally used for fixed wiring should not be used as flexible extension cords.

12.7.2 Flexible extension cords shall not be located with plug socket connections in wet places or places where they may be subject to damage by liquids. Fittings for flexible cables or flexible extension cords shall be wired identically and the identity of phase, neutral and earth connections are preserved in a like manner. Bending radius limits for cables should be strictly ensured; else internal breakage of strands can occur leading to reduction of capacity, spot heating, etc.

Flexible extension cords used in multi-storeyed building construction works shall be confined to the same floor as the power source, except in case of formwork; external staging; lift or service shafts; and stairwells. Extension cords shall be confined to not more than one storey above or below the location of the switchboard and be mechanically protected in the transition area between storeys and in places where damage is likely to occur.

The recommended maximum length of a 230 V cord extension is given below:

Sl No.	*Cord Extension Set Rating*	*Conductor Area*	*Maximum Length of Flexible Cord*
	A	mm^2	m
(1)	(2)	(3)	(4)
i)	10	1.0	25
		1.5	35
		2.5	60
ii)	15	1.5	25
		2.5	40
iii)	20	2.5	30
		4.0	50

12.7.3 Joints in temporary wiring shall be avoided. Unavoidable joints should be made with suitable crimped ferrule and insulated with PVC tape on individual core joints and further protected by a sleeve or a covering of tape. Combination of teflon tape followed by PVC tape is recommended where exposure to water is anticipated.

12.7.4 Construction wiring shall be readily distinguishable from permanent wiring by using cable of a different colour or by attaching iridescent yellow tape spaced at intervals not exceeding 5 m and stamped with the words ‘construction wiring’.

12.8 Electrical Plant in Service Testing

Electrical plant shall be inspected and tested in accordance with the following:

a) Movable electrical plant that is hand held or portable during operation or moved between operations and is subject to damage or harsh environment shall be examined and tested every 3 months.
b) All other electrical plant used for construction purposes shall be inspected and tested at intervals not exceeding 6 months.
c) When any equipment inspected or tested in accordance with (a) and (b) is found to be unsatisfactory, it shall be withdrawn from service immediately and have a label attached to it, “Warning against Further Use”. Electrical plant found to be unsatisfactory shall not be returned to service until it has been repaired and retested.
d) The inspection and testing specified should be carried out by an authorized/qualified person.
e) The results of the inspection of electrical plant should be recorded and kept on site or made available for inspection by authorities. Information recorded shall include,

    1) the name of the person or company who performed the tests;
    2) the test or retest date; and
    3) identification of faulty equipment and action taken to repair or remove it from use.

12.9 Lighting

Following in respect of lighting shall be ensured in construction and demolition sites:

a) *Access Lighting* – Adequate artificial lighting should be installed to illuminate the work area if there is insufficient natural lighting. Lamps in luminaires shall be protected against mechanical damage. Luminaires installed as part of the permanent electrical installation in site accommodation, may not require further mechanical protection.

   Sufficient battery powered lighting shall be installed in stairways and passageways to allow safe access and exit from the area if there is insufficient natural lighting. If there is a loss of supply to the normal lighting in the area, it should be ensured that battery powered lighting has sufficient capacity to operate for one hour to allow persons to exit the building safely.

   Temporary wiring supplying lighting circuits should be connected to the designated lighting circuits of the switchboard.

b) *Task Lighting* – Portable luminaires shall be provided with the appropriate ingress protection (IP) rating. Task lighting in many construction site may have to move continuously in steps as the work progresses. The lighting system should also be shifted in suitable steps instead of simply extending the cables without any consideration for safety. Hand held additional lights, if any, should be taken from a socket protected by a RCCB/RCD of 30 mA setting just like hand held tools.

c) *Lift and Service Shaft Lighting* – Lift and service shaft lighting may have either construction wiring or permanent wiring. Fluorescent lighting should be used. The lights should be located on the floor above or below the work area. It shall be ensured that the emergency lighting has sufficient battery capacity to operate for a minimum of 1 h if there is a loss of supply to the normal lighting in the area.

d) *Lighting in Means of Egress* – Sufficient battery powered lighting shall be installed in stairways and passageways to allow safe access and exit from the area if there is insufficient natural lighting. If there is a loss of supply to the normal lighting in the area it shall be ensured that battery powered lighting has sufficient capacity to operate for 1 h to allow persons to exit the building safely.

e) Illumination of Signs and Warning Boards – Sufficient lighting should be available to illuminate the sign boards and warning boards. These lights may also be a part of the lighting set for means of egress.

12.10 Transportable Construction Buildings (Site Sheds)

Electrical installations to transportable construction buildings shall comply with the following:

a) If supply is by means of a flexible cord, the same shall not be taken from one transportable building to another transportable building;
b) The flexible cord supplying a transportable building should not be more than 15 m in length;
c) Each amenities in the building shall be connected/supplied by a flexible cord to a final sub-circuit protected by an RCCB/RCD device with a rated tripping current not exceeding 30 mA; these flexible cords should be protected from mechanical damage and power outlets in site sheds should be used to supply power to the equipment and lighting within the shed only; and
d) Socket-outlets installed on the outside of transportable building shall be used only to supply power to the following:

    1) Electrical equipment and lighting immediately adjacent to those transportable buildings.
    2) Other transportable buildings when the socket-outlet is part of an interconnecting system and the flexible cord supplying those transportable buildings has a maximum length of 15 m.

12.11 Lock-Out and Tag-Out Practices

Whenever an electrician is to work on a branch feeder from the switchboard it becomes necessary that the switch feeding the feeder on which work is done is to be switched-off and should be kept switched-off till the same electrician decides to switch on after completion of work either for testing or for putting the section back into service. To ensure that during the period an electrician is working on a feeder or the equipment it feeds, the practice is to put a ‘Tag’ on the concerned switch. The tag will carry details about which authorized worker has put the tag and when and who is authorized to remove it. This is a very critical operating practice for maintenance of the electrical system and following it is of particular importance in the case of temporary installations, where such requirements arise more often than in permanent installations.

Lock-out procedure shall be similar to the above but the difference is that the relevant switch is kept locked in off position and the key is kept by the person or the team leader who will be working on the feeder. The system should also maintain a register where the activities of this nature and the details of action (repair, transfer of the end equipment to a new location, addition of a new appliance on the feeder, etc) are recorded.

12.12 Standard Operating and Maintenance Practices in Sites with More Than One Source of Electricity

12.12.1 In medium and large construction sites it is common to use local generation of electricity by a diesel generating set. The reasons may be lack of dependable local/city distribution system for continuous power supply, high cost of temporary connection charges, restrictions on use of certain equipment like welding transformers on temporary connection, etc. Apart from DG sets for power requirement of site construction equipment, there may be office equipment with computers, site laboratory equipment which require un-interruptible power supply. Shock hazards depend on the voltage of the system and the consequent current flow through the body. As such shock risk associated with all these sources is the same.

12.12.2 Wherever an alternative power supply is provided, proper protocols shall be adopted for the supply from different systems and the associated change-over switch or contactors. Risk increases due to existence of more than one source of power supply. System schematics, operating practice and essential interlock between the different sources of power should be displayed and followed systematically. Earthing for each system should be provided. Changeover switches should be of 4-pole in order to ensure that earth leakage protections operate properly with each one of the power sources. The system should also maintain a register where the activities related to each source of power is recorded and the actions to be taken are provided.

12.13 Earthing or Grounding

12.13.1 Earthing or grounding is an essential pre-requisite for any electrical system from the aspect of safety of personnel, equipment, appliances and for avoidance of fire due to short-circuit or of feeding energy to a short circuit originating from any other cause consequent to damage to insulation by the fire.

12.3.2 The standard earthing practice is applicable to temporary installations also. The earth sets installed at the initial development of the site can be planned to be retained as earthing sets for use even after the completion of the building for the permanent installation.

12.3.3 The minimum requirement of earthing for any temporary electrical installation is given hereunder for easy adherence to the basic minimum. It is recommended to follow the earthing requirements given in **8**.

12.3.3.1 The neutral of the system of each source or generator shall be having two distinct connection to two distinct earthing sets. All metal parts associated with electrical equipment are required to be connected to earth. The minimum requirement is the provision of two pipe earthing sets each with a pipe of 2.5 m length and separated by at least 2.5 m between them and connected to the source neutral by a conductor of cross-section more than half the size used for the phase conductor.

12.3.3.2 Earth continuity shall be maintained all over the site wherever electricity is made available and the earth continuity conductor shall have a cross-section at least more than that used for the phase conductor.

12.3.3.3 Wherever the requirements of earthing and use of RCD or RCCB cannot be satisfactorily met with at any site and electrical hand tools are required to be used, low voltage (< 50 V) appliances or self-contained battery operated tools shall be used as a safe alternative. This applies to work under damp or water logged areas also.

13 PROTECTION OF HUMAN BEINGS FROM ELECTRICAL HAZARDS

13.1 General

Danger to persons due to contact with live parts is caused by the flow of the current through the human body. The effects on the human body are dependent on the amount of the current flow and the duration of the flow. The current flow through the human body depends on the voltage and the resistance in the path. The contact resistance forms an important or significant contributor to the total resistance for the current flow. The contact resistance reduces by a factor of 100 to 1 000 due to the body part being wet and also the touch pressure at the point of contact.

13.1.1 *Physiological Effects of Electric Shock*

The following are the physiological effects of electric shock:

a) *Tetanization* – The muscles affected by the current flow involuntarily contract and letting go of gripped conductive parts is difficult.

