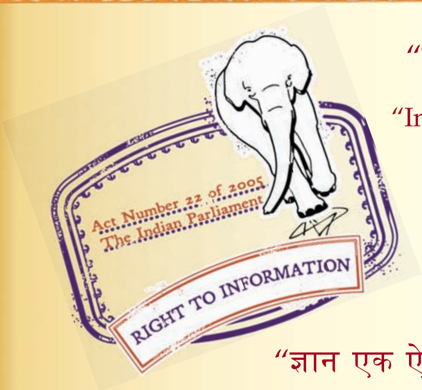
SP 30 (2011): National Electrical Code 2011 [ETD 20: Electrical Installation]



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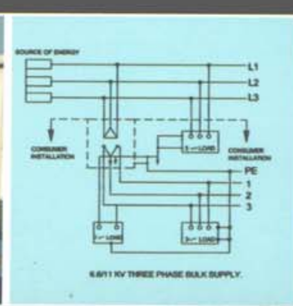
National Electrical Code 2011

SP 30 : 2011






भारतीय मानक ब्यूरो

BUREAU OF INDIAN STANDARDS

राष्ट्रीय विद्युत संहिता 2011

(प्रथम पुनरीक्षण)

NATIONAL ELECTRICAL CODE 2011

(First Revision)

भारतीय मानक ब्यूरो
BUREAU OF INDIAN STANDARDS

SP 30 : 2011

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INTRODUCTION

India is on the path of development and its infrastructure sector has grown progressively. The buildings and services so constructed depend on power for their construction and effective utilization. In fact, power is one of the prime movers of development and electrical energy is the predominant form of energy being used due to ease of generation/conversion, transmission, and final utilization.

Specific regulations to be adhered to in the supply and use of electrical energy had been laid down by the *Indian Electricity Act,* 1910 and the *Indian Electricity Rules,* 1956 framed thereunder. However, a need was felt to elaborate upon these regulations since the agencies involved have varied practices in view of their diverse interests and different accessibility levels to technological developments. In order to rationalize these practices, India's first National Electrical Code, formulated in 1985, was a compendium of several well established codes of practice which provided assistance on economic selection, installation and maintenance of electrical equipment employed in the usage of electrical energy. The code complemented and elaborated on the *Indian Electricity Rules,* 1956 for the ease of application by the system engineers by recommending the best practices for electrical installations in a consolidated form in order to provide for unified practices and procedures along with consideration for safety and economic usage of energy in the design, execution, inspection and maintenance of electrical installations of various locations.

During the formulation of the National Electrical Code in 1985, it was realized that the referred codes, for example, those on wiring practice, earthing, lightning protection etc need to be revised in line with the practice and technology available at that time. It had also been planned that after the relevant codes are revised, the National Electrical Code would also need to be revised. After the publication of NEC 1985, the referred Codes were revised. However, the task of revision of NEC could not be taken up in earnest immediately after the revision of various codes of practice. Over the years, there have been yet more changes in the technology; new practices have evolved and got modified. There have been tremendous socio-economic changes, and corresponding change in the pattern of the usage of electricity. *Electricity Act* 2003 has been notified and power sector reforms have been firmly established. During the Ninth Plan, it was realized that it is necessary to have an *Energy Conservation Act*. Accordingly, the Government has enacted the *Energy Conservation Act*, 2001 to meet the legal requirement needed to enforce energy efficiency and conservation measures. Due to all such changes, the present scenario is at great variance with that of 1985, when the Code was first formulated. Therefore, an urgent need was felt to revise the NEC at the earliest to maintain its relevance in the present context.

The task for revision of NEC was taken up by the Electrical Installations Sectional Committee, ETD 20 considering the above factors. This revision follows the earlier structure of NEC, with modifications and additions being incorporated in line with IEC 60364 series on 'Electrical Installations' as well as the changes and developments that took place since the publication of NEC 1985. It is visualized that in future, further harmonization with international codes may be considered.

Electrical installation should be carried out in accordance with the *Indian Electricity Rules*, 1956 and relevant regulations as amended or brought into force from time to time. All material, accessories, appliances etc., used in an electrical installation should conform to Indian Standards wherever they exist. There should be good workmanship and proper coordination and collaboration between the architect, building engineer and the electrical engineer from the planning stage itself. The design of electrical installation is required to take into account the characteristics of available supply, nature of demand, environmental conditions, type of wiring and methods of installations, protective equipment, emergency control, disconnecting devices, preventing of mutual influence between electrical and non electrical installations, accessibility etc.

The Code is divided into eight parts, which are further divided into sections. Part 1 covers the General and common aspects, which would apply to all types of electrical installations. Wiring installations are an important aspect of any electrical installation. These have been revised to align with international practice and it is proposed to revise the relevant code of practice for wiring installations also. The Sections related to Earthing and Lightning protection have been modified and corresponding modification is also being initiated to respective codes. Aspect of voltage surges has also been included. Energy conservation aspects had been emphasized in NEC 1985. Meanwhile, *Energy Conservation Act,* 2001 has been notified. Therefore, energy conservation aspects have been further elaborated and energy audit has also been included.

This Code excludes the requirements coming under the purview of utilities, namely, the large generating stations, distribution substations and associated transmission system, or captive generator sets of very large capacity. It covers the requirements relating to standby or emergency generating stations and captive substations intended for serving an individual occupancy and intended to serve a building or a group of buildings normally housed in and around it. It gives guidelines on layout and building construction aspects, selection of equipment, transformer installations, switching stations and station auxiliaries. Reference to pollution norms as laid down in *Environment Protection Act* 1986 for diesel generator sets has now been included.

Non-industrial buildings include domestic dwellings, office buildings, shopping and commercial centers and institutions, recreational & assembly buildings, medical establishments, hotels and sports buildings etc. Optimum benefits from the use of electricity can be obtained only if the installation is of sufficient capacity and affords enough flexibility. Safety, economy, efficiency, reliability, convenience as well as provision for future expansion are major considerations in planning the electrical layout. Guidelines are provided based on general characteristics of installations, supply characteristics and parameters. Switchgear for control and protection, service lines, metering, earthing, building services, fire protection and miscellaneous provisions have been covered. Miscellaneous provisions include telephone wiring, call bell system, clock system, group control, audio visual systems, closed circuit TV where applicable, emergency lights for critical areas of the dwelling. Provision of increased number of points for residential units in order to accommodate the gadgets available and to avoid overloading of points by consumer and reference to miniature circuit breakers in addition to fuses under requirement of switchgear for control and protection has been made.

Electrical networks in industrial buildings serve the purpose of distributing the required power to the consuming points where it is used for a multitude of purposes in the industry. The design of electrical installation in industrial premises is therefore more complicated than those in non-industrial buildings. Industrial installation has to take care of load requirements and supply limitations in a simple and economic manner, ensuring at the same time full protection to human life and loss of property by fire. The network layout should also facilitate easy maintenance and fault localization. A particular feature of electrical installations in industrial buildings is the reliability of supply to essential operations for which standby and emergency supply sources/networks are available. The needs of such systems would depend on the type and nature of the industrial works.

Locations in industrial buildings which are by their nature hazardous, require special treatment in respect of design of electrical installations therein. Industrial installations have been classified depending on the specified criteria therein in order to help identify the specific nature of each industry and the locations therein, for assisting the design engineer in the choice of equipment and methods.

Electrical installations are often required to be designed and erected for use for short periods of time ranging from a few hours to few months and are connected to the supply source in open ground. Such installations are generally unprotected from environmental hazards as compared to installations in buildings. Major risks in the use of power in such installation arise from short circuit resulting in fire accidents and exposure to live wire resulting in shock. Outdoor installations are required to comply not only with the general requirements, but also additional requirements regarding supply intake arrangements, control of circuits, earthing, and protection against overload, short circuit and earth leakage.

There is increased use of electricity for essential purposes in agriculture with the increase in sophistication in organising the farm output of the country. Installations in agricultural premises are different as the external influences on the electrical services are quite different from those encountered elsewhere. Even though the overall power requirements for such installations could be small, the presence of livestock and other extraneous factors necessitate laying down specific requirements to ensure safety. Specific requirements of electrical installations in agricultural premises which include premises where livestock are present and farm produce are handled or stored have been covered. Agricultural processing at the farm premises has now been included.

Any area, where during normal operations a hazardous atmosphere is likely to occur in sufficient quantity to constitute a hazard had to be treated in a special manner from the point of the design of electrical installation.

Many liquids, gases and vapours which in industry are generated, processed, handled and stored are combustible. When ignited these may burn readily and with considerable explosive force when mixed with air in the appropriate proportions. With regard to electrical installations, essential ignition sources include arcs, sparks or hot surfaces produced either in normal operation or under specified fault conditions. NEC provides guidelines for electrical installations and equipment in locations where a hazardous atmosphere is likely to be present with a view to maximizing electrical safety. When electrical equipment is to be installed in or near a hazardous area, effort is to be made to locate much of the equipment in less hazardous or non-hazardous areas and thus reduce the amount of special equipment required. Hazardous areas can be limited in extent by construction measures, that is, walls or dams. Ventilation or application of protective gas also reduces the probability of the presence of explosive gas atmosphere so that areas of greater hazard can be transformed to areas of lesser hazard or to non-hazardous areas. A number of product standards offering different types of protection are available. Regulatory requirements are to be adhered to for such installations. Standards pertaining to classification of hazardous areas having flammable gases and vapours for electrical installation and guide for selection of electrical equipment for hazardous area have been revised and the changes have been incorporated in the NEC.