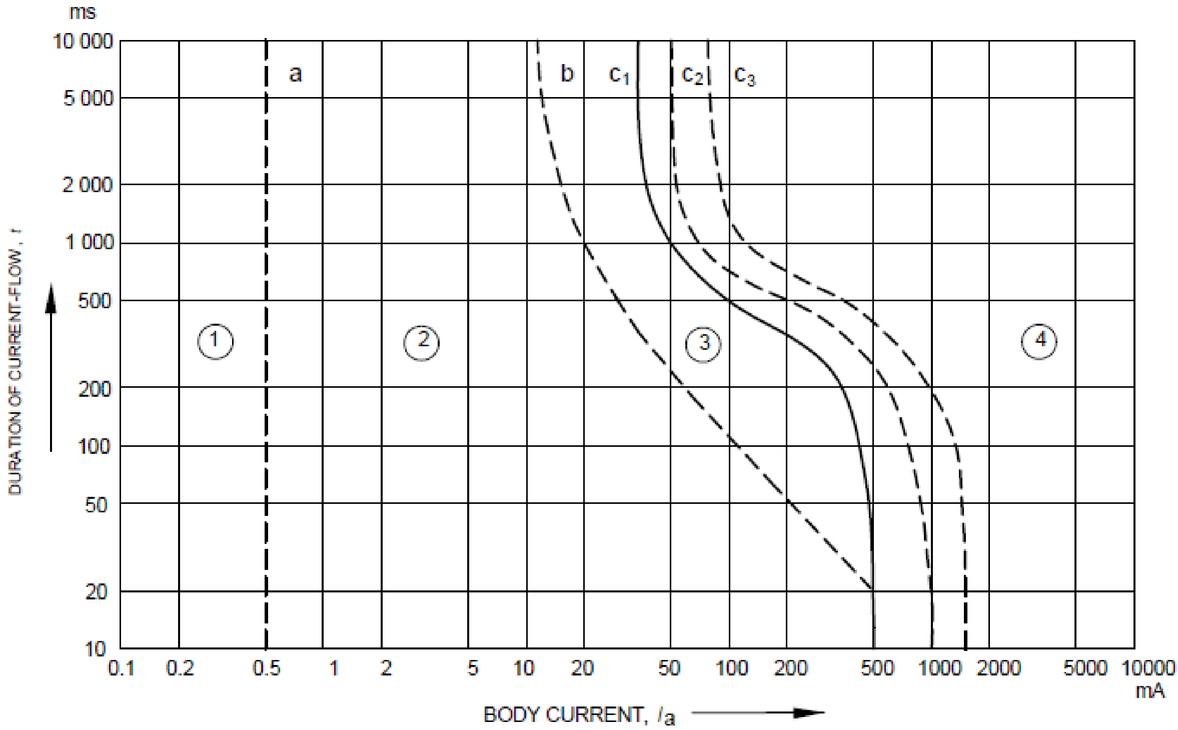
   NOTE — Very high currents do not usually induce muscular tetanization because, when the body touches such currents, the muscular contraction is so sustained that the involuntary muscle movements generally throw the subject away from the conductive part.

b) *Breathing arrest* – If the current flows through the muscles controlling the lungs, the involuntary contraction of these muscles alters the normal respiratory process and the subject may die due to suffocation or suffer the consequences of traumas caused by asphyxia.

c) *Ventricular fibrillation* – The most dangerous effect is due to the superposition of the external currents with the physiological ones, which, by generating uncontrolled contractions, induce alterations of the cardiac cycle. This anomaly may become an irreversible phenomenon since it persists even when the stimulus has ceased.

d) *Burns* – They are due to the heating deriving, by Joule effect, from the current passing through the human body.

13.1.2 On a time-current diagram (*see* Fig. 31), four zones to which the physiological effects of alternating current (15 to 100 Hz) passing through the human body have been related as given below:



NOTES

1 As regards ventricular fibrillation, this figure relates to the effects of current which flows in the path "left hand to feet". For other current paths, *see* Clause 5 and Table III of the accepted standard [8-2(50)].

2 The point 500 mA/100 ms corresponds to fibrillation probability in the order of 0.14 percent.

Zones	Physiological effects
Zone 1	Usually no reaction effects.
Zone 2	Usually no harmful physiological effects.
Zone 3	Usually no organic damage to be expected. Likelihood of muscular contractions and difficulty in breathing, reversible disturbances of formation and conduction of impulses in the heart, including atrial fibrillation and transient cardiac arrest without ventricular fibrillation increasing with current magnitude and time.
Zone 4	In addition to the effects of Zone 3, probability of ventricular fibrillation increasing up to about 5 percent (curve c_2), up to about 50 percent (curve c_3) and above 50 percent beyond curve c_3. Increasing with magnitude and time, pathophysiological effects such as cardiac arrest, breathing arrest and heavy burns may occur.

FIG. 31 TIME/CURRENT ZONES OF THE EFFECTS OF a.c. CURRENTS (15 Hz to 100 Hz)

13.1.3 In general, 'special locations' involve one or more of the following environmental conditions or different risks, which in the absence of special arrangements, will give rise to an increased risk of electric shock:

a) Wetness or condensation, that is, reduced skin resistance;
b) Absence of clothing, that is, greater opportunity to make direct or indirect contact through increased area of bare skin and bare feet;
c) Proximity of earthed metalwork, that is, increased risk of indirect contact; and
d) Arduous or onerous site conditions, that is, conditions of use that may impair the effectiveness of the protective measures.

13.1.3.1 The additional requirements for these 'special locations' have been devised by assessing the relevant risks under each of the above categories and making adjustments to the protective measures accordingly. The intention is to remove or minimize the additional risks to users presented by the electrical installations within these 'special locations'. Designers, installers and operators of such installations should consider the particular requirements of the installation and design and install or operate the installation to reduce or protect against risks from these requirements. It should be however recognized, that all installations require adequate regular periodic inspection and testing, and any necessary maintenance or repair works be properly carried out.

13.2 Protection Against Electric Shocks

13.2.1 Protective measures against electric shock are based on following two common dangers:

a) Contact with an active conductor, which is live with respect to earth in normal circumstances; and is referred to as a 'direct contact' hazard.
b) Contact with a conductive part of an apparatus which is normally dead, but which has become live due to insulation failure in the apparatus; and is referred to as an 'indirect contact' hazard. The third type of shock hazard exists in the proximity of MV or LV (or mixed) earth electrodes which are passing earth-fault currents.
c) This hazard is due to potential gradients on the surface of the ground and is referred to as a 'step-voltage' hazard; shock current enters one foot and leaves by the other foot, and is particularly dangerous for four-legged animals. A variation of this danger, known as a 'touch voltage' hazard can occur, for instance, when an earthed metallic part is situated in an area in which potential gradients exist. Touching the part would cause current to pass through the hand and both feet. Animals with a relatively long front-to-hind legs span are particularly sensitive to step-voltage hazards.

NOTE — Cattle have been killed by the potential gradients caused by a low voltage (240/415 V) neutral earth electrode of insufficiently low resistance.

13.2.2 Potential-gradient problems as mentioned in **13.2.1** are not normally encountered in electrical installations of buildings, provided that equipotential conductors properly bond all exposed metal parts of equipment and all extraneous metal (that is, those which are not part of an electrical apparatus or the installation, for example structural steelwork, etc) to the protective-earthing conductor.

Potential-gradient problems do exist at the switchboards of electrical installations. Even where components, such as the metallic cubicle and operating handle are earthed, there is a possibility that for very short duration when a fault current is flowing through the metal part, the potential of the earthed metal part may be increased due to the current flow. The practice of using an insulating mat at places where the switches are to be operated, is for protection against such transient over-voltages in earthed metal parts (if the metal part is not earthed the transient overvoltage will be beyond safe limits).

With the increased use of pumped water in bathrooms for spa-baths, power showers, etc, there is a need, on occasions, to provide for motive power within the area of the bath. In order to protect against direct and indirect contact, supplies for such equipment shall be by extra-low-voltage-system with the nominal voltage not exceeding 12 V r.m.s.

It is a requirement to provide supplementary equipotential bonding by bonding all simultaneously accessible exposed and extraneous conductive parts. This should include all in-coming metallic services (including metal wastes) and any structural metalwork, including a metallic floor grid, if provided.

Protection measures as given in **13.2.3** to **13.2.5** shall also be provided for protection against electric shock.

13.2.3 *Direct-Contact Protection or Basic Protection*

The main form of protection against direct contact hazards is to contain all live parts in housings of insulating material or in metallic earthed housings, by placing out of reach (behind insulated barriers or at the top of poles) or by means of obstacles. Where insulated live parts are housed in a metal envelope, for example transformers, electric motors and many domestic appliances, the metal envelope is connected to the installation protective earthing system. Protection classification and the details of the different levels of protection are designated by IP XX and IK X {*see* good practice [8-2(6)]}. The metallic enclosure has to demonstrate an electrical continuity, then establishing a good segregation between inside and outside of the enclosure. Proper grounding of the enclosure further participates to the electrical protection of the operators under normal operating conditions. For LV appliances this is achieved through the third pin of a 3-pin plug and socket. Total or even partial failure of insulation to the metal, can raise the voltage of the envelope to a dangerous level (depending on the ratio of the resistance of the leakage path through the insulation, to the resistance from the metal envelope to earth). The minimum standard for any equipment has to be IP2X to limit the possibility of a finger touching a live part of an electrical system.

13.2.4 *Indirect-Contact Protection or Fault Protection*

A person touching the metal envelope of an apparatus with a faulty insulation is said to be making an indirect contact. An indirect contact is characterized by the fact that a current path to earth exists (through the protective earthing (PE) conductor) in parallel with the shock current through the person concerned. The hazard in such cases is dependent on the earth resistance and the resistance of the earth continuity conductor, which would effectively be in parallel to the path of flow of current through the human body.

Extensive tests have shown that, providing the potential of the metal envelope not greater than 50 V with respect to earth, or to any conductive material within reaching distance, no danger exists.

If the insulation failure in an apparatus is between a MV conductor and the metal envelope, it is not generally possible to limit the rise of voltage of the envelope to 50 V or less, simply by reducing the earthing resistance to a low value. The solution in this case is to create an equipotential 'Earthing systems'. Insulation faults affecting the MV substation's equipment (internal) or resulting from atmospheric overvoltages (external) may generate earth currents capable of causing physical injury or damage to equipment. Preventive measures essentially consist of,

a) connecting all substation frames to the earth bar;
b) minimizing earth resistance; and
c) fast tripping and isolation of the fault by the operation of the fuse or circuit breaker.

13.2.5 In order to provide protection against electric shock due to leakage current for human being, a 30 mA RCCB/ RCD shall be installed at distribution board incomer of buildings, such as residential, schools and hospitals. For all other buildings, a 100 mA RCCB will suffice for protection against leakage current.

13.2.6 *Additional Protection Against Electric Shocks*

In a.c. systems, additional protection by means of a residual current protective device (RCD) with sensitivity not exceeding 30 mA shall be provided for:

a) socket-outlets with a rated current not exceeding 20 A that are for use by ordinary person and are intended for general use; and
b) mobile equipment with a current rating not exceeding 32 A for use outdoors.

The residual current devices shall be independent of the line voltage, except for installation operated, tested and inspected by skilled persons.

13.3 Hazards Due to Multiple Electrical Sources

The need for reliability of power supply and continued supply for different equipment leads to provision of redundant equipment chains as well as the provision of more than one source of power.

For critical installations it is normal to have more than one service connection, preferably from two different paths, so that at least one of the pats is in service at any time.

At the next level to cover the failure of the area distribution network local standby generating systems such as diesel generating sets are provided. For extremely critical loads which cannot tolerate even short break in service UPS systems which store energy in a battery bank and release it during the power failure become necessary.

As such multiple sources have become a necessary common feature in most large buildings. Even in small buildings activities depending on computers, etc, leads us to provide a standby system with an UPS or an inverter.

Where there is more than one source the shock hazards increase due to various reasons and a proper drill and display of instructions becomes necessary so that the users and in particular the operating and maintenance personnel are warned of the different sources and the associated protocol.

13.4 Care and Design of Electrical Installations for Human Safety

Location of switches and location of electrical equipment has to be done with a view to avoid electrical hazards to the users from the angle of human safety.

Most common hazard is of direct contact and that too when associated with wet surfaces. Wet surface reduces the contact resistance and thereby increases the current flow.

The second most common hazard comes up from old or/and damaged or under-sized flexible cords used for connection of portable equipment or devices.

The recommendations for typical areas requiring special attention are given in **13.4.1** to **13.4.5**.

13.4.1 *Bath Room Installations*

13.4.1.1 Geyser

The geyser or a storage water heater in not a portable device as it requires connection to the electricity line as well as to the water supply lines. The electrical connection will be from a 16 A socket outlet located at least 500 mm away from the plumbing connections. The switch for the geyser should not be accessible from the bath area or the shower area, to avoid a person standing on the wet surface touching the switch. The switch should be located away from the wet floor area of a bath room and preferably outside near the entrance to the bath room. This switch should have a built in indicator to display the status.

13.4.1.2 *Shaver socket*

Shaver sockets are located near the mirror. The socket will be fed from an isolating transformer (which in addition to providing electrical isolation between the output to the shaver and the building electrical system, may also give a voltage choice selection) to avoid shock hazard.

Shaver sockets which do not have a built in isolating transformer should be protected at the back by a RCCB/RCD of 10 mA sensitivity.

13.4.1.3 *Protection against electric shocks in bathrooms*

All circuits in bathrooms shall be protected by a RCCB/RCD with a sensitivity of 30 mA. The RCCB/RCD shall be in compliance with its relevant Indian Standards.

13.4.1.4 *Protection against electric shocks in sauna heater*

All circuits in sauna shall be protected by a RCCB/RCD with a sensitivity of 30 mA. The RCCB/RCD shall be in compliance with its relevant Indian standards.

13.4.2 *Bed Room Installations*

For the convenience of operating the lights, fan, etc, from the bed, it is quite a common practice to provide a pendent switch wired with a flexible cord. The flexible cord used should be with an outer sheath and the sheath should be securely clamped at the pendent switch. Use of twisted flexible cables without double insulation is hazardous and should be avoided.

A bed-head control set for all outlets to be controlled, mounted either on the wall accessible from the bed or mounted on the head board of the bed would be a preferable and safer alternative. This alternative requires the termination of the permanently installed wiring at a box near the bed and a flexible multicore sheathed cable for connection from the wall termination box to the control switch set mounted on the bed-head.

13.4.3 *Kitchen Installations*

Today a large number of gadgets are in use in the kitchen and it would be desirable to provide a large number of combination of 6 A/16 A sockets. As a general guideline any part of the kitchen counter should be within 1 m from a socket outlet as most kitchen appliances come with a 1.5 m or 2 m flexible cord.

The sockets should be located on the basis of the equipment layout and the general purpose outlets would be placed at 150 mm above the kitchen counter level.

For safety, all the socket outlets should be from circuits with a RCCB/RCD protection of sensitivity 30 mA. If an instant geyser is provided the same has to be wired from circuit with a 100 mA RCCB/RCD as 30 mA may cause nuisance tripping for a geyser.

13.4.4 *Protection Against Electric Shocks in Swimming Pools and the Other Basins.*

For swimming pools and other basins such as basins of swimming pools, paddling pools and their surrounding zones; areas in natural waters such as lakes in gravel pits, coastal and similar areas, specially intended to be occupied by persons for swimming, paddling and similar purposes and their surrounding zones, basins of fountains and their surrounding zones; all electrical systems provided shall be protected by residual current devices with a sensitivity not exceeding 30 mA. The RCD shall be in compliance with its product standard. All circuits for lighting, etc, in contact with water shall be at 24 V or less.

13.4.5 For protection against electric shock in other applications, reference shall be made to National Electric Code.

13.5 Earthing Requirements

Earthing is an essential need for protection against shock. Almost all devices require a proper earth connection through the earthing pin (and socket) and in turn through the earth continuity conductor.

13.6 Heating Appliances and Hot Appliances

Electrical appliance incorporating a heating element pose additional hazards from the possibility of overheating and inadvertent ignition of combustible material in the vicinity. While the installation by itself cannot be made failsafe, it is necessary to provide conspicuous indicators with the switches for the sockets used for such appliances, so that visible indication warns the user that the appliance is ON (many appliances which have their own built in indication, may be in OFF position in their standby mode or in the cut-off mode. Under such conditions the indication associated with the switch would be a gentle reminder.).

Almost all electrical appliances produce heat and require ventilation. The surface of the equipment is likely to be hot. Wherever the surface temperature is likely to be more than 45 °C, there should be a protection against the possibility of touching the surface and getting scalded or burnt.

13.7 Switches Getting Supply from Multiple Sources

Use of critical electrical equipment requiring continued power supply even in the absence of the commercial supply are on the increase both at home and in any general office, apart from special functional buildings where multiple or redundant sources is a necessity. Use of UPS systems has become common.

Where there are such points or switches fed from multiple sources, it is desirable to mark these switches or adopt a colour code so that they are identified readily.

Many UPS and Inverters have the feature of tripping on overload followed by automatic restoration after a brief time delay. Such characteristics should be made known to the users, so that accidents do not happen by the uninformed user taking some action assuming that the power supply is not there. Shock hazards are dependent on the system voltage and the hazard level is the same whether it is from the power system or from a mini UPS of a few watts.

13.8 Protection Against Environmental Over-Voltages

Any building today has a number of metallic connections coming into the building or installed over (or near) the building such as lines for electricity, telephone, dish antenna, radio antenna, pipe lines for water supply, sewage, cable of cable TV, solar hot water system, solar photovoltaic array, cell phone tower, wind generator, etc. External disturbances such as lightning, faults in external systems, can induce over-voltage in the installations within the building.

Buildings are to be provided protection from lightning strikes by a system of 'Faraday Cage' on the basis of hazard assessment. But at the same time use of dish antenna for TV, cable TV (the cable for which is run from building to building on the top, apparently forming a line to catch a lightning stroke) are on the rise and are without any regulation. These installations pose hazards to the installations inside the building.

For sensitive and critical equipment it is necessary to make a separate detailed study and build in appropriate protective device such as shield, suppressor or diverter as may be appropriate for the equipment as well as the type of hazard assessed.

13.9 Flammable Atmosphere and Risk of Ignition by Electricity Leading to Fire or Explosion

13.9.1 Flammable atmospheres are part of the electrical fire and explosion hazards. They are dealt with separately because of the complexities and problems peculiar to the subject. They occur when flammable gas, vapour, mist, aerosol or dust is present in a concentration in air between the upper (UEL) and lower (LEL) explosive limits. Such mixtures ignite if there is a source of ignition also present, such as incentive arcs or sparks from electrical equipment. The risk areas are divided into following zones for flammable gases/vapours:

a) *Zone 0* – Where the flammable atmosphere is always present.
b) *Zone 1* – Where the flammable material is present during normal operations and a flammable atmosphere is likely to occur.
c) *Zone 2* – Where the flammable atmosphere is unlikely during normal operation and if it occurs it will exist only for a short time.

13.9.2 A spark such as from a switch in an explosive atmosphere can trigger a fire or an explosion. In such areas special 'flame-proof' category switches, light fittings, cables, etc, will have to be used. The installation practices are also precise. Zonal boundaries have to be determined by the occupier's specialist staff and marked on the site drawing in plan and elevation. It is a difficult task and requires a knowledge of the characteristics of the material and how it disperses from the source of emission.

To illustrate by an example, if LPG leaks from a domestic gas cylinder it creates a hazardous situation. LPG is heavier than air and will settle down at the bottom on the floor with gradually changing ratio of air/LPG mixture as you go up above the floor level and it would be an explosive mixture at a height of a few centimeters above the floor level, which can easily be ignited by a spark or a flame. LPG stored in a basement (particularly if it is without exhaust picked up from floor level) can be serious situation.

Armed with the zonal boundary plans, the next step is to determine the position of the electrical equipment. Wherever possible, the risk should be avoided or minimized by locating the electrical equipment outside the risk areas or in Zone 2 areas rather than in Zones 0 and 1.

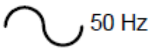
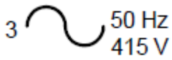
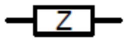
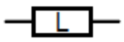
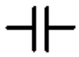
Zone 0 is usually inside reaction vessels or storage tanks. There is not much electrical equipment available for use in Zone 0 and as the risk is high it should be avoided by locating the equipment outside, example, a container can have glazed port-holes so that the interior can be viewed through one and lit from a luminaire shining through another. Zone 1 areas often occur only in the immediate vicinity of where the flammable material is processed. They are invariably surrounded by Zone 2 areas where the electrical apparatus should preferably be situated. It is sometimes possible to light outside site zones by luminaires located at high level in safe areas above the vertical zone boundaries. For flammable interiors, lighting can often be provided by positioning the luminaires outside in a safe location and shining the light through glazed panels in the roof or walls. Again, motors can be outside and drive an internal machine through a long shaft extension passing through a gas-tight seal in the wall. In some plants, it is convenient to locate the motor starters together on a starter panel in a motor control room. This room may either be in a safe area or if within the flammable zone, fed with clean air, from outside the zone, maintained at a positive pressure to ensure that gas cannot enter. Conduits for wiring should be solid drawn or seam welded with screwed joints. Where flammable gases have to be excluded from equipment, barrier seals may be necessary. Flexible metallic conduit should be lined to prevent abrasion of the cable insulation. Aluminium and aluminium alloy conduits and accessories should not be used where frictional contact with oxygen-rich items such as rusty steel might occur and cause sparking.

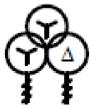
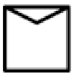
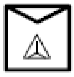
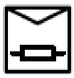
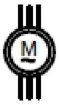
13.10 Protection against Fire due to Leakage Current in the Building

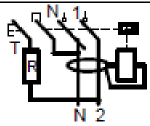
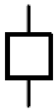
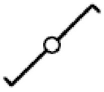
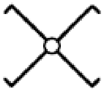
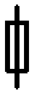
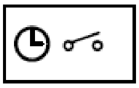
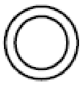
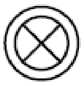
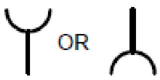
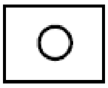
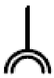
Large number of fire in the building occur due to faulty electrical installation. Mostly, the cause is assigned to over load or short-circuit fault. But there can be one more reason for causing the fire in the building. As the quality of insulation of the cables deteriorate due to ageing over a period of time, certain amount of leakage current flows in the system. This leakage current or tracking is difficult to detect and if it is allowed for a long period of time, say months or years, sparks occur which on a favourable condition, may lead to devastating fire in the building. Ignition of fire due to leakage current or tracking may be prevented by providing residual current devices of 300/500 mA as part of the main distribution board.