Excessive reliance on fossil fuel resources to meet the energy requirement of the country is considered unsustainable in the long-run and has an adverse impact on the environment and ecology. This has resulted in the quest of renewable sources of energy as a viable option to achieve the goal of sustainable development. Harnessing of solar energy is one such area which is expected to supplement energy supply efforts. Hence a new part on solar photovoltaic installations has been added.

The Code excludes guidance on tariff. Product details are also excluded from the Code as separate product standards are available for these. When these standards are revised subsequent to the revision of NEC, there could be instances where the latest Codes differ from the revised NEC. It is therefore recommended to follow the provisions of the latest standards/codes of practice. In order to avoid instances where the Indian Standards and provisions of this Code differ, attention has been drawn to the relevant standard. However, for certain provisions in this Code, the relevant requirements from corresponding Indian Standards have been extracted and reproduced. In all cases, for detailed guidance, reference should be made to the individual standard and should any contradiction be observed between the provisions in individual standard and those reproduced herein, the provisions of the former shall be considered accurate. As a general rule, technological innovations such as better materials or new and better method also proved as 'good practice' would first be introduced in the individual standard as appropriate than in the National Electrical Code. In order to keep pace with such changes and to incorporate the additional knowledge that will be gained through the implementation of the Code, a continuous review is envisaged. Thus, the users of this Code are encouraged to bring to the notice of Bureau of Indian Standards, need of modifications that may be required in the light of changes in technology or other factors, as this is a continuous process.

The National Electrical Code (hereafter referred to as the Code) is intended to be advisory. It contains guidelines, which can be immediately adopted for use by the various interests concerned. Its provisions are presently not mandatory but are expected to serve as a model for adoption in the interest of safety and economy and with the intent to keep our electrical installation practices at par with the best practices in the world.

COMMITTEE COMPOSITION

Electrical Installations Sectional Committee, ETD 20

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SHRI N. NAGARAJAN
Chief Engineer
Central Public Works Department, New Delhi

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Member Secretary
SHRIMATI NISHAT S. HAQUE
Scientist E (Electrotechnical)

CONTENTS

NATIONAL ELECTRICAL CODE

PART 1

PART 1 GENERAL AND COMMON ASPECTS

0 FOREWORD

Electrical installations require adequate planning right from concept stage to layout and designing, selection of proper equipment, their installation and their maintenance. Fundamental aspects of installation practice are common for most of the types of electrical installations. Part 1 of the National Electrical Code covers these aspects under its various Sections.

An account has been taken of the Indian Standards existing on different aspects of electrical installation practice. However, some practices have changed over time and corresponding Codes of practice either do not exist or are yet to be modified. An attempt has been made through this Code to refer to the present good practices. A reference has also been made to product standards in order to inform the user of the Code about the availability and desirability to use them.

Aspects concerning specific occupancies are covered in other Parts and Sections of this Code. The fundamental principles of installation practice covered under Part 1 of this Code generally apply, unless modified or supplemented by subsequent Parts. This Part 1 would also be a useful reference for occupancies not explicitly covered by the scope of subsequent Parts of the Code.

SECTION 1 SCOPE OF THE NATIONAL ELECTRICAL CODE

0 FOREWORD

Each Part/Section of the National Electrical Code covers the requirements relating to electrical installations in specific occupancies. The fundamental and general principles governing electrical installation practice together with common aspects applicable to all types of installations has been brought out in a separate Part in order to serve as a reference document on such matters.

The details enumerated in this Part are generally applicable to all types of occupancies and are to be read as modified or supplemented with the information provided in the relevant Parts of the Code.

Effort has been made to make this part self-contained, so that users of the Code can derive utmost advantage in using it for application in the field even for occupancies not explicitly covered by the scope of subsequent Parts of the Code. Efforts have also been made to ensure that all the relevant details required for the understanding of the Code are available to the extent possible within Part 1 and effort has been made to keep the references of individual standards to the minimum.

1 SCOPE

This Part 1/Section 1 of the Code describes the scope of the National Electrical Code.

2 REFERENCES

The National Electrical Code takes into account the stipulations in several Indian Standards dealing with the various aspects relating to electrical installation practice. Several product standards also exist, and compliance with relevant Indian Standards is desirable. It is therefore recommended that individual Parts/Sections of the Code should be read in conjunction with the relevant Indian Standards. List of such Indian Standards is given at relevant Part/Section of the Code.

At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards.

3 SCOPE OF THE NATIONAL ELECTRICAL CODE

3.1 The National Electrical Code covers the following:

a) Standard good practices for selection of various items of electrical equipment forming part of power systems;
b) Recommendations concerning safety and related matter in the wiring of electrical installations of buildings or industrial structures, promoting compatibility between such recommendations and those concerning the equipment installed;
c) General safety procedures and practices in electrical work; and
d) Additional precautions to be taken for use of electrical equipment for special environmental conditions like explosive and active atmosphere.

3.2 The Code applies to electrical installations such as those in:

a) Standby/emergency generating plants and building substations;
b) Domestic dwellings;
c) Office buildings, shopping and commercial centres and institutions;
d) Recreation and other public premises;
e) Medical establishments;
f) Hotels;
g) Sports buildings;
h) Industrial premises;
j) Temporary and permanent outdoor installations;
k) Agricultural premises;
m) Installations in hazardous areas; and
n) Solar photovoltaic installations.

NOTES

1 Any type of installation not covered by the above shall be classified in the group which most nearly resemble its existing or proposed use.

2 Where change in the occupancy places it under the scope of a different Section of the Code, the same installation shall be made to comply with the requirements of the Code for the new occupancy.

3.3 The Code applies to circuits other than the internal wiring of apparatus.

3.4 The Code does not apply to traction, motor vehicles, installations in rolling-stock, on board-ships, aircraft or installations in underground mines.

3.5 The Code covers only electrical aspects of lightning protection of buildings and in so far as the effects of lightning on the electrical installations are concerned.

It does not cover lightning protection aspects from structural safety point of view.

3.6 The Code is also not intended to apply to,

a) Systems of distribution of energy to public; and

b) Power generation and transmission for such systems.

3.7 The Code also does not cover guidelines on the payment for electrical work done in installations.

SECTION 2 DEFINITIONS

0 FOREWORD

Each Part of the Code gives, where necessary, definitions of terms and phrases relevant for the comprehension of the requirements stipulated therein. Users may find it convenient to refer to a detailed list of terms and their definitions contained in this section that are relevant to electrical installation practice. It may however be noted that for further guidance, recourse should be made to IS 1885 (series) on electrotechnical vocabulary containing a compendium of terms in the field.

The definitions contained in the Code are based on the current international terminology as far as possible. Some definitions are based on the terminology drawn up by the relevant expert groups under the Electrotechnical Division Council with the object of striking a correct balance between absolute precision and simplicity. The principal object of this exercise is to provide definitions which are sufficiently clear so that each term is understood with the same meaning by all concerned. It may sometimes be felt that the definitions are not identical with those which may be found in other publications designed with different objectives and for other readers. Such differences are inevitable and should be accepted in the interest of clarity.

1 SCOPE

This Part 1/Section 2 of the Code covers definitions of terms.

2 REFERENCES

A list of Indian Standards on electrotechnical vocabulary relevant for the purpose of the Code is given at Annex A.

3 TERMINOLOGY

3.0 For the purpose of the National Electrical Code, the following definitions shall apply, in addition to those contained in individual Parts/Sections and relevant Indian Standards.

3.1 Fundamental Definitions

3.1.1 *Capacitor* — A system of two conductors (plates) separated over the extent of their surfaces by an insulation medium which is capable of storing electrical energy as electrical stress.

3.1.2 *Conductor* — A substance or body which allows current of electricity to pass continuously.

3.1.3 *Dielectric* — A material medium in which an electric field can exist in a stationary state.

3.1.4 *Electrode* — A conducting element used for conveying current to and from a medium.

3.1.5 *Current* — The elementary quantity of electricity flowing through a given section of a conductor divided by the corresponding indefinitely small time.

3.1.6 *Electric Circuit* — An arrangement of bodies or media through which a current can flow.

3.1.7 *Electric Current* — The movement of electricity in a medium or along a circuit. The direction of the current is accepted as opposite to that of the motion of negative electricity.

3.1.8 *Voltage, Potential Difference* — The line of integral from one point to another of an electric field, taken along a given path.

3.1.9 *Arc* — A luminous discharge of electricity across a gas, characterized by a large current and a low voltage gradient, often accompanied by partial volatilization of the electrodes.

3.1.10 *Flashover* — The passage of a disruptive discharge round in insulating material.

3.1.11 *Spark* — A brilliantly luminous phenomenon of short duration which characterized a disruptive discharge.

3.1.12 *Connection of Circuits*

3.1.12.1 *Series* — An arrangement of elements so that they all carry the same current or flux.

3.1.12.2 *Parallel* — An arrangement of elements so that they all carry a portion of total current or flux through them

3.1.12.3 *Series parallel* — An arrangement of elements of which some are connected in series and others in parallel.

3.1.13 *Earth Fault* — Accidental connection/contact of a conductor to earth. When the impedance is negligible, the connection is called a dead earth.

3.1.14 *Earth Leakage Current* — The current flowing to earth on account of imperfect insulation.

3.1.15 *Insulation Fault* — An abnormal decrease in insulation resistance.

3.1.16 *Overload* — Operating conditions in an electrically undamaged circuit which causes an overcurrent.

3.1.17 *Short-circuit* — The intentional or accidental connection of two points of a circuit through a negligible impedance. The term is often applied to the group of phenomena which accompany a short circuit between points at different potentials.