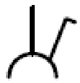
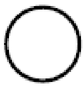
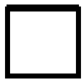
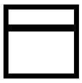
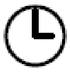
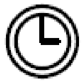
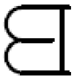
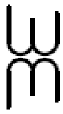
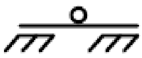
ANNEX A
(*Clause* 2.2)

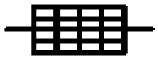
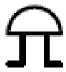
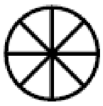
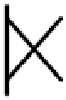
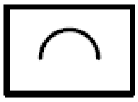
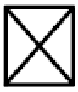
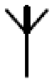
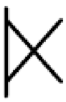
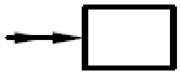
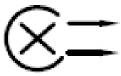
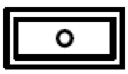
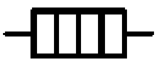
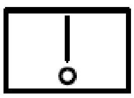
DRAWING SYMBOLS FOR ELECTRICAL INSTALLATIONS IN BUILDINGS

Sl No.	*Details*	*Symbol*	*Sl No.*	*Details*	*Symbol*
1.	Direct current	—	12.	Overhead Line	
2.	Alternating current, general symbol		13.	Winding, delta	
3.	Alternating current, single-phase, 50Hz		14.	Winding, star	
4.	Alternating current, three-phase, 415 V		15.	Terminals	○
5.	Alternating current, three-phase with neutral, 50 Hz		16.	Resistance/Resistor	
6.	Neutral	N	17.	Variable resistor	
7.	Positive polarity	+	18.	Impedance	
8.	Negative polarity	−	19.	Inductance/Inductor	
9.	Direct current, 2 conductors 110 V	2 —— 110 V	20.	Winding	
10.	Direct current 3 conductors including neutral 220 V	2N —— 220 V	21.	Capacitance, capacitor	
11.	Underground cable		22.	Earth	

Sl No.	*Details*	*Symbol*	*Sl No.*	*Details*	*Symbol*
23.	Fault		34.	Auto-transformer	
24.	Flexible conductor		35.	3-Phase transformer with three separate windings-Star-star-delta	
25.	Generator		36.	Starter	
26.	a.c. generator		37.	Direct-on-line-starter for reversing motor	
27.	d.c. generator		38.	Star-delta starter	
28.	Motor		39.	Auto-transformer starter	
29.	Synchronous motor		40.	Rheostatic starter	
30.	Mechanically coupled machines		41.	Switch	
31.	Induction motor, Three-phase, squirrel cage		42.	Contactor	
32.	Induction motor with wound rotor		43.	One - way switch, single pole	
33.	Transformers with two separate windings		44.	One - way switch, two pole	

Sl No.	*Details*	*Symbol*	*Sl No.*	*Details*	*Symbol*
45.	One - way switch, three pole		56.	Relay	
46.	Single pole pull switch		57.	Circuit-Breaker	
47.	Multiposition switch for different degrees of lighting		58.	Isolator	
48.	Two-way switch		59.	Residual current circuit breaker	
49.	Intermediate switch		60.	Surge protective device	
50.	Period limiting switch		61.	Fuse	
51.	Time switch		62.	Signal lamp	
52.	Pendant switch		63.	Link	
53.	Push botton		64.	Distribution boards, cubicle box, main fuse board with switches	
54.	Luminous push botton		65.	Socket outlet, 6A	
55.	Restricted access push botton		66.	Socket outlet, 16 A	

Sl No.	*Details*	*Symbol*	*Sl No.*	*Details*	*Symbol*
67.	Combined Switch and Socket Outlet, 6A		78.	Indicating instrument (General symbol)	
68.	Combined switch and socket outlet, 16 A		79.	Recording instrument (General symbol)	
69.	Interlocking switch and socket outlet, 6A		80.	Integrating meter	
70.	Interlocking switch and socket outlet, 16A		81.	Watthour meter	
71.	Plug		82.	Clock	
72.	Voltmeter	V	83.	Master clock	
73.	Ammeter	A	84.	Current transformer	
74.	Wattmeter	W	85.	Voltage transformer	
75.	Varmeter	Var	86.	Wiring on the surface	
76.	Power factor meter	Cos ø	87.	Wiring under the surface	
77.	Ohmmeter	Ω	88.	Conduit on surface	

Sl No.	*Details*	*Symbol*	*Sl No.*	*Details*	*Symbol*
89.	Concealed conduit		101.	Storage type water heater	
90.	Wiring in conduit		102.	Bell	
91.	Lamp		103.	Buzzer	
92.	Lamp mounted on a ceiling		104.	Siren	
93.	Lamp, mounted on a wall		105.	Ceiling fan	
94.	Emergency lamp		106.	Exhaust fan	
95.	Panic lamp		107.	Fan regulator	
96.	Water-tight lighting fitting	 WT	108.	Aerial	
97.	Battern lamp holder	 BH	109.	Radio receiving set	
98.	Spot light		110.	Television receiving set	
99.	Flood light		111.	Manually operated fire alarm	
100.	Heater		112.	Automatic fire detector switch	

ANNEX B

[*Clauses* 3.1.2 (b), 4.2.1 (15) (xi), 4.9.1.2, 4.9.1.4, 4.9.1.5, 4.9.3.1, 5.3.6.7, 5.4.1.1, 5.4.1.3, 6.4.6, 8.2.1 *and* 9.1.1]

LIST OF RELEVANT REGULATIONS OF *CENTRAL ELECTRICITY AUTHORITY (MEASURES RELATING TO SAFETY AND ELECTRIC SUPPLY) REGULATION*, 2023

B-1 The following is the list of regulation number(s) of CEA Regulations 2023. For specific information/details the regulations and up to date amendments may be referred.

Sl. No.	*Regulation Number*	*Regulation Title*
(1)	(2)	(3)
1)	4	Inspection of record of designated person
2)	5	Electrical Safety Officer
3)	6	Chartered Electrical Safety Engineer.
4)	10	Keeping of records and inspection thereof
5)	14	General safety requirements pertaining to construction, installation, protection, operation and maintenance of electric supply lines and apparatus
6)	15	Service lines and apparatus on consumer’s premises
7)	16	Switchgear on consumer’s premises
8)	17	Identification of earthed and earthed neutral conductors and position of switches and switchgear therein
9)	18	Earthed terminal on consumer’s premises
10)	19	Accessibility to bare conductors
11)	20	Danger Notices
12)	21	Handling of electric supply lines and apparatus
13)	24	Cables protected by bituminous materials
14)	25	Street boxes
15)	26	Distinction of different circuits
16)	27	Distinction of the installations having more than one feed
17)	28	Accidental charging
18)	29	Provisions applicable to protective equipment
19)	30	Display of instructions for resuscitation of persons suffering from electric shock
20)	31	Precautions to be adopted by consumers, owners, occupiers, electrical contractors, electrical workmen and suppliers
21)	32	Periodic inspection and testing of installations
22)	33	Testing of consumer’s installation
23)	34	Generating units required to be inspected by Electrical Inspector
24)	35	Precautions against leakage before connection
25)	36	Leakage on consumer’s premises
26)	37	Supply and use of electricity
27)	38	Provisions for supply and use of electricity in multi-storeyed building more than fifteen metre in height

Sl. No.	*Regulation Number*	*Regulation Title*
(1)	(2)	(3)
28)	39	Conditions applicable to installations of voltage exceeding 250 Volts
29)	41	Precautions against failure of supply and notice of failures
30)	42	Test of insulation resistance
31)	43	Connection with earth
32)	44	Residual Current Device
33)	45	Approval by the Electrical Inspector and self-certification
34)	46	Use of electricity at voltage exceeding 650 V
35)	47	Inter-locks and protection for use of electricity at voltage exceeding 650 V
36)	48	Testing, Operation and Maintenance
37)	49	Precautions to be taken against excess leakage in case of metal sheathed electric supply lines
38)	50	Connection with earth for apparatus exceeding 650 V
39)	51	General conditions for transformation and control of electricity
40)	52	Pole type substations
41)	54	Supply to luminous tube sign installations of voltage exceeding 650 V but not exceeding 33 kV
42)	60	Clearance in air of the lowest conductor of overhead lines
43)	62	Clearance from buildings of lines of voltage and service lines not exceeding 650 V
44)	63	Clearances from buildings of lines of voltage exceeding 650 V
45)	65	Erection or alteration of buildings, structures, flood banks and elevation of roads
46)	66	Transporting and storing of material near electric lines
47)	67	General clearances
48)	75	Anti-climbing devices
49)	79	Laying of cables

ANNEX C

[*Clauses* 4.2.1 (28), 4.2.2.2 *and* D-1]

AREA REQUIRED FOR TRANSFORMER ROOM AND SUBSTATION FOR DIFFERENT CAPACITIES

C-1 The requirement for area for transformer room and substation for different capacities of transformers is given below for guidance:

Sl No.	*Capacity of Transformer(s)*	*Total Transformer Room Area, Min*	*Total Substation Area (Incoming, HV Panels, MV Panels, Transformer Roof but Without Generators), Min*	*Suggested Minimum Face Width*
	kVA	m^2	m^2	m
(1)	(2)	(3)	(4)	(5)
i)	1 x 160	14.0	90	9.0
ii)	2 x 160	28.0	118	13.5
iii)	1 x 250	15.0	91	9.0
iv)	2 x 250	30.0	121	13.5
v)	1 x 400	16.5	93	9.0
vi)	2 x 400	33.0	125	13.5
vii)	3 x 400	49.5	167	18.0
viii)	2 x 500	36.0	130	14.5
ix)	3 x 500	54.0	172	19.0
x)	2 x 630	36.0	132	14.5
xi)	3 x 630	54.0	176	19.0
xii)	2 x 800	39.0	135	14.5
xiii)	3 x 800	58.0	181	14.0
xiv)	2 x 1 000	39.0	149	14.5
xv)	3 x 1 000	58.0	197	19.0

NOTES

1 The areas given in respect of the different categories of rooms hold good, if they are provided with independent access doors in accordance with local regulations.

2 The minimum height of substation room/HV switch room/MV switch room shall be arrived at considering 1 200 mm clearance requirement from top of the equipment to the below of the soffit of the beam. In case cable entry/exit is from above the equipment (transformer, HV switchgear, MV switchgear), height of substation room/HV switch room/MV switch room shall also take into account requirement of space for turning radius of cable above the equipment height

3 Additional space will be required in cases where the load requirement calls for redundancy for enhanced reliability through addition of switchgear, such as, bus couplers, etc.