3.2 Equipment

3.2.1 *Electrical Equipment* — The electrical machines, apparatus and circuits forming part of an electrical installation or a power system.

NOTES

1 Outdoor electrical equipment are those suitable for installation in open air.

2 For the purpose of this Code, the term electrical equipment can in general be used to any item used for such purposes as generation, conversion, transmission, distribution or utilization of electrical energy such as machines, transformers, apparatus, measuring instruments, protective devices, wiring material and appliances.

3.2.2 *Current Using Equipment* — Equipment intended to convert electrical energy into another form of energy, for example, light, heat or motive power.

3.2.3 *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.

3.2.4 *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.

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

3.2.6 *Fixed Equipment* — Equipment fastened to a support or otherwise secured in a specific location.

3.2.7 *Generator* — A machine for converting mechanical energy into electrical energy.

3.2.8 *Electric Motor* — A machine for converting electrical energy into mechanical energy.

3.2.9 *Induction Motor* — An alternating current motor without a commutator in which one part only, the rotor or a stator, is connected to the supply network, the other working by induction.

3.2.10 *Motor Generator Set* — A machine which consists of an electric motor mechanically coupled to a generator.

3.2.11 *Auto-transformer* — A transformer in which the primary and secondary windings have common part or parts.

3.2.12 *Transformer* — A piece of apparatus, without continuously moving parts, which by electromagnetic induction transforms variable voltage and current in one or more other windings usually at different values of voltage and current and at the same frequency.

3.2.13 *Relay (Including Gas-operated Relay)* — A device designed to produce sudden pre-determined changes in one or more *physical* systems on the appearance of certain conditions in the *physical* system controlling it.

3.2.14 *Switchgear and Controlgear* — A general term covering switching devices and their combination with associated control, measuring, protective and regulating equipment, also assemblies of such devices and equipment with associated inter-connections, accessories, enclosures and supporting structures intended in principle for use in connection with generation, transmission, distribution and conversion of electric energy. Controlgears are switching devices intended in principle for the control of electrical energy consuming equipment.

3.2.15 *Switch (Mechanical)* — A mechanical switching device capable of making carrying and breaking currents under normal circuit conditions which may include specified operating overload conditions and also carrying for a specified time currents under specified abnormal circuit conditions such as those of a short-circuit.

3.2.16 *Switch-fuse* — A switch in which one or more poles have a fuse in series in a composite unit.

3.2.17 *Fuse-switch* — A switch in which a fuse-link or a fuse-carrier with fuse-link forms the moving contact of the switch.

3.2.18 *Circuit-Breaker (Mechanical)* — A mechanical switching device capable of making carrying and breaking currents under normal circuit conditions and also making, carrying for a specified time and breaking currents under specified abnormal circuit conditions such as those of a short-circuit.

3.2.19 *Fuse* — device that, by the fusing 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

NOTE — The fuse comprises all the parts that form the complete device.

3.2.20 *Enclosed Distribution Fuse-board* — An enclosure containing bus-bars, with fuses, for the purposes of protecting, controlling or connecting more than one outgoing circuit fed from one or more incoming circuits.

3.2.21 *Enclosed Fuse-link* — Fuse-link in which the fuse-element is totally enclosed, so that during operation within its rating it cannot produce any harmful external effects, for example, due to development of an arc, the release of gas or the ejection of flame or metallic particles.

3.2.22 *Fuse-link* — Part of a fuse including the fuse-element(s) intended to be replaced after the fuse has operated.

3.2.23 *Miniature Circuit-breaker* — A compact mechanical device for making and breaking a circuit both in normal conditions and in abnormal conditions such as those of overcurrent and short-circuit.

3.2.24 *D-Type Fuse* — A non-interchangeable fuse comprising a fuse-base a screw type fuse-carrier, a gauge piece and a fuse-link.

3.2.25 *Distribution Pillar* — A totally enclosed structure cubicle containing bus-bars connected to incoming and outgoing distribution feeders controlled through links fuses.

3.2.26 *Interconnecting Bus-bar* — A conductor other than cable, used for external connection between terminals of equipment.

3.2.27 *Bimetallic Connector* — A connector designed for the purpose of connecting together two or more conductors of different materials (normally copper and aluminium) for preventing electrolytic corrosion.

3.2.28 *Fuse-element (Fuse-wire in Rewirable Fuse)* — That part of a rewirable fuse, which is designed to melt when the fuse operates.

3.2.29 *Fuse-base (Fuse-mount)* — The fixed part of a fuse provided with contacts and terminals for connection to the system. The fuse-base comprises all the parts necessary for insulation.

3.2.30 *Fuse-carrier* — The movable part of a fuse designed to carry a fuse-link. The fuse-carrier does not include any fuse-link.

3.2.31 *Lightning Arrester (Surge Diverter)* — A device designed to protect electrical apparatus from high transient to protect electrical apparatus from high transient voltage and to limit the duration and frequently the amplitude of follow-current. The term 'lightning arrester' includes any external series gap which is essential for the proper functioning of the device as installed for service, regardless of whether or not it is supplied as an integral part of the device.

3.3 Wiring Practice

3.3.1 *Accessory* — Any device, associated with the wiring and electrical appliance of an installation, for example, a switch, a fuse, a plug, a socket-outlet, a lamp holder, or a ceiling rose.

3.3.2 *Apparatus* — Electrical apparatus including all machines, appliances and fittings in which conductors are used for of which they may form a part.

3.3.3 *Aerial Conductor* — Any conductor which is supported by insulators above the ground and is directly exposed to the weather.

NOTE — The 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.

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

3.3.5 *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.

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

3.3.7 *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.

3.3.8 *Circuit* — An arrangement of conductor or conductors for the purpose of conveying energy and forming a system or a branch of a system.

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

3.3.10 *Cleat* — An insulated incombustible support normally used for insulated cable.

3.3.11 *Conductor, Bare* — A conductor not covered with insulating material.

3.3.12 *Conductor, Earthed* — A conductor with no provision for its insulation from earth.

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

3.3.14 *Connector Box or Joint Box* — A box forming a part of wiring installation provided to contain joints in the conductors of cables of the installation.

3.3.15 *Conductor for Portable Appliances* — A combination of a plug and socket arranged for attachment to a portable electrical appliance or to a flexible cord.

3.3.16 *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.

3.3.17 *Cord, Flexible* — A flexible cable having conductor of small cross-sectional area. Two flexible cords twisted together are known as 'Twin Flexible Cord'.

NOTE — For the maximum diameter and minimum number of wires for flexible cord, *see* relevant standard.

3.3.18 *Cut-out* — Any appliance for automatically interrupting the transmission of energy through any conductor when the current rises above a predetermined amount, for example, fusible cut-out.

3.3.19 *Dead* — At or about earth potential and/or disconnected from any live system.

3.3.20 *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.

3.3.21 *Distribution Fuse-board* — An assemblage of parts including one or more fuses arranged for the distribution of electrical energy to final sub-circuits.

3.3.22 *Earth* — A connection to the general mass of earth by means of an earth electrode. An object is said to be 'earthed' when it is electrically connected to an earth electrode; and a conductor is said to be 'solidly earthed' when it is electrically connected to earth electrode without a fuse, switch, circuit-breaker, resistance or impedance in the earth connection.

3.3.23 *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.

3.3.24 *Earth Electrode* — A metal plate, pipe or other conductor electrically connected to the general mass of the earth.

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

3.3.26 *Fitting, Lighting* — A device for supporting or containing a lamp or lamps (for example, fluorescent or incandescent) together with any holder, shade, or reflector, for example, a bracket, a pendant with ceiling rose, or a portable unit.

3.3.27 *Flammable* — A material capable of being easily ignited.

3.3.28 *Disconnector* — A device used to open (or close) a circuit when either negligible current is interrupted (or established) or when the significant change in the voltage across the terminal of each of the pole of the disconnector occurs; in the open position it provides an isolating distance between the terminals of each pole.

3.3.29 *Double Insulation*

a) *Of a conductor* — A conductor is said to have double insulation when insulating material intervenes not only between the conductor and its surrounding envelope (if a cable) or immediate support (if bare), but also between the envelope or support and earth.
b) *Of an appliance* — An appliance having accessible metal part is doubly insulated when protective insulation is provided in addition to the normal functional insulation, in order to protect against electric shock in case of breakdown of the functional insulation.

3.3.30 *Live or Alive* — Electrically charged so as to have a potential difference from that of earth.

3.3.31 *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.

3.3.32 *Neutral or Neutral Conductor* — Includes the neutral conductor of a three-phase four-wire system, the conductor of a single-phase or dc 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 dc or single-phase ac system.

3.3.33 *Point* — A point shall consist of the branch wiring from the branch distribution board, together with a switch as required, as far as and including the ceiling rose or socket-outlet or suitable termination. A three-pin socket-outlet point shall include, in addition, the connecting wire or cable from the earth pin to the earth stud of the branch distribution board.

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

3.3.35 *Socket-outlet and Plug* — A device consisting of two portions for easily connecting portable lighting fittings or other current-using appliances/devices to the supply. The socket-outlet is an accessory having socket contacts designed to engage with the pins of a plug and having terminals for the connection of cable(s).

The plug portion has pins designed to engage with the contacts of a socket-outlet, also incorporating means for the electrical connection and mechanical retention of flexible cable(s).

3.3.36 *Switchboard* — An assemblage of switchgear with or without instruments but the term does not apply to a group of local switches or a final sub-circuit where each switch has its own insulating base.

3.3.37 *Voltage, Low* — The voltage which does not normally exceed 250 V.

3.3.38 *Voltage, Medium* — The voltage which normally exceeds 250 V but does not exceed 650 V.

3.3.39 *Voltage, High* — The voltage which normally exceeds 650 V (but less than 33 kV).

3.3.40 *Voltage, Extra-High* — The voltage exceeding 33 kV under normal conditions.

NOTE — The *Indian Electricity Rules*, 1956 define four ranges of voltages, namely, low (up to 250 V), medium (250-650 V), high (650 V-33 kV) and extra-high (greater than 33 kV). The definitions given in **3.3.37** to **3.3.40** are based on the provisions of IE Rules. It may however, be noted that voltage ranges as defined internationally are at variance with the above definitions.

3.4 Miscellaneous Terms

3.4.1 *Building* — Any structure for whatsoever purpose and of whatsoever materials constructed and every part thereof whether used as human habitation or not and includes foundation, plinth, walls, floors, roofs, chimneys, plumbing and building services, fixed platforms, verandah, balcony, cornice or projection, part of a building or any thing affixed thereto or any wall enclosing or intended to enclose any land or space and signs and outdoor display structures. Tents, *shamianahs*, tarpaulin shelters, etc, erected for temporary of the Authority shall not be considered as building.

3.4.2 *Occupancy or Use Group* — The principal occupancy for which a building or a part of a building is used or intended to be used; for the purposes of classification of a building according to occupancy, an occupancy shall be deemed to include the subsidiary occupancies which are contingent upon it.

3.4.3 *Room Height* — The vertical distance measured from the finished floor surface to the finished ceiling surface. Where a finished ceiling is not provided, the underside of the joints or beams or tie beams shall determine the upper point of measurement for determining the head room.

3.4.4 *Impulse* — Usually an aperiodic transient voltage or current which rises rapidly to a peak value and then falls, generally more slowly, to zero. Ideally it approximates a double exponential form. Other forms are sometimes used for special purposes.

3.4.5 *Clearance* — The distance between two conducting parts along a string stretched the shortest way between these conducting parts.

3.4.6 *Creepage Distance* — The shortest distance between two conducting parts along the surface of the insulating material or along the joint of two insulating bodies.

3.4.7 *Simultaneously Accessible Parts* — Conductors or conductive parts that can be touched simultaneously by a person or where applicable by livestock.

NOTE — Simultaneously accessible parts may be;

a) live parts,

b) exposed conductive parts,

c) extraneous conductive parts,

d) protective conductors, and

e) earth electrodes.

3.4.8 *Arm's Reach* — A zone extending from any point on a surface where persons usually stand or move about to the limits which a person can reach with the hand in any direction without assistance.

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

3.4.10 *Barrier* — A part providing protection against direct contact from any usual direction of access.

3.4.11 *Obstacle* — A part preventing unintentional direct contact, but not preventing deliberate action.

3.4.12 *Leakage Current (in an Installation)* — A current which flows to earth or to extraneous conductive parts in a circuit in the absence of a fault.

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

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

NOTE — The actual voltage may differ from the nominal voltage by a quantity within permitted tolerances.

3.4.14 *Supply Terminals* — The point at which a consumer received energy.

3.4.15 *Service Line, Service* — A line for connecting a current consuming installation to the distribution network.

3.4.16 *Distribution Undertaking* — The party supplying electricity to consumers entirely from external sources of power via a distribution network.

3.4.17 *Consumer or Customer* — The party who receives electricity from the supply or distribution undertaking for his own needs or for further distribution.

3.4.18 *Demand* — The magnitude of electricity supply, expressed in kW or kVA.

3.4.19 *Installed Load* — The sum of the rated inputs of the electrical apparatus installed on the consumer's premises.

3.4.20 *Connected Load* — The part of the installed load of consumer supplied by the supply undertaking.

3.4.21 *Kilowatthour Rate (kWh Rate)* — The amount to be paid per unit of energy (kWh) consumed.

3.4.22 *Meter Rent* — An amount to be paid for a specified period for metering, and associated equipment installed.

3.4.23 *Tariff* — A statement setting out the components to be taken into account and the methods to be employed in calculating the amounts to be charged by the supply/distribution undertaking to the consumer, according to the characteristics of the supply.

3.4.24 *Domestic Tariff* — A tariff applicable particularly or exclusively to domestic consumers.

3.4.25 *Industrial Tariff* — A tariff applicable exclusively to industrial consumers.

3.4.26 *Lighting Tariff* — A tariff applicable to electricity supplies taken mainly for lighting and other small appliances, for example, fans and radios.

3.4.27 *Heating Tariff* — A tariff applicable to electricity supplies taken for space heating or for thermal applications or for both.

3.4.28 *Power Factor Clause* — A clause setting out increase in charges to be applied if the ratio of the kWh to kVAh consumed by a consumer during a specified period below a set limit; the same clause may provide for a decrease in charges in the opposite case.

NOTE — The power factor is generally measured by the ratio of kWh to kVAh consumed during the specified period.

3.4.29 *Load Factor* — The ratio, expressed as a numerical value or as a percentage, of the energy consumption within a specified period (year, month, day, etc) to the energy consumption that would result from continuous use of the maximum kW demand occurring within the same period.

NOTE — The load factor for a given demand is also equal to the ratio of the utilization time to the time in hours within the same period.

ANNEX A

(*Clause* 2)

LIST OF INDIAN STANDARDS ON ELECTROTECHNICAL VOCABULARY

IS No.	*Title*
1885	Electrotechnical vocabulary:
(Part 1) : 1961	Fundamental definitions
(Part 8) : 1986	Secondary cells and batteries (*first revision*)
(Part 9) : 1992/ IEC 60050 (446) : 1983	Electrical relays (*second revision*)
(Part 10) : 1993/ IEC 60050 (448) : 1986	Power system protection (*first revision*)
(Part 11) : 1966	Electrical measurements
(Part 14) : 1967	Nuclear power plants
(Part 15) : 2003/ IEC 60050 (481) : 1996	Primary cells and batteries (*first revision*)
(Part 16/Sec 1) : 1968	Lighting, Section 1 General aspects
(Part 16/Sec 2) : 1968	Lighting, Section 2 General illumination, lighting fittings and lighting for traffic and signalling
(Part 16/Sec 3) : 1967	Lighting, Section 3 Lamps and auxiliary apparatus
(Part 17) : 1979	Switchgear and controlgear (*first revision)*
(Part 27) : 1993/ IEC 60050 (551) : 1982	Power electronics (*second revision*)
(Part 28) : 1993/ IEC 60050 (321) : 1986	Instrument transformers (*first revision*)
(Part 29) : 1971	Mining terms
(Part 30) : 1971	Overhead transmission and distribution of electrical energy

IS No.	*Title*
(Part 32) : 1993/ IEC 60050 (461) : 1984	Electric cables (first revision)
(Part 34) : 1972	Cinematography
(Part 35) : 1993/ IEC 60050 (411) : 1996	Rotating machinery (first revision)
(Part 37) : 1993/ IEC 60050 (691) : 1973	Part 37 Tariffs for electricity (first revision)
(Part 38) : 1993/ IEC 60050 (421) : 1990	Power transformers and reacto (second revision)
(Part 43) : 1977	Electrical equipment used in medical
(Part 51) : 1993/ IEC 60050 (841) : 1983	Industrial electro-heating
(Part 53) : 1980	Mica
(Part 54) : 1993/ IEC 60050 (471) : 1984	Insulators (first revision)
(Part 55) : 1981	Electric fans
(Part 57) : 1993/ IEC 60050 (131) : 1978	Electric and magnetic circuits (first revision)
(Part 60) : 1993/ IEC 60050 (426) : 1990	Electrical apparatus for explosive atmospheres (first revision)
(Part 61) : 1985	Nuclear medical instruments
(Part 62) : 1993/ IEC 60050 (212) : 1990	Solid insulating materials (first revision)
(Part 69) : 1993/ IEC 60050 (602) : 1993	Generation, transmission and distribution of electricity — Generation
(Part 70) : 1993/ IEC 60050 (604) : 1987	Generation, transmission and distribution of electricity — Operation
(Part 71) : 1993/ IEC 60050 (605) : 1983	Generation, transmission and distribution of electricity — Substations
(Part 72) : 1993/ IEC 60050 (101) : 1977	Mathematics
(Part 73/Sec 1) : 1993/IEC60050 (111-1) : 1984	Physics and chemistry, Section 1 physical concepts
(Part 73/Sec 2) : 1993/IEC 60050 (111-2) : 1984	Physics and chemistry — Section 2 Electrotechnical concepts
(Part 73/Sec 3) : 1993/IEC 60050 : (111-3) : 1977	Physics and chemistry — Section 3 Concepts related to quantities and units
(Part 74) : 1993/ IEC 60050 (151) : 1978	Electrical and magnetic devices
(Part 75) : 1993/ IEC 60050 (351) : 1975	Automatic control
(Part 77) : 1993/ IEC 60050 (466) : 1990	Overhead lines
(Part 78) : 1993/ IEC 60050 (601) : 1985	Generation, transmission and distribution of electricity — General
(Part 79) : 1993/ IEC 60050 (603) : 1986	Generation, transmission and distribution of electricity — Power system planning and management
(Part 80) : 1994/ IEC 60050 (301) : 1983	General terms on measurements in electricity
(Part 81) : 1993/ IEC 60050 (302) : 1983	Electrical measuring instruments

SECTION 3 GRAPHICAL SYMBOLS FOR DIAGRAMS, LETTER SYMBOLS AND SIGNS

0 FOREWORD

Several graphical symbols are used for installation diagrams. Considerable amount of standardization has been achieved in the field of

symbols for electrotechnology that it is now possible to device electrical network schematics using them so that these schematic diagrams could be uniformly understood by all concerned.