4 For transformers of other capacity, it may lead to some minor changes in dimensioning.

ANNEX D
(*Clause* 4.3.2)

ADDITIONAL AREA REQUIRED FOR GENERATOR IN ELECTRIC SUBSTATION

D-1 The requirement of additional area for generator in electric substation for different capacities of generators is given in the table below for guidance.

NOTES

1 The space requirements vary for specific installations due to factors such as derating due to site conditions (temperature, altitude etc); type of cooling (radiator, heat exchanger, cooling tower, etc); type of ventilation; noise suppression system and special characteristics of loads, if any.

2 If the generator is located away from the substation, then additional switchgear will be required, area requirement for which can be estimated from the norms given in Annex C.

3 The area requirement suggested below covers the space requirement for day-tank and not the space for the bulk fuel storage.

Sl No.	*Capacity*	*Area*	*Clear Height below the Soffit of the Beam*
	kVA	m^2	m
(1)	(2)	(3)	(4)
i)	25	56	3.6
ii)	48	56	3.6
iii)	100	65	3.6
iv)	150	72	3.6
v)	248	100	4.2
vi)	350	100	4.2
vii)	480	100	4.2
viii)	600	110	4.6
ix)	800	120	4.6
x)	1 010	120	6.5
xi)	1 250	120	6.5
xii)	1 600	150	6.5
xiii)	2 000	150	6.5

NOTE — The area and height required for generating set room given in the above table are for general guidance only and may be finally fixed according to actual requirements.

ANNEX E
(*Clause* 9.4)

CHECKLIST FOR INSPECTION, HANDING OVER AND COMMISSIONING OF VARIOUS EQUIPMENT OF SUBSTATION

E-1 Typical format for checklist for inspection, handing over and commissioning of HV cables is given below:

NOTE — Format given below covers a basic minimum check list; it should be augmented for specific and special cases. The checklist has to be repeated for each HV cable.

HV CABLE INSPECTION, HANDING OVER AND COMMISSIONING DETAILS

A. DETAILS OF WORK

1) Scope of works :
2) Handed over by :
3) Taken over by :
4) Date of commissioning :
5) Date of handing over :
6) Details of enclosures :

Sl No.	**Description**	**Applicable**	**Not Applicable**
(1)	(2)	(3)	(4)
i)	Quality check list		
ii)	Site test report		
iii)	As built GA drawing/layout		
iv)	Manufacturer's test certificates		
v)	Operation and maintenance manual		

Handed Over By   Taken Over By

Authorized Signatory   Authorized Signatory

B. QUALITY CHECK LIST

Item: Installation of HV Cables				
Make:				
Sl No.	**Tests Parameters**	**Bench Mark**	**Actual Observations**	**Remark**
(1)	(2)	(3)	(4)	(5)
i)	Cable size			

ii)	Voltage grade			
iii)	Type of material			
iv)	Check for routing			
v)	Meggering using 2.5 kV insulation tester			
	R-Y			
	Y-B			
	B-R			
	R-E			
	Y-E			
	B-E			
vi)	Minimum width of trench			
vii)	Minimum depth of trench			
viii)	Hume pipes used			
ix)	Hume joints with collar properly aligned and packed with 75 mm of cement concrete			
x)	Cable laying with suitable rollers			
xi)	Bending radius			
xii)	Cable tagging			
xiii)	Hi-Pot test (18 kV)			
xiv)	Sealing of cable ends, if not being terminated immediately			
xv)	Trench closing			

C. HI-POT TEST REPORT

1) Date of testing:
2) Equipment details:
   Cable details

   Location :
   Panel No. :
   Size :

3) Insulation Resistance Test (Value in MΩ, using 5 kV Megger):

Reference	**Measured Values** MΩ	
	Before	After
R-E		
Y-E		
B-E		
R-Y		
Y-B		
B-R		

4) Winding Resistance Test:

Applied Voltage kV	**Measured Current** mA
R=Y+B+E	
Y=B+R+E	
B=R+Y+E	

5) Remarks

E-2 Typical format for checklist for handing over and commissioning of HV panels is given below:

NOTE — Format given below covers a basic minimum check list; it should be augmented for specific and special cases. The checklist has to be repeated for each HV panel.

HV PANEL INSPECTION, HANDING OVER AND COMMISSIONING DETAILS

Project:
Owner:
Package:
Contractor:

A. HANDING OVER DETAILS

1) Scope of works :
2) Panel name and number :
3) Location :
4) Handed over by :
5) Taken over by :
6) Date of commissioning :
7) Date of handing over :
8) Details of enclosures :

Sl No.	**Description**	**Applicable**	**Not Applicable**
(1)	(2)	(3)	(4)
i)	Quality check list		
ii)	Site test report		
iii)	As built GA drawing/layout		
iv)	Manufacturer’s test certificates		
v)	Operation and maintenance manual		

Handed Over By   Taken Over By

Authorized Signatory Authorized Signatory

B. QUALITY CHECK LIST

Item: HV panel
Make:
Relevant Indian Standard:
As-built Drawing No:

Sl No.	**Test Parameters**	**Bench Mark**	**Actual Observations**
(1)	(2)	(3)	(4)
	Physical Checks For:		
	Circuit Breaker		
i)	Dimension enclosure		
ii)	Gauge		
iii)	Paint		
iv)	Degree of protection		
v)	Front doors		
vi)	Back cover		
vii)	Extension type enclosure		
viii)	Type of circuit breaker		
ix)	Number of circuit breakers		
x)	Type of surge arresting device included in the circuit breakers		
xi)	Earthing terminal		
xii)	Front plate with view glass		
xiii)	Space for mounting of current transformers		
xiv)	Space for mounting of potential transformers		
xv)	Cable entry		
xvi)	Interlocking with isolator		
xvii)	Earthing switch for cable in cable chamber		
xviii)	Earthing switch interlock with circuit breaker only it can be operated in ‘OFF’ condition		
xv)	Low voltage plug and socket		
xvi)	Vents for breaker/busbar/cable chambers		
xvii)	Insulation level		
xviii)	Toggle switch		
xix)	Ammeter selector switch		
xx)	Voltmeter selector switch		
xxi)	Trip/Neutral/Close		
xxii)	Local/remote selector switch		
xxiii)	LED lamps		

xxiv)	Mechanical operation		
xxv)	Remote operation		
xxvi)	Local operation		
xxvii)	Interlocking with isolator		
	Meters		
xxviii)	Voltmeter		
xxix)	Ammeter		
xxx)	Tri vector meter		
xxxi)	Power factor meter		
xxxii)	Frequency meter		
	Specification Checks for		
xxxiii)	Rated current		
xxxiv)	Rated voltage		
xxxv)	Rated short circuit breaking capacity		
xxxvi)	Contact resistance		
xxxvii)	Control wiring		
xxxviii)	All control circuits Alarm and trip for OTI/WTI/Buchholz/ PRV		
xxxix)	SF6 pressure alarm and trip operation test		

C. COMMISSIONING REPORT

Customer:	
Project:	
Contractor:	
Panel Name:	
Location:	
Breaker Details:	

INSULATION TEST (MΩ)

R-Y	Y-B	B-R	R-E	Y-E	B-E	R-N	Y-N	B-N

RELAY SETTINGS

Over Current, Earth Fault and Undervoltage Relay	
CT ratio: Earth fault >Settings: I_0> Settings: Under voltage relay:	

GENERAL CHECKS

Breaker 'ON'/'OFF'	
Meters reading	
Indicating lamps	
Control supply	

E-3 Typical format for checklist for handing over and commissioning of transformers is given below:

NOTE — Format given below covers a basic minimum check list; it should be augmented for specific and special cases. The checklist has to be repeated for each transformer.

TRANSFORMER INSPECTION, HANDING OVER AND COMMISIONING DETAILS

Project:
Owner:
Package:
Contractor:

A. HANDING OVER DETAILS

1) Scope of works :
2) Transformer No. :
3) Location :
4) Handed over by :
5) Taken over by :
6) Date of commissioning :
7) Date of handing over :
8) Details of enclosures :

Sl No.	Description	Applicable	Not Applicable
(1)	(2)	(3)	(4)
i)	Quality check list		
ii)	Site test report		
iii)	As built GA drawing/layout		
iv)	Manufacturer's test certificates		
v)	Operation and maintenance manual		

Handed Over By　　　　Taken Over By

Authorized Signatory　　　　Authorized Signatory

B. QUALITY CHECK LIST

Item: Transformer
Make:
Relevant Indian Standard:

As-built Drawing No:

Sl No.	**Test Parameters**	**Bench Mark**	**Actual Observation**
(1)	(2)	(3)	(4)
	Physical Checks for		
i)	Transformer Sl No.		
ii)	Dimension of enclosure		
iii)	Enclosure – Degree of protection		
iv)	Gauge		
v)	Paint		
vi)	Provision for lifts and jacking		
vii)	Wheels		
viii)	Locking facility for wheel		
ix)	Enclosure door (if applicable)		
x)	Enclosure door interlock wiring		
xi)	Removable case for access of taps		
xii)	Earthing terminal		
xiii)	Disconnecting type chamber for cable termination		
xiv)	LT side flanges (Bus ducts/Cables/ Overhead)		
xv)	Oil temperature indicator (relay unit)		
xvi)	Winding temperature indicator (relay unit)		
xvii)	Marshalling box winding and door switch		
xviii)	Thermistors for alarm and trip		
xix)	Separate neutral earthing chamber		
xx)	Rating and diagram plate		
xxi)	Tap changing options name plate		
xxii)	Oil level in conservator tank		
xxiii)	Oil level in breather cup		
xxiv)	Operation of PRV		
xxv)	Oil leakage (if applicable)		
xxvi)	Clearances around transformer		
xxvii)	Body earthing resistance		
xxviii)	Neutral earthing resistance		
	Specification checks for:		
xxix)	Rating of transformer		
xxx)	Type		
xxxi)	Winding conductor		
xxxii)	Primary voltage		
xxxiii)	HV winding connections		
xxxiv)	Secondary voltage		
xxxv)	LV side connections		
xxxvi)	Vector symbol		
xxxvii)	System of supply		

xxxviii)	Impedance percentage		
xxxix)	Oil temperature rise		
xl)	Winding temperature rise		
xli)	Tap changing		
xlii)	Tapping range		
xliii)	Insulation type		
xliv)	Type of cooling		
xlv)	Vector group test		
xlvi)	Polarity test		
xlvii)	Magnetizing test		
xlviii)	Tan delta test (as per capacity)		
xlix)	Breakdown voltage test: *Oil sample – I (Top)* *Oil sample – II (Bottom)*		

C. COMMISSIONING REPORT

Customer:	
Project:	
Contractor:	
Transformer Number:	
Location:	
Rating:	

INSULATION TEST (MΩ)

R-Y	Y-B	B-R	R-E	Y-E	B-E	R-N	Y-N	B-N

RELAY SETTINGS

Transformer Protection Relay **(WTI Scanner):** Winding temperature alarm set Winding temperature trip set **(OTI Scanner):** Oil temperature alarm set Oil temperature trip set	
Buchholz Relay	

GENERAL CHECKS

Breaker ‘ON’/‘OFF’	

Meters reading	
Indicating lamps	
Control supply	

E-4 Typical format for checklist for handing over and commissioning of MV/LV panel is given below:

NOTE — Format given below covers a basic minimum check list; it should be augmented for specific and special cases. The checklist has to be repeated for each MV/LV panel.