The symbols contained in this Section of the Code have been drawn up by individual expert groups under the Electrotechnical Division Council. They represent a consensus of opinion in the discipline and are recommended for direct adoption. Assistance has also been drawn from International Electrotechnical Commission (IEC) database IEC 60617 'Graphical symbols for diagrams'.

It has also been felt essential for the purposes of this Section to draw the attention of practicing engineers to standardized letter symbols and signs.

1 SCOPE

This Part 1/Section 3 of the Code covers graphical symbols for diagrams, letter symbols and signs which may be referred to for further details.

2 REFERENCES

A list of relevant Indian Standards on graphical symbols is given at Annex A.

3 GRAPHICAL SYMBOLS

3.0 For the purposes of the Code, the graphical symbols given below shall apply.

NOTE — A list of Indian Standards on graphical symbols used in electrotechnology relevant to the Code is given in Annex A.

3.1 Fundamental Symbols

3.1.1 *Direct Current*

—

3.1.2 *Alternating Current, General Symbol*

a) *Alternating current, single-phase*, 50 Hz

b) *Alternating current, three-phase*, 415 V. 50 Hz

c) *Alternating current, three-phase with neutral*. 50 Hz

3.1.3 *Neutral*

N

3.1.4 *Positive Polarity*

+

3.1.5 *Negative Polarity*

—

3.1.6 *Direct Current, 2 Conductors 110 V*

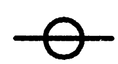
2 —— 110V

3.1.7 *Direct Current, 3 Conductors including Neutral, 220 V*

2N —— 220V

3.1.8 *Underground Cable*

3.1.9 *Overhead Line*



3.1.10 *Winding, Delta*

△

3.1.11 *Winding, Star*

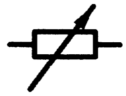
Y

3.1.12 *Terminals*

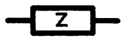
o

3.1.13 *Resistance/Resistor*

3.1.13.1 *Variable resistor*



3.1.14 *Impedance*

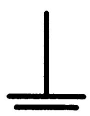


3.1.15 *Inductance/Inductor*

3.1.16 *Winding*

3.1.17 *Capacitance, Capacitor*

3.1.18 *Earth*



3.1.19 *Fault*

3.2 Equipment

3.2.1 *Flexible Conductor*

3.2.2 *Generator*

3.2.2.1 *AC generator*

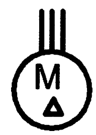
3.2.2.2 *DC generator*

3.2.3 *Motor*

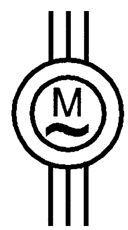
3.2.4 *Synchronous Motor*

3.2.5 *Mechanically Coupled Machines*

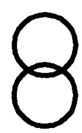
3.2.6 *Induction Motor, Three-Phase, Squirrel Cage*



3.2.6.1 *Induction motor with wound rotor*

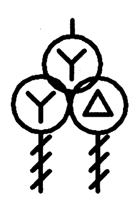


3.2.7 *Transformers with Two Separate Windings*

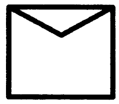


3.2.8 *Auto-Transformer*

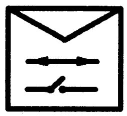
3.2.9 *3-Phase Transformer with Three Separate Windings—Star—Star—Delta*



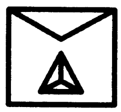
3.2.10 *Starter*



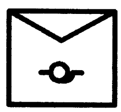
3.2.11 *Direct-on-Line Starter for Reversing Motor*



3.2.12 *Star-Delta Starter*



3.2.13 *Auto-Transformer Starter*

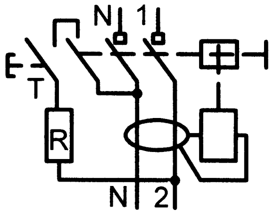


3.2.14 *Rheostatic Starter*

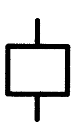
3.2.15 *Switch*

3.2.16 *Contactor*

3.2.17 *Relay*

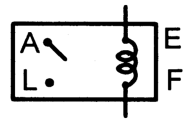


3.2.18 *Circuit-Breaker*



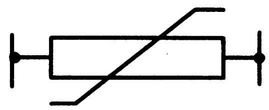
3.2.19 *Isolator*

3.2.20 *Earth Leakage Circuit Breaker*



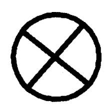
3.2.21 *Residual Current Circuit Breaker*

3.2.22 *Surge Protective Device*



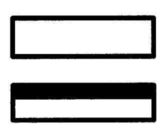
3.2.23 *Fuse*

3.2.24 *Signal Lamp*

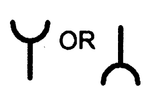


3.2.25 *Link*

3.2.26 *Distribution Board, Cubicle Box, Main Fuse Board with Switches*



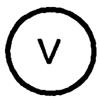
3.2.27 *Socket Outlet, 5A*



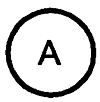
Socket Outlet, 15A

3.2.28 *Plug*

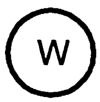
3.2.29 *Voltmeter*



3.2.30 *Ammeter*

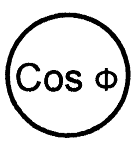


3.2.31 *Wattmeter*

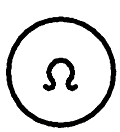


3.2.32 *Varmeter*

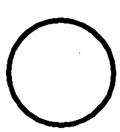
3.2.33 *Power Factor Meter*



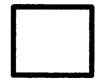
3.2.34 *Ohmmeter*



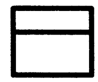
3.2.35 *Indicating Instrument* (general symbol)



3.2.36 *Recording Instrument* (general symbol)

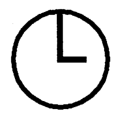


3.2.37 *Integrating Meter*

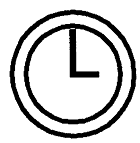


3.2.38 *Watthour Meter*

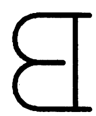
3.2.39 *Clock*



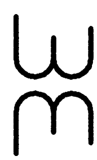
3.2.40 *Master Clock*



3.2.41 *Current Transformer*



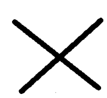
3.2.42 *Voltage Transformer*



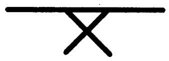
3.2.43 *Wiring on the Surface*

3.2.44 *Wiring in Conduit*

3.2.45 *Lamp*

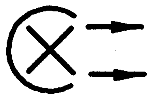


3.2.46 *Lamp Mounted on a Ceiling*

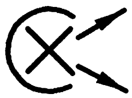


3.2.47 *Emergency Lamp*

3.2.48 *Spot Light*



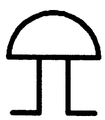
3.2.49 *Flood Light*



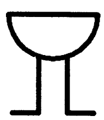
3.2.50 *Heater*

3.2.51 *Storage Type Water Heaters*

3.2.52 *Bell*

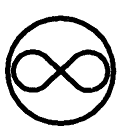


3.2.53 *Buzzer*

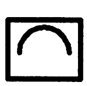


3.2.54 *Ceiling Fan*

3.2.55 *Exhaust Fan*

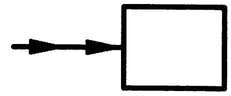


3.2.56 *Fan Regulator*

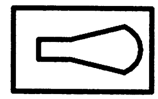


3.2.57 *Aerial*

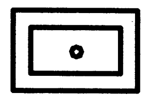
3.2.58 *Radio Receiving Set*



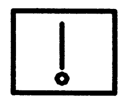
3.2.59 *Television Receiving Set*



3.2.60 *Manually Operated Fire Alarm*



3.2.61 *Automatic Fire Detector Switch*



4 LETTER SYMBOLS AND SIGNS

4.0 General

4.0.1 Quantities and units used in electrotechnology cover in addition to electricity and magnetism other subjects such as radiation and light, geometry, kinematics, dynamics and thermodynamics. Several disciplines interact with the result that terminology used in one discipline becomes closely interrelated with that of the other. In order to enable uniform understanding of the meaning they represent, the letter symbols and signs used in abbreviations for denoting quantities, their functions and units shall conform to those recommended in IS 3722 (Part 1) and IS 3722 (Part 2).

4.0.2 Guidance on the choice of alphabet and their type, representation of vector quantities, symbols of units, numerical values, and guidance on the use of subscripts are covered in IS 3722 (Part 1).

Ready reference tables for symbols and subscripts are contained in IS 3722 (Part 2). For the purposes of this Code, a list of symbols, names of quantities and of constants and subscripts referred to frequently is given in **4.1**.

4.1 Symbols and Subscripts

4.1.1 Table 1 of IS 3722 (Part 2) gives a reference list of symbols and subscripts used in electrotechnology.

ANNEX A

(*Clause* 2)

LIST OF INDIAN STANDARDS ON GRAPHICAL SYMBOLS

IS No.	*Title*
2032	Graphical symbols used in electro-technology:
(Part 15) : 1976	Aircraft electrical symbols
(Part 19) : 1977	Electrical equipment used in medical practice
(Part 25) : 1980	Electrical installations in ships
3722	Letter symbols and signs used in electrical technology:
(Part 1) : 1983	General guidelines on symbols and subscripts
(Part 2) : 1983	Reference tables for symbols and subscripts
10381 : 1982	Terms (and their Hindi equivalents) commonly used for name plates and similar data of electrical power equipment
11353 : 1985	Guide for uniform system of marking and identification of conductors and apparatus terminals
12032 (Part 1): 1987/IEC 60617-1 (1985)	Graphical symbols for diagrams in the field of electrotechnology: Part 1 General information, general index, cross reference table
12032 (Part 2): 1987/IEC 60617-2 (1983)	Graphical symbols for diagrams in the field of electrotechnology: Part 2 Symbols elements, qualifying symbols and other symbols having general application
12032 (Part 3) :	Graphical symbols for diagrams in the field of electrotechnology: Part 3 Conductors and connecting devices
12032 (Part 4) : 1987/IEC 60617-4 (1984)	Graphical symbols for diagrams in the field of electrotechnology: Part 4Passive components
12032 (Part 6) : 1987/IEC 60617-6 (1983)	Graphical symbols for diagrams in the field of electrotechnology: Part 6 Production and conversion of electrical energy
12032 (Part 7) : 1987/IEC 60617-7 (1983)	Graphical symbols for diagrams in the field of electrotechnology: Part 7 Switchgear, controlgear and protective
12032 (Part 8) : 1987/IEC 60617-8 (1983)	Graphical symbols for diagrams in the field of electrotechnology: Part 8 Measuring instruments, lamps and signalling devices
12032 (Part 11) : 1987/IEC 60617-11 (1983)	Graphical symbols for diagrams in the field of electrotechnology: Part 11 Architectural and topographical installation plans and diagrams

SECTION 4 GUIDE FOR PREPARATION OF DIAGRAMS, CHARTS, TABLES AND MARKING

0 FOREWORD

Various types of diagrams and charts are required to be prepared during the planning and execution stages of an electrical installation work. It is therefore necessary to define the different types of diagrams, charts and tables, their purposes and format and the guiding principles for preparing them for the sake of uniformity.

This Section 4 of the Code covers general guidelines on the subject. A list of relevant Indian Standards is given at Annex A.

The guidelines for marking of conductors given in **3.6**. Table 1 are in line with the guidelines accepted internationally on such matters. They provide for a common basis for understanding and identifying conductors and apparatus terminals, but more important, ensure safety to operating, maintenance personnel.

1 SCOPE

This Part 1/Section 4 of the Code covers guidelines for preparation of diagrams, charts and tables in electrotechnology and for marking of conductors.

2 REFERENCES

A list of Indian Standards on general guidelines on various types of diagrams and charts is given at Annex A.

3 PREPARATION OF DIAGRAMS, CHARTS AND TABLES

3.0 General

3.0.1 *Diagram*

A diagram may show the manner in which the various parts of a network, installation, group of apparatus or items of an apparatus are interrelated and or interconnected.

3.0.2 *Chart*

A chart may show the interrelation between;

a) different operations.
b) operations and time.
c) operations and physical quantities, and
d) states of several items.

3.0.3 *Table*

A table replaces or supplements a diagram or a chart.

3.1 Classification According to Purpose

3.1.0 The main classifications are:

a) Explanatory diagrams,
b) Explanatory charts or tables,
c) Wiring diagrams or wiring tables, and
d) Location diagrams or tables.

3.1.1 *Explanatory Diagrams*

Explanatory diagrams are intended to facilitate the study and understanding of the functioning of an installation or equipment. Three types are defined below:

a) *Block diagram* — Relatively simple diagram to facilitate the understanding of the principle of operation. It is a diagram in which an installation or equipment together with its functional interrelationships are represented by symbols, block symbols or pictures without necessarily showing all the connections.
b) *Circuit diagram* — Explanatory diagram intended to facilitate the understanding of the functioning in detail. It shows by symbols an installation or part of an installation and the electrical connections and other links concerned with its operation.
c) *Equivalent circuit diagram* — Special type of circuit diagram for the analysis and calculation of circuit characteristics.

3.1.2 *Explanatory Charts or Tables*

Explanatory charts or tables are intended to facilitate the study of diagrams and to give additional information. Two examples are given below:

a) *Sequence chart or table* — gives the successive operation in a specified order, and
b) *Time sequence chart or table* — is one which in addition takes account of the time intervals between successive operations.

3.1.3 *Wiring Diagrams or Wiring Tables*

Wiring diagrams are intended to guide the making and checking of the connection of an installation or equipment. For an equipment, they show the internal or external connections or both. The diagrams may sometimes show the layout of the different parts and accessories, such as terminal blocks and the wiring between them.

3.1.3.1 *Unit wiring diagram*

Diagram is representing all connections within a unit of an installation.

3.1.3.2 *Interconnection diagram*

Diagram representing the connections between the different units of an installation.

3.1.3.3 *Terminal diagram*

Diagram showing the terminals and the internal and/or external conductors connected to them.

NOTE — Any of the wiring diagram may be replaced or supplemented by a table.

3.1.4 *Location Diagrams or Tables*

A location diagram or table contains detailed information about the location of parts of the equipment, for example, terminal blocks, plug-in units, sub-assemblies, modules, etc. It shows the item designations used in related diagrams and tables.

NOTES

1 A location diagram need not necessarily be to scale.

2 Several types of diagrams may be combined into a single diagram, forming a mixed diagram. The same drawing may form both an explanatory and wiring diagram.

3.2 Classification According to Method of Representation

3.2.1 The method of representation is distinguished by:

a) the number of conductors, devices or elements represented by a single symbol (*see* **3.2.1.1**);
b) the arrangement of the symbols representing the elements or parts of an item of apparatus (for example, detached or assembled) (*see* **3.2.1**); and
c) the placing of the symbols to correspond with the topographical layout of the devices (*see* **3.2.1.3**).

3.2.1.1 *Number of conductors*

According to the number of conductors, devices or elements represented by a single symbol, the two methods of representation as given below may be distinguished.

a) *Single-line representation* — Two or more conductors are represented by a single line.

   In particular, a single line may represent:

   1) circuits of a multi-phase system,
   2) circuits which have a similar electrical function,
   3) circuits or conductors which belong to the same signal path,
   4) circuits which follow the same physical route, and
   5) conductor symbols which would follow the same route on the diagram.

   Several similar items of apparatus may accordingly be represented by a single symbol.

b) *Multi-line representation* — Each conductor is represented by an individual line.

3.2.1.2 *Arrangement of symbols*

According to the arrangement of the symbols representing the elements or parts of an item of apparatus on the diagram, the methods of representation are given below:

a) *Assembled representation* — The symbols for the different parts of an item of apparatus or of an installation or equipment are drawn in close proximity on the diagram.
b) *Semi-assembled representation* — The symbols for the different parts of an item of apparatus or of an installation are separated and arranged in such a way that the symbols for mechanical linkages between the parts which work together may be drawn easily.
c) *Detached representation* — The symbols for the different parts of an item of apparatus or of an installation are separated and arranged in such a way that the circuits may easily be followed.

3.2.1.3 *Topographical representation*

The positions of the symbols on the diagram correspond wholly or partly to the topographical (physical) location of items represented.

The following are examples where topographical representation may be used.

a) Wiring diagrams,
b) Architectural diagrams, and
c) Network diagrams.

NOTE — Several of these methods of representation may be used on the same diagram.

3.3 Item Designation

3.3.1 Item is a term used for component equipment, plant, unit, etc, which is represented by a graphical symbol on a diagram. The item designation is shown at an appropriate place near the graphical symbol of the item. This designation correlates the item on different diagrams, parts list, circuit descriptions and in the equipment.

3.3.2 An item designation may be used for general or special purposes depending on the kind of information required. Guidelines on assignment of item designation, groups together with standard letter codes for the same are covered in IS 8270 (Part 2).

3.4 General Rules for Diagrams

3.4.1 Paper sizes for drawings shall preferably be according to the international A-series (*see* IS 1064). The choice of drawing sizes should be decided after taking into account the necessary factors enumerated in **2.2** of IS 8270 (Part 2).

3.4.2 In IS 2032, different kinds of symbols as well as symbols of different forms are shown. All the possible examples are also not covered there. Any symbol may be composed using the guidance from relevant Part of IS 2032 and Part 1/Section 3 of the Code. The basic rules for the choice of symbols shall be:

a) to use the simplest form of symbol adequate for the particular purpose,
b) to use a preferred form wherever possible, and
c) to use the chosen form consistently throughout the same set of documentation.

3.4.3 Specific guidelines on the application of IS 2032 (All parts) from the point of view of choice of alternative symbols, symbol sizes, line thickness, orientation of symbols and methods of indicating symbol location are covered in IS 8270 (Part 3).

3.5 Interconnection Diagrams and Tables

3.5.1 Interconnection diagrams and tables provide information on the external electrical connections between equipment in an installation. They are used as an aid in the fabrication of wiring and for maintenance purposes. Information on the internal connections of units are normally not provided but references to the appropriate circuit diagram [*see* IS 8270 (Part 4)] may be provided.

3.5.2 The diagrams may employ single or multiple representation and may be combined with or replaced by tables, provided clarity is maintained. Tables are recommended when the number of interconnections is large.

3.5.3 Guidance on layout, identification and types of interconnection diagrams and tables are given in IS 8270 (Part 5).

3.6 Marking and Arrangement of Conductors

3.6.0 *General*

3.6.0.1 The purpose of marking is to provide a means whereby conductors can be identified in a circuit and also after they have been detached from the terminals to which they are connected. Main marking is a system of marking characterizing each conductor or group of conductors irrespective of their electrical function. Supplementary marking is used as supplement to a main marking based on the electrical function of each conductor or group of conductors.

3.6.0.2 The various methods of marking applicable to electrical installations and the equipment which form part of them are covered in IS 5578.