MV/LV PANEL INSPECTION, HANDING OVER AND COMMISIONING DETAILS

Project:
Owner:
Package:
Contractor:

A. HANDING OVER DETAILS

1) Scope of works :
2) Panel name :
3) Location :
4) Handed over by :
5) Taken over by :
6) Date of commissioning :
7) Date of handing over :
8) Details of enclosures :

Sl No.	**Description**	**Applicable**	**Not Applicable**
(1)	(2)	(3)	(4)
i)	Quality check list		
ii)	Site test report		
iii)	As built GA drawing		
iv)	Manufacturer’s test certificates		
v)	Operation and maintenance manual		

Handed Over By — Taken Over By

Authorized Signatory — Authorized Signatory

B. QUALITY CHECK LIST

Item: MV/LV Panel
Make:
Relevant Indian Standard:
As-built Drawing No:

Sl No.	**Test Parameters**	**Bench Mark**	**Actual Observation**
(1)	(2)	(3)	(4)
	Physical Checks For		
i)	Dimension enclosure		
ii)	Paint		
iii)	Degree of protection		
iv)	Front doors		
v)	Back cover		
vi)	Earthing terminal		
vii)	Front plate with view glass		
viii)	Cable entry		
ix)	Indication lamps		
x)	Check for any damages		
xi)	Check for rubber beading for the panel sections		
xii)	Coupling of panel		
xiii)	Coupling of busbars		
xiv)	Coupling of earth bus		
xv)	Number of shipping sections		
xvi)	Fish plate tightening		
xvii)	Any damages in busbar supports		
xviii)	Make of MCCB		
	Specification Checks For		
xix)	Rated current		
xx)	Rated voltage		
xxi)	Rated short circuit capacity		
	Circuit Breaker:		
xxii)	Current rating		
xxiii)	Interlocks with other CB/relay		
xxiv)	Compartment		
xxv)	End terminals segregation		
	Bus bar:		
xxvi)	Earth bus bar		
xxvii)	Main bus bar		
xxviii)	Link bus bar		
xxix)	Bus bar sleeve		
	3 Phase – Potential transformer:		
xxx)	Make		
xxxi)	Ratio		
xxxii)	Class		

xxxiii)	Serial Nos.		
	Current transformer:		
xxxiv)	Make		
xxxv)	Ratio		
xxxvi)	Class		
xxxvii)	Serial No's		
	Multi digital meter:		
xxxviii)	Make		
xxxix)	Input voltage		
xl)	Input current		
xli)	Wiring		
xlii)	For potential transformer		
xliii)	For current transformer		
xliv)	Incomer		
xlv)	Outgoing		

C. COMMISSIONING REPORT

Customer:	
Project:	
Contractor:	
Panel Name:	
Location:	
Breaker Details:	

INSULATION TEST (M Ohm)

R-Y	Y-B	B-R	R-E	Y-E	B-E	R-N	Y-N	B-N

RELAY SETTINGS
Why blank

GENERAL CHECKS

Breaker 'ON'/'OFF'	
Meters reading	
Indicating lamps	
Control supply	

ANNEX F
(*Clause* 9.4)

EARTHING PITS HANDING OVER DETAILS

F-1 Typical format for checklist for handing over of earthing pits is given below:

Project:
Owner:
Package:
Contractor:

A. HANDING OVER DETAILS

1) Scope of works :
2) Handed over by :
3) Taken over by :
4) Date of commissioning :
5) Date of handing over :
6) Details of enclosures :

Sl No.	**Description**	**Applicable**	**Not Applicable**
(1)	(2)	(3)	(4)
i)	Quality check list		
ii)	Site test report		
iii)	As built GA drawing/layout		

Handed Over By　　　　　　　　Taken Over By

Authorized Signatory　　　　　　　　Authorized Signatory

B. QUALITY CHECK LIST

Item: Installation of earthing pit
As-built Drawing No:

Sl No.	**Test Parameters**	**Bench Mark**	**Actual Observations**	**Remarks**
(1)	(2)	(3)	(4)	(5)
i)	Material (Cu/GI/Copper bonded) and size			
ii)	Depth of the pit			

iii)	Check for length of pipe/rod and size of the plate and strip			
iv)	For copper earthing, brazing done on both surfaces before jointing; and on one side in case of exothermic welding			
v)	Packing of pit by sand, salt and charcoal/earth enhancing material			
vi)	Check connection for tightness			
vii)	Check for distance between earth pits			
viii)	Interconnection of earth strips			
ix)	Earth enhancing Material used in earth pits			

C. Test Report: Earth Pit

Date of testing :
Equipment details :

Earth pit

1) Location :
2) Sl No. :
3) EP No. :
4) Type of earthing :
5) Description :
6) Size of earth cond :

Earth Pit Test: Values (Ω)

Ref	**Measured Values Ω**
Pit	
Width grid	

ANNEX G
(*Clause* 9.3.2.6)

FORM OF COMPLETION CERTIFICATE

I/ We certify that the installation detailed below has been installed by me/us and tested and that to the best of my/our knowledge and belief, it complies with *Central Electricity Authority (Measures Relating to Safety and Electricity Supply) Regulations*, 2023 as amended up-to-date.

Electrical Installation at ____

A. INSTALLATION DATA

Voltage and system of supply ______________________________________

a) *Particulars of Works:*

1) Internal electrical installation

Sl No.	**Description**	**No.**	**Total Load**	**Type of System of Wiring**
i)	Light point			
ii)	Fan point			
iii)	Plug point			
	3-pin 6 A			
	3-pin 16 A			
	5-pin 6 A			
	6-pin 16 A			

2) Others

Sl No.	**Description**	**HP/kW**	**Type of Starting**
i)	Motors		
	1)		
	2)		
	3)		
ii)	Other plants		
	1)		
	2)		
	3)		

3) If the work involves installations of overhead line and/or underground cable

i)	1) Type and description of over headline	
	2) Total length and No. of spans	
	3) No. of street lights and its description	
ii)	1) Total length of underground cable and its size	
	2) No. of joints:	
	End joint:	
	Tee joint:	
	Straight through joint:	

b) *Earthing:*

i)	Description of earthing electrode	
ii)	No. of earth electrodes	
iii)	Size of main earth lead	
iv)	Earth electrode resistance	

The date on which the measurements for items (iv) and (v) were taken has to be recorded.

NOTE — The above data should be supported by an appropriate drawing and tables indicating the reference points at which the measurements were taken at the construction/installation stage.

B. PRE-COMMISSIONING TEST DATA

a) *Test Results:*

1) Appropriate drawings showing the points at which the measurements were taken should accompany this report.

2) Environmental notes pertaining to the day on which the tests are conducted:
   i) Temperature:
   ii) Date and time:
   iii) Previous day/days history from the aspect of rain (in as much as it would affect the test results):

3) List of test instruments used:
   (Please record the calibration certificate date, calibration authority and the validity date of each instrument listed.)

   i) -------------------
   ii) -------------------

4) Results:

   i) Insulation resistance

a)	Insulation resistance of the whole system of conductors to earth	………… Megaohms
b)	Insulation resistance between the phase conductor and neutral:	
	Between phase R and neutral	………… Megaohms
	Between phase Y and neutral	………… Megaohms
	Between phase B and neutral	………… Megaohms
c)	Insulation resistance between the phase conductors in case of polyphase supply	
	Between phase R and phase Y	………… Megaohms
	Between phase Y and phase B	………… Megaohms
	Between phase B and phase R	………… Megaohms
d)	Insulation resistance between neutral conductor and earth in case of systems with neutral solidly earthed at the source	………… Megaohms

ii) Polarity test:

Polarity of non-linked single pole branch switches:

iii) Earth continuity test:

Maximum resistance between any point in the earth continuity conductor including metal conduits and main earthing lead ……………Ohms.

iv) Earth electrode resistance:

a) Resistance of each earth electrode:

1) …………….. Ohms
2) …………….. Ohms
3) …………….. Ohms
4) …………….. Ohms

b) Resistance of each earth grid:

1) …………….. Ohms
2) …………….. Ohms
3) …………….. Ohms
4) …………….. Ohms

v) Lightning protective system:

a)	Designed lightning protection level (LPL)	…..

b)	Total roof area (L X W)	….. m^2
c)	Air-termination mesh size (L X W)	….. m x m
d)	Number of vertical rods/terminal (Down-conductors)	…..
e)	Distance between down-conductors	….. m
f)	Impulse current rating of SPD, if any	…… kA
g)	Voltage protection level of incoming SPD	…….kV
h)	Resistance of down-conductor for reinforced concrete structure/PEB structures, if natural components are used as per National Building Code of India (Part 8/Section 2) 'Building Services, Electrical and Allied Installations'	……. ohms
j)	Resistance of the whole of lightning protective system to earth before any bonding is effected with earth electrode and metal in/on the structure	……. ohms

Signature of Supervisor Signature of Contractor

Name and Address Name and Address

---------------------------------- ------------------------------

---------------------------------- -------------------------------

---------------------------------- -------------------------------

---------------------------------- -------------------------------

Persons witnessing the test:

Name Designation/Address Signature Remarks

--------- ------------------------------------ ------------ -------------

ANNEX H
(*Clause* 3.5)

DECLARATIONS

H-1 DECLARATION FOR DESIGN

I/We being the person(s) responsible for the design of the electrical installation (as indicated by my/our signatures below), particulars of which are described below, having exercised reasonable skill and care when carrying out the design, hereby DECLARE that the design work for which I/we have been responsible is to the best of my/our knowledge and belief conform to CEA (Measures relating to Safety and Electric Supply) Regulations 2023 and in accordance with National Building Code 20xx and relevant standards of the products used, and except for the departures, if any, detailed as follows:
Departures

Project / Site details

(Sign)
Electrical Consultant
Name & Address

(Sign)
Electrical Engineer on site

H-2 DECLARATION FOR CONSTRUCTION

I/We being the person(s) responsible for the construction of the electrical installation (as indicated by my/our signatures below), particulars of which are described below, having exercised reasonable skill and care when carrying out the construction, hereby DECLARE that the construction work for which I/we have been responsible is to the best of my/our knowledge and belief conform to CEA (Measures relating to Safety and Electric Supply) Regulations 2023 and in accordance with National Building Code 20xx and relevant standards, and except for the departures, if any, detailed as follows:
Departures

Project / Site details

(Sign)
Electrical Contractor
Name & Address

(Sign)
Electrical Engineer on site

H-3 DECLARATION FOR INSPECTION AND TESTING

I/We being the person(s) responsible for the inspection and testing of the electrical installation (as indicated by my/our signatures below), particulars of which are described below, having exercised reasonable skill and care when carrying out the inspection and testing, hereby DECLARE that the construction work for which I/we have been responsible is to the best of my/our knowledge and belief conform to CEA (Measures relating to Safety and Electric Supply) Regulations 2023 and in accordance with National Building Code 20xx and relevant standards and except for the departures, if any, detailed as follows:
Departures

Project / Site details

(Sign)
Electrical Safety Verifier
L. No./Registration No.
Name & Address

(Sign)
Electrical Engineer on site

LIST OF STANDARDS

The following list records those standards which are acceptable as 'good practice' and 'accepted standards' in the fulfillment of the requirements of the Code. The latest version of a standard shall be adopted at the time of enforcement of the Code. The standards listed may be used by the Authority for conformance with the requirements of the referred clauses in the Code.