3.6.1 *Identification of Insulated and Bare Conductors*

For the purposes of this Code, the provisions of Table 1 shall apply for the general application of marking conductors in installation. The rules also apply for marking conductors in assembles, equipment and apparatus. Reference is also drawn to the provision contained in relevant Indian Standard.

3.6.2 *Arrangement of Conductors*

3.6.2.0 Bus-bars and main connections which are substantially in one plane shall be arranged in the order given in either **3.6.2.1** or **3.6.2.2** according to the system. The relative order remains applicable even if any poles of the system are omitted.

3.6.2.1 *AC systems*

The order of phase connection shall be red, yellow and blue:

a) When the run of the conductors is horizontal, the red shall be on the top or on the left or farthest away as viewed from the front.
b) When the run of the conductors is vertical, the red shall be on the left or farthest away as viewed from the front.
c) When the system has a neutral connection in the same place as the phase connections, the neutral shall occupy an outer position.
d) Unless the neutral connection can be readily distinguished from the phase connections, the order shall be red, yellow, blue and black.

3.6.2.2 *DC systems*

The arrangement shall be as follows:

a) When the run of the conductors is horizontal, the red shall be on the top or on the left or farthest away as viewed from the front.
b) When the run of the conductors is vertical, the red shall be on the left or farthest away as viewed from the front.
c) When the system is 3-wire with the conductors in the same place, the neutral shall occupy the middle position.

Table 1 Alphanumeric Notation, Graphical Symbols and Colours

(*Clause* 3.6.1)

Sl No.	Designation of Conductors		Identification by		
			Alphanumeric Notation	Graphical Symbol	Colour
(1)	(2)		(3)	(4)	(5)
i)	Supply ac system	Phase 1	L1		Red
		Phase 2	L2		Yellow
		Phase 3	L3		Blue
		Neutral	N		Black
ii)	Apparatus ac system	Phase 1	U		Red
		Phase 2	V		Yellow
		Phase 3	W		Blue
		Neutral	N		Black
iii)	Supply dc system	Positive	L+	+	Red
		Negative	L–	–	Blue
		Midwire	M		Black
iv)	Supply dc system (single phase)	Phase	L		Red
		Neutral	N		Black
v)	Protective conductor		PE		Green and Yellow
vi)	Earth		E		No colour other than the colour of the bare conductor. If insulated, the colour for insulation so chosen to avoid those listed above for designation of other conductors
vii)	Noiseless (clean earth)		TE		Under consideration
viii)	Frame or chassis		MM		—
ix)	Equipotential Terminal		CC		—

ANNEX A

(*Clause* 2)

LIST OF INDIAN STANDARDS ON DIAGRAMS, CHARTS, TABLES AND MARKING

IS No.	*Title*
1064 : 1980	Specification for paper standard sizes
2032	Graphical symbols used in electrotechnology:
(Part 15) : 1976	Aircraft electrical symbols
(Part 19) : 1977	Electrical equipment used in medical practice
(Part 25) : 1980	Electrical installations in ships
5578 : 1984	Guide for marking of insulated conductors
8270	Guide for the preparation of diagrams, charts and tables for electrotechnology:
(Part 1) : 1976	Definitions and classification
(Part 2) : 1976	Item designation
(Part 3) : 1977	General requirements for diagrams
(Part 4) : 1977	Circuit diagram
(Part 5) : 1976	Interconnection diagrams and tables
(Part 6) : 1983	Unit wiring diagrams and tables

SECTION 5 UNITS AND SYSTEMS OF MEASUREMENT

0 FOREWORD

The International System of Units (SI) have received worldwide acceptance and are accepted in most of the countries. It had been introduced in India under the *Weights and Measures Act*, 1976. Use of SI Units in matters relating to electrical engineering practice has many advantages.

This Section 5 of the Code for reasons of brevity is restricted to electrical units only.

1 SCOPE

This Part 1/Section 5 of the Code covers units and systems of measurement in electrotechnology.

2 REFERENCE

The following Indian Standard may be referred for further information:

'IS 10005 : 1994/ISO 1000 : 1992 SI units and recommendations for the use of their multiples and of certain other units'.

3 UNITS AND SYSTEMS OF MEASUREMENT

3.1 Absolute Units

3.1.1 *Ampere* (*Unit of Electric Current*)

A constant current which, maintained in two parallel straight conductors of infinite length, of negligible circular cross-section an placed at a distance of one metre apart in a vacuum will produce a force of 2×10^{-7} Newton per metre length between the conductors.

3.1.2 *Coulomb* (*Unit of Quantity of Electricity*)

The quantity of electricity conveyed in one second by a current of one ampere.

3.1.3 *Farad* (*Unit of Electric Capacitance*)

The capacitance of an electric capacitor having a difference of electric potential of one volt between the plates, when it is charged with a quantity of electricity of one coulomb.

3.1.4 *Henry* (*Unit of Electric Inductance*)

The inductance of a closed circuit in which an emf of one volt is produced when the current in the circuits varies at the uniform rate of one ampere per second.

3.1.5 *Ohm* (*Unit of Electrical Resistance*)

The electrical resistance between two points of a conductor when a constant potential difference of one volt, applied to these points, produces a current of one ampere in the conductor, provided no emf is generated in the conductor.

3.1.6 *Volt* (*Unit of Electric Potential Difference*)

The difference of electric potential which exists between two points of a conductor carrying a constant current of one ampere, when the power dissipated between these points is one watt.

3.1.7 *Weber* (*Unit of Magnetic Flux*)

The magnetic flux which, linked with a circuit composed of a single turn produces in it an emf of one volt if it is uniformly reduced to zero in one second.

3.1.8 *Watt* (*Unit of Electric Power*)

The power which results in the production of energy at the rate of 1 J/s.

3.1.9 *Siemens* (*Unit of Electric Conductance*)

The conductance of a conductor of resistance 1 ohm and is numerically equal to 1 ohm^{-1}.

3.1.10 *Tesla*

The tesla is a magnetic flux density of 1 Wb/m^2.

3.2 The electrical units defined in **3.1**, together with their expression in terms of other units, recommendations on the selection of their multiples and submultiples and supplementary remarks (if any) are enumerated in Table 1.

Table 1 Electrical Units of Measurement

(*Clause* 3.2)

Sl No. (1)	Quantity (2)	Name (3)	Symbol (4)	Expression in Terms of Other Units (5)	Expression in Terms of SI Base Units (6)	Selection of Multiples (7)
i)	Electric current	ampere	A	—	—	kA, mA, μA, nA, pA
ii)	Power	watt	W	J/s	$m^2.kgs^{-3}$	GW, MW, kW, mW, μW
iii)	Quantity of electricity, electric charge	coulomb	C	—	s.A	kC, μC, nC, pC
iv)	Electric potential, potential difference, electromotive force	volt	V	W/A	$m^2.kgs^{-3}.A^{-1}$	MV, kV, mV, μV
v)	Capacitance	farad	F	C/V	$m^2 \cdot kg.s^{-1}.A^{-1}$	mF, μF, nF, pF
vi)	Electrical resistance	ohm	Ω	V/A	$m^2 \cdot kg.s^{-1}.A^{-2}$	GΩ, MΩ. KΩ, mΩ, … μΩ
vii)	Conductance	siemens	S	A/V	$m^{-2} \cdot kg^{-1}.s^{-1}$	kS, mS, µS
viii)	Magnetic flux	weber	Wb	V.s	$m^2 \cdot kg.s^{-2}.A^{-1}$	mWb
ix)	magnetic flux density	tesla	T	Wb/m^2	$kg.s^{-1}.A^{-1}$	mT, μT. nT
x)	Inductance	henry	H	Wb/A	$m^2 \cdot kg.s^{-2}.A^{-2}$	mH, μH, nH, *p*H
xi)	Conductivity	siemens/metre	S/m	—	$m^1 \cdot kg^{-1}.S^1, A^1$	MS/m, kS/m
xii)	Electric field strength	volt/metre	V/m	—	$m.kg.s^{-1}.A^{-1}$	MV/m, kV/m or V/mm, V/m, mV/m, μV/m
xiii)	Permeability	henry/metre	H/m	—	$m.kg.s^{-2}.A^{-2}$	μH/m, nH/m
xiv)	Permittivity	farad per metre	F/m	—	$m^{-1}.kg^{-1}.s^4.A^2$	μF/m, nF/m, pF/m
xv)	Reluctance	1 per henry	H^{-1}	—	$m^{-2} \cdot kg^{-1}.s^2.A^2$	—
xvi)	Resistivity	ohm/metre	Ω.m	—	$m^1 \cdot kg.s^{-1}.A^{-2}$	GΩm, MΩ m, kΩm, Ωcm, mΩm, μΩm, nΩm

SECTION 6 STANDARD VALUES

0 FOREWORD

Standardization of basic parameters such as voltage, currents and frequency is one of the primary exercizes undertaken at the national level. This standardization helps in laying a sound foundation for further work relating to product or installation engineering. The values of voltages recommended as standard in this Section are based on the contents of IS 12360 : 1988 'Voltage bands for electrical installations including preferred voltages and frequency'.

This history of standardization of system voltages particularly those of systems operating below medium voltage levels is enumerated in IS 12360. Reference to *Indian Electricity Rules* may also be made.

1 SCOPE

This Part 1/Section 6 of the Code covers standard values of ac and dc distribution voltages, preferred values of current ratings and standard system frequency.