In the following list, the number appearing in the first column within parenthesis indicates the number of the reference in this Section.

(1)	IS 8270(Part 1):2023	Preparation of document used in electrotechnology: Part 1 Rules
	IS 1885	Electrotechnical vocabulary
	(Part 16):2023	Part 16 Lighting
	(Part 17):2024	Switchgear and control gear (*second revision*)
	(Part 32):2019	Electrical cables (*second revision*)
	(Part 78):1993	Generation, transmission and distribution of electricity – General
	IS 12032	Graphical symbols for diagrams in the field of electrotechnology
	(Part 6):1987	Protection and conversion of electrical energy
	(Part 7):1987	Switchgear, controlgear and protective devices
(2)	IS 16246:2015	Specification of elastomer insulated cables with limited circuit integrity when affected by fire
(3)	IS 694:2010	Polyvinyl chloride insulated unsheathed and sheathed cables/cords with rigid and flexible conductor for rated voltages up to and including 450/750 V (*fourth revision*)
(4)	IS/IEC 62271-202:2014	High-voltage switchgear and controlgear: part 202 High-voltage/low-voltage prefabricated substation
(5)	IS/IEC 60947-1:2020	Low-voltage switchgear and controlgear :Part 1 General rules (*second revision*)
	IS/IEC 60947-2:2016	Low-voltage switchgear and controlgear – Part 2 : Circuit breakers(*first revision*)
	IS/IEC 60947-3:2020	Low-voltage switchgear and controlgear : Part 3 Switches, disconnectors, switch-disconnectors and fuse combination units (*second revision*)
	IS/IEC 60947-4-1:2018	Low-voltage switchgear and controlgear – Part 4 : Contractors and motor-starters – Section 1 : Electromechanical contactors and motors-starters(*second revision*)

	IS/IEC 60947-4-2:2020	Low-voltage switchgear and controlgear : Part 4 – Contractors and Motor-Starters Section 2 Semiconductor Motor Controllers , starters and Softstarters (*second revision*)
	IS/IEC 60947-4-3:2020	Low-voltage switchgear and controlgear : Part 4 Contactors and motor starters Section 3 semiconductor controllers and semiconductor contactors for non-motor loads (*third revision*)
	IS/IEC 60947-5-1:2016	Low-voltage switchgear and controlgear – Part 5 : Control circuit devices and switching elements – Section 1 : Electromechanical control circuit devices (*second revision*)
	IS/IEC 60947-5-2:2019	Low-voltage switchgear and control gear- Part 5 Control circuit devices and switching elements-Section 2 Proximity switches(*first revision*)
(6)	IS/IEC 60529:2001	Degrees of protection provided by enclosures (IP code)
	IS 17050 : 2023 IEC 62262 : 2001 +AMD1 : 2021	Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK Code) (*first revision*)
(7)	IS 7752(Part 1):1975	Guide for improvement of power factor in consumer installation: Part 1 Low and medium supply voltages
(8)	IS 5216	Recommendations on safety procedures and practices in electrical work
	(Part 1):1982	General (*first revision*)
	(Part 2):1982	Life saving techniques (*first revision*)
(9)	IS 10028(Part 2):1981	Code of practice for selection, installation and maintenance of transformers: Part 2 Installation
(10)	IS 10118(Part 3):1982	Code of practice for selection, installation and maintenance of switchgear and controlgear: Part 3 Installation
(11)	IS 732:2019	Code of practice for electrical wiring installations (*fourth revision*)
(12)	IS 10118(Part 2):1982	Code of practice for selection, installation and maintenance of switchgear and controlgear: Part 2 Selection

(13)	IS 1646:2015	Code of practice for fire safety of buildings (general): Electrical installations (*third revision*)
(14)	IS/IEC 62271-106:2020	Low-Voltage switchgear and controlgear: Part 106 Alternating current contactors, contactor-based controllers and motorstarters (*first revision*)
	IS/IEC 62271-1:2017	High-voltage switchgear and controlgear: Part 1 Common specifications for alternating current switchgear and control gear (*first revision*)
	IS/IEC 62271-100:2021	High-voltage switchgear and controlgear: Part 100 Alternating-current circuit-breakers (*first revision*)
	IS/IEC 62271-103:2021	High-voltage switchgear and controlgear: Part 103 Alternating current switches for rated voltages above 1 kV up to and including 52 kV (*first revision*)
	IS/IEC 62271-104:2023	High-voltage switchgear and controlgear: Part 104 Alternating current switches for rated voltages higher than 52 kV (*first revision*)
	IS/IEC 62271-105:2021	High-voltage switchgear and controlgear: Part 105 Alternating current switch-fuse combinations for rated voltages above 1 kv up to and including 52 kv (*second revision*)
	IS/IEC 62271-111:2019	High-voltage switchgear and controlgear: Part 111 Automatic circuit reclosers for alternating current systems up to and including 38 kV (*first revision*)
	IS/IEC 62271-200:2021	High-voltage switchgear and controlgear: Part 200 A.C. Metal-Enclosed switchgear and controlgear for rated voltages above 1 kv and up to and including 52 kV (*second revision*)
	IS/IEC 62271-201:2014	High-voltage switchgear and controlgear: Part 201 AC Solid-Insulation enclosed switchgear and controlgear for rated voltages above 1 kV up to and including 52 kV (*first revision*)
	IS/IEC 62271-203:2022	High-voltage switchgear and controlgear: Part 203 A.C. Gas-Insulated metal enclosed switchgear for rated voltages above 52 kV (*second revision*)
(15)	IS 1255:1983	Code of practice for installation and maintenance of power cables (up to and including 33 kV rating) (*second revision*)
(16)	IS 8084:2025	Specification for interconnecting bus-bars for A.C. voltage above 1 kV up to and including 36 kV (*first revision*)

(17)	IS 1180 (Part 1):2014	Specification for outdoor type oil immersed distribution transformers up to and including 2 500 kVA, 33kV: Part 1 Mineral oil immersed (*fourth revision*)
	IS 2026	Power transformers
	(Part 1):2011	General (*second revision*)
	(Part 2):2010	Temperature-rise (*first revision*)
	(Part 3):2018 IEC 60076-3:2013	Insulation levels, dielectric tests and external clearances in air (*fourth revision*)
	(Part 4):1977	Terminal marking, tappings and connections (*first revision*)
	(Part 5):2011	Ability to withstand short circuit (*first revision*)
	(Part 7):2009 IEC 60076-7:2005	Loading guide for oil-immersed power transformers
	(Part 8):2009 IEC 60076-8:1997	Applications guide
	(Part 10):2025 IEC 60076-10:2016	Determination of sound levels (*first revision*)
	IS 2026 (Part 11) : 2021 IEC 60076-11 : 2018	Power Transformers Part 11 Dry-Type Transformers
(18)	IS/IEC 61439-2:2020	Low-voltage switchgear and controlgear assemblies: Part 2 Power Switchgear and Controlgear Assemblies (*first revision*)
	IS/IEC 60947-1:2020	Low-voltage switchgear and controlgear: Part 1 General rules (*second revision*)
	IS/IEC 60947-2:2016	Low-voltage switchgear and controlgear: Part 2 Circuit breakers (*first revision*)
	IS/IEC 60947-3:2020	Low-voltage switchgear and controlgear : Part 3 Switches, disconnectors, switch-disconnectors and fuse combination units (*second revision*)
	IS/IEC 60947-4-1:2018	Low-voltage switchgear and controlgear: Part 4 Contractors and motor-starters, Section 1 Electromechanical contactors and motors-starters (*second revision*)
	IS/IEC 60947-4-2:2020	Low-voltage switchgear and controlgear: Part 4 Contractors and motor-starters, Section 2 Semiconductor motor controllers and soft-starters (*second revision*)
	IS/IEC 60947-4-3:2020	Low-voltage switchgear and controlgear: Part 4 Contractors and motor-starters, Section 3 Semiconductor controllers and Semiconductor contactors for non-motor loads (*third revision*)
	IS/IEC 60947-5-1:2016	Low-voltage switchgear and controlgear: Part 5 Control circuit devices and switching elements,

		Section 1 Electromechanical control circuit devices (*second revision*)
	IS/IEC 60947-5-2:2019	Low-voltage switchgear and control gear: Part 5 Control circuit devices and switching elements, Section 2 Proximity switches (*first revision*)
	IS/IEC 61439 (Part 0): 2014	Low-voltage switchgear and controlgear assemblies: Part 0 Guidance to specifying assemblies
	IS/IEC 61439-1 : 2020	Low-Voltage Switchgear and Controlgear Assemblies Part 1 General Rules (*first revision*)
	IS/IEC 61439-2 : 2020	Low-Voltage Switchgear and Controlgear Assemblies Part 2 Power Switchgear and Controlgear Assemblies (*first revision*)
(19)	IS 11353:2023 IEC 60445 : 2021	Basic and safety principles for man-machine interface, marking and identification — Identification of equipment terminals, conductor terminations and conductors (*first revision*)
(20)	IS 8623(Part 2):1993	Specification for low-voltage switchgear and controlgear assemblies: Part 2 Particular requirements for busbar trunking systems (busways) (*first revision*) (Withdrawn)
(21)	IS 13010:2002	Specification for a.c. watthour meters, class 0.5, 1 and 2 (*first revision*)
	IS 13779:2020	Specification for a.c. static watthour meters, class 1 and 2 (*second revision*)
	IS 8530:1977	Specification for maximum demand indicators, class 1 (Withdrawn)
	IS 14372:1996	Specification for volt-ampere hour meters for full power factor range (Withdrawn)
	IS 14415:1997	Specification for volt-ampere hour meters for restricted power factor range (Withdrawn)
	IS 14697:2021	Specification A.C. Static Transformer Operated Watthour Meters (Class 0.2 S and 0.5 S) and Var-Hour Meters (Class 0.2S, 0.5S and 1S) — Specification (*first revision*)
	IS 15884 : 2024	Alternating Current Direct Connected Static Prepayment Meters for Active Energy (Class 1 and Class 2) — Specification (*first revision*)
	IS 16444:2015	Specification for a.c. static direct connected watthour smart meter class 1 and 2
(22)	IS 15707:2006	Code of practice for testing, evaluation, installation and maintenance of a.c. electricity meters

(23)	IS/IEC 60079-1:2014	Explosive atmospheres: Part 1 Equipment protection by flameproof enclosures "d" (*first revision*)
(24)	IS 5578:1984	Guide for marking of insulated conductors (*first revision*)
	IS 11353:2023 IEC 60445 : 2021	Basic and Safety Principles for Man-Machine Interface, Marking and Identification — Identification of Equipment Terminals, Conductor Terminations and Conductors (*first revision*)
(25)	IS/IEC 60309-1:2021	Plugs, Fixed or Portable Socket-Outlets and Appliance Inlets for Industrial Purposes: Part 1 General requirements (*second revision*)
	IS/IEC 60309-2:2021	Plugs, Fixed or Portable Socket-Outlets and Appliance Inlets for Industrial Purposes: Part 2 Dimensional interchangeability requirements for pin and contact-tube accessories (*second revision*)
(26)	IS 2206(Part 1):1984	Flameproof electric lighting fittings: Part 1 Well-glass and bulkhead types (*first revision*) (Withdrawn)
	IS 3528:1966	Specification for waterproof electric lighting fittings (Withdrawn)
	IS 3553:1966	Specification for watertight electric lighting fittings (Withdrawn)
	IS 5077:1969	Specification for decorative lighting outfits (Withdrawn)
	IS 10322 (Part 5/Sec 5): 2013	Luminaires: Part 5 Particular requirements, Section 5 Flood lights (*first revision*)
(27)	IS 12640 (Part 1):2024 IEC 61008-1:2012	Residual current operated circuit- breakers without integral overcurrent protection for household and similar uses (RCCBs): Part 1 General rules (*third revision*)
	IS 12640 (Part 2):2016 IEC 61009-1:2012	Residual current operated circuit- breakers with integral overcurrent protection for household and similar uses (RCBOs): Part 2 General rules (*second revision*)
	IS 14614:2023 IEC 1543:2022	Residual current operated protective devices (RCDs) for household and similar use – Electromagnetic compatibility (*first revision*)
	IS/IEC 60898-1:2015	Electrical accessories – Circuit breakers for over current protection for household and similar installations: Part 1 Circuit breakers for a.c. operation (*first revision*)

	IS/IEC 60947-1:2020	Low-voltage switchgear and controlgear: Part 1 General rules (*second revision*)
	IS/IEC 60947-2:2016	Low-voltage switchgear and controlgear: Part 2 Circuit breakers (*first revision*)
	IS/IEC 60947-3:2020	Low-voltage switchgear and controlgear : Part 3 Switches, disconnectors, switch-disconnectors and fuse combination units (*second revision*)
	IS/IEC 60947-4-1:2018	Low-voltage switchgear and controlgear: Part 4 Contractors and motor-starters, Section 1 Electromechanical contactors and motors-starters (*second revision*)
	IS/IEC 60947-4-2:2020	Low-voltage switchgear and controlgear: Part 4 Contractors and motor-starters, Section 2 a.c. semiconductor motor controllers and soft starters (*second revision*)
	IS/IEC 60947-4-3:2020	Low-voltage switchgear and controlgear: Part 4 Contractors and motor-starters, Section 3 a.c. semiconductor motor controllers and contactors for non-motor loads (*third revision*)
	IS/IEC 60947-5-1:2016	Low-voltage switchgear and controlgear: Part 5 Control circuit devices and switching elements, Section 1 Electromechanical control circuit devices (*second revision*)
	IS/IEC 60947-5-2:2019	Low-voltage switchgear and control gear: Part 5 Control circuit devices and switching elements, Section 2 Proximity switches (*first revision*)
(28)	IS 3961	Recommended current ratings for cables
	(Part 1):2018	Paper insulated lead sheathed cables (Withdrawn)
	(Part 2):2017	PVC insulated and PVC sheathed heavy duty cables (*first revision*)
	(Part 3):1968	Rubber insulated cables
	(Part 5):1968	PVC insulated light duty cables
	(Part 6):2016	Crosslinked polyethylene insulated PVC sheathed cables
(29)	IS 2086:1993	Specification for carriers and bases used in rewireable type electric fuses for voltages up to 650 V (*third revision*)
	IS/IEC 60269-1 : 2014	Low-Voltage Fuses Part 1 General Requirements
(30)	IS 2672:1966	Code of practice for library lighting
	IS 4347:1967	Code of practice for hospital lighting
	IS 6665:1972	Code of practice for industrial lighting
	IS 8030:1976	Specification for luminaires for hospitals (Withdrawn)

(31)	IS 4648:1968	Guide for electrical layout in residential buildings
(32)	IS 900:2019	Code of practice for Storage, installation and maintenance of induction motors (*third revision*)
(33)	IS 3480:1966	Specification for flexible steel conduits for electrical wiring (*first revision*)
	IS 3837:1976	Specification for Accessories for rigid steel conduits for electrical wiring (*first revision*)
	IS 3419:1988	Fittings for rigid non-metallic conduits (*second revision*)
	IS 9537	Conduits for electrical installations
	(Part 1):1980	General requirements
	(Part 2):1981	Rigid steel conduits
	(Part 3):1983	Rigid plain conduits of insulating materials
	IS 14768	Conduit fittings for electrical installations
	(Part 1):2000	General requirements
	(Part 2):2003	Metal conduit fittings
	IS 14772:2020	Boxes and Enclosures for Electrical Accessories for Household and Similar Fixed Electrical Installations — General Requirements (*first revision*)
(34)	IS 16205	Conduit systems for cable management
	(Part 1):2017	General requirements
	(Part 2):2001	Particular requirements – conduit systems buried underground (Withdrawn)
(35)	IS 14297:2024	Corrosion of metals and alloys – Methods of determination of corrosion rate of standard specimens for the evaluation of corrosivity (*first revision*)
(36)	IS 9537	Conduits for electrical installations
	(Part 1):1980	General requirements
	(Part 2):1981	Part 2 Rigid steel conduits
(37)	IS 3837:1976	Accessories for rigid steel conduits for electrical wiring (*first revision*)
	IS 14768	Conduit fittings for electrical installations
	(Part 1):2000	General requirements
	(Part 2):2003	Metal conduit fittings
	IS 14772:2020	General requirements for enclosures for accessories for household and similar fixed electrical installations (*first revision*)
(38)	IS 9537	Conduits for electrical installations
	(Part 1):1980	General requirements

	(Part 3):1983	Rigid plain conduits of insulating materials
(39)	IS 3419:1988	Fittings for rigid non-metallic conduits (*second revision*)
	IS 14772:2020	Boxes and Enclosures for Electrical Accessories for Household and Similar Fixed Electrical Installations — General Requirements (First Revision)
(40)	IS 13021(Part 1):1991	Specification for a.c. supplied electronic ballasts for tubular florescent lamps: Part 1 General and safety requirements (Withdrawn)
(41)	IS 1258:2024	Bayonet lamp holders (*fifth revision*)
(42)	IS 418:2004	Tungsten filament lamps for domestic and similar general lighting purposes (*fourth revision*)
	IS 1569:1976	Specification for capacitors for use in tubular fluorescent, high pressure mercury and low pressure sodium vapour discharge lamp circuits (First Revision)
	IS 2215:2006	Specification for starters for fluorescent lamps (*third revision*)
	IS 2418	Specification for tubular fluorescent lamps for general lighting service
	(Part 1):2018	Safety Requirements (*second revision*)
	(Part 2):2018	Performance Requirements (*second revision*)
	(Part 3):1977	Dimensions of G-5 and G-13 bi-pin caps (*first revision*)
	(Part 4):1977	Go and no-go gauges for G-5 and G-13 bi-pin caps (*first revision*)
	IS 3323:1980	Bi-pin lampholders for tubular fluorescent lamps (*first revision*)
	IS 3324:1982	Holders for starters for tubular fluorescent lamps (*first revision*)
	IS 9900	Specification for high pressure mercury vapour lamps
	(Part 1):1981	Requirements and tests
	(Part 2):1981	Standard lamp data sheets
	(Part 3):1981	Dimensions of lamp caps
	(Part 4):1981	Go and no-go gauges of lamp caps
(43)	IS 374:2019	Specification for Electric ceiling type fans and regulators (*third revision*)
(44)	IS 3043:2018	Code of practice for earthing(*second revision*)

(45)	IS/IEC 62305-3:2010	Protection against lightning: Part 3 Physical damage to structures and life hazard
(46)	IS/IEC 62305-1:2010	Protection against lightning: Part 1 General principles
(47)	IS/IEC 62305-2:2010	Protection against lightning: Part 2 Risk management
(48)	IS/IEC 62305-4:2010	Protection against lightning : Part 4 Electrical and electronic systems within structures
(49)	IS 16463 (Part 11):2016 IEC 61643-11:2011	Low-voltage surge protective devices: Part 11 Surge protective devices connected to low-voltage power systems — Requirements and test methods
(50)	IS 8437 (Part 1):1993 IEC Pub 479-l (1984)	Guide on effects of current passing through the human body: Part 1 General aspects (*first revision*)
(51)	IS 18732 : 2023	Guide for implementation of electrical installation standards in building
(52)	IS 17050 : 2023 IEC 62262 : 2001 +AMD1 : 2021	Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK Code) (*first revision*)
(53)	IS/IEC 61537 : 2006	Cable Management — Cable Tray Systems and Cable Ladder Systems
(54)	IS 18925 (Part 5) : 2025 IEC 62561-5 : 2023	Lightning Protection System Components (LPSC) Part 5 Requirements for Earth Electrode Inspection Housings and Earth Electrode Seals
(55)	IS 18925 (Part 7) : 2025 IEC 62561-7 : 2024	Lightning Protection System Components (LPSC) Part 7 Requirements for Earthing Enhancing Compounds
(56)	IS 18925 (Part 1) : 2025 IEC 62561-1 : 2023	Lightning protection system components (LPSC) Part 1 Requirements for Connection Components
(57)	IS 15382 (Part 1) : 2022 IEC 60664-1 : 2020	Insulation Coordination for Equipment within Low-Voltage Systems Part 1 Principles, Requirements and Tests (*second revision*)

****