2 REFERENCES

This Part 1/Section 6 of the Code may be read in conjunction with the following Indian Standards:

IS No.	*Title*
1076 (Part 1) : 1985/ ISO 3 : 1973	Preferred numbers: Part 1 Series of preferred numbers
12360 : 1988	Voltage bands for electrical installations including preferred voltages and frequency

3 STANDARD VALUES OF VOLTAGES

3.0 General

3.0.1 For the sake of completeness, all the standard values of voltages given in IS 12360 relating to ac transmission and distribution systems are reproduced in this Section. However, it is noted that for most of the types of installations covered in subsequent parts of the Code, only the lower voltage values would be relevant.

3.0.2 For medium and low voltage of distribution system, the original recommended standard values of nominal voltages were 230 V for single-phase and 230/400 V for three-phase system. However, during 1959, to align with IEC recommendations and in view of the economic advantages they offered, values of 240 V single-phase and 240/415 V three-phase had been adopted with a tolerance of ± 6 percent. However, in view of the latest international developments, it was decided to align Indian Standards nominal system voltages with IEC recommendations and accordingly revise the values of ac nominal system voltages from 240/415 to 230/400 with the tolerance of ± 10 percent and it was also decided to effect the complete transition by 31 December 2009, as given in IS 12360. IS 12360 may be referred for the latest values.

3.0.3 In the case of voltages above 1 kV, the importance of highest system voltage, which are generally 10 percent above the corresponding nominal voltages given in **2.1.2.1** is recognized and product standards relate the voltage rating of equipment with respect to highest system voltages only.

3.1 Standard Declared Voltage

3.1.1 *Single-phase, Two-Wire System*

The standard voltage shall be 240 V(*see* **3.0.2**).

3.1.2 *Three-phase System*

3.1.2.1 The standard voltages for three-phase system shall be as under:

415 V (*see* **3.0.2**)	(Voltage to neutral— 240 V) (*see* **3.0.2**)
3.3 kV	66 kV
6.6 kV	110 kV
11 kV	132 kV
22 kV	220 kV
33 kV	400 kV

NOTES

1 However, in view of the latest international developments, it was decided to align Indian Standards nominal system voltages with IEC recommendations and accordingly revise the values of a.c. nominal system voltages from 240/415 to 230/400 with the tolerance of ± 10 percent and it was also decided to effect the complete transition by 31 December 2009, as given in IS 12360

2 These voltages refer to the line-to-line voltage.

3 110 kV is not a standard voltage for transmission purposes but this value has been included for the sake of equipment that are required for use on the 110 kV systems already in existence. It is realized that because of economic and other considerations, extensions to existing systems at this voltage may have to be made at the same voltage.

3.1.3 The standard dc distribution voltage shall be 220/440 V.

3.2 Voltage Limits for ac Systems

3.2.1 The voltage at any point of the system under normal conditions shall not depart from the declared voltage by more than the values given below:

a) 6 percent in the case of low or medium voltage (*see* **3.0.2**); or

NOTE — Supply variation will become 230 V ± 10 percent with effect from 31 December 2009. *See* IS 12640 : 1988 for the latest provision.

b) 6 percent on the higher side or 9 percent on the lower side in the case of high voltage; or

c) 12.5 percent in the case of extra high voltage.

NOTE — The permissible variations given above are in accordance with *Indian Electricity Rules*, 1956, and are applicable to the supply authorities.

3.2.2 For installation design purposes, the limits of voltage between which the system and the equipment used in the system shall be capable of operating continuously are as follows:

System Voltage (U_n) (1)	*Highest Voltage* (U_m) (2)	*Lowest Voltage* (3)
240 V	264 V	216 V
415 V	457 V	374 V
3.3 kV	3.6 kV	3.0 kV
6.6 kV	7.2 kV	6.0 kV
11 kV	12 kV	10 kV
22 kV	24 kV	20 kV
33 kV	36 kV	30 kV
66 kV	72.5 kV	60 kV
132 kV	145 kV	120 kV
220 kV	245 kV	200 kV
400 kV	420 kV	380 kV

NOTES

1 This variation in voltage should not be confused with the permissible variation from the declared voltage as given in **3.2.1**.

2 For system voltage 230/400 highest voltage and lowest voltage shall be ±10 percent.

4 PREFERRED CURRENT RATINGS

4.1 The preferred current ratings shall be selected from the R5 series. If intermediate values are required, the same shall be selected from R10 series [*see* IS 1076 (Part 1)].

5 STANDARD SYSTEM FREQUENCY

5.1 The standard system frequency shall in 50 Hz.

5.2 The limits within which the frequency is to be maintained are governed by the *Indian Electricity Rules*.

SECTION 7 FUNDAMENTAL PRINCIPLES

0 FOREWORD

The basic criteria in the design of electrical installation are enumerated in this Section which could be taken note of in the planning stages. The specific nature of each occupancy calls for additional information which are summarized in the respective Sections of the Code.

Assistance has been derived for this Section from IEC 60364-1 'Low-voltage electrical installations—Part 1: Fundamental principles, assessment of general characteristics, definitions' issued by the International Electrotechnical Commission. Measures for achieving protection against the various hazards are under consideration by the National Electrical Code Sectional Committee. It may be added that subsequent requirements of the Code would, however, provide sufficient guidelines in respect of achieving the desired level of safety.

1 SCOPE

This Part 1/Section 7 of the Code enumerates the fundamental principles of design and execution of electrical installations.

2 REFERENCE

Reference has been made to the following Indian Standard:

IS No.	*Title*
IS 3792 : 1978	Guide for heat insulation of non-industrial buildings

3 FUNDAMENTAL PRINCIPLES

3.0 General

3.0.1 *Conformity with Indian Electricity Rules*

The installation shall generally be carried out in conformity with the requirements of the *Indian Electricity Rules*, 1956 as amended from time to time, and also the relevant regulations of the electric supply authority concerned.

3.0.2 *Materials*

All materials, fittings, equipment and their accessories, appliances, etc, used in an electrical installation shall conform to Indian Standards wherever they exist. In case an Indian Standard does not exist, the materials and other items shall be those approved by the competent authority.

3.0.3 *Workmanship*

Good workmanship is an essential requirement for compliance with this Code. Unless otherwise exempted under the *Indian Electricity Rules*, the work on electrical installations shall be carried out under the supervision of a person holding a certificate of competency issued by a recognized authority. The workmen shall also hold the appropriate certificate of competency.

3.1 Coordination

3.1.1 *Exchange of Information*

3.1.1.1 Proper coordination and collaboration between the architect, building engineer and the electrical engineer shall be ensured from the planning stage of the installation. The provisions that would have to be made for the accommodation of substation, transformer switchgear rooms, lift wells and other spaces required to be provided for service cable ducts, openings, etc. in the civil work, and such other relevant data shall be specified in advance.

3.1.1.2 In all cases, that is, whether the proposed electrical work is a new installation or an extension to the existing one, or a modification, the relevant authority shall be consulted. In all such cases, it shall also be ensured that the current carrying capacity and the condition of the existing equipment and accessories are adequate.

3.1.1.3 Sufficient coordination shall be ensured with the civil architect in the initial stages itself to ensure that sufficient building space be allotted for electrical installation purposes such as those required for sub-station installation, from the point of safety.

3.1.1.4 The building services plan shall also include at the early stages all the details of services that utilize electrical energy and the requirements of the electrical installation in order to enable the designers and others involved to decide the coordination to be ensured.

3.2 Distance from Electric Lines

No building shall be allowed to be erected or re-erected, or any additions or alterations made to the existing building, unless the following minimum clearances are provided from the overhead electric supply lines:

Sl No.	Type of Supply Line	Voltage	Clearance	
			Vertical m	Hori-zontal, m
(1)	(2)	(3)	(4)	(5)
i)	Low and medium voltage		2.5	1.2
ii)	High voltage	Up to and including 11 000 V	3.7	1.2
		Above 11 kV up to and including 33 kV	3.7	2.0
iii)	Extra high voltage		3.7 (*see* Note)	2.0 (*see* Note)

NOTE — For extra high voltage lines apart from the minimum clearances indicated, a vertical and horizontal clearance of 0.30 m for every additional kV or part thereof shall be provided.

3.3 Lighting and Ventilation

From the point of view of conserving energy, it is essential to consider those aspects of design of buildings as vital, which would enable use of natural lighting and ventilation to the maximum. Attention is, however, drawn to the general requirements stipulated in Part 1/Section 14.

3.4 Heat Insulation

3.4.1 For information regarding recommended limits of thermal transmittance of roofs and walls and transmission losses due to different constructions, reference shall be made to IS 3792.

3.4.2 Proper coordination shall be ensured to provide for necessary arrangements to install and serve the electrical equipment needed for the air-conditioning and heating services in the building.

3.5 Lifts and Escalators

For information of the electrical engineer, the lift/escalator manufacturer in consultation with the building planners, shall advise of the electrical requirements necessary for the lifts and escalators to be installed in the building. General provisions are outlined in Part 1/Section 14.

3.6 Location and Space for Electrical Equipment

Even though specific provisions regarding the choice of location and space requirements for electrical installation in buildings have been provided in the relevant parts of the Code. The following aspects shall be taken note of in general while planning the building design:

a) Need for and location and requirements of building substation.
b) Load centre and centre of gravity of buildings,
c) Layout,
d) Room/spaces required for electrical utility,
e) Location and requirements of switch rooms,
f) Levels of illumination, and
g) Ventilation.

4 DESIGN OF ELECTRICAL INSTALLATION

4.0 General

4.0.1 The design of the electrical installation shall take into account the following factors:

a) The protection of persons, livestock and property in accordance with **4.1**, and
b) The proper functioning of the electrical installation for the use intended.

4.0.2 The following factors shall therefore be kept in view:

a) Characteristics of the available supply or supplies,
b) Nature of demand,
c) Emergency supply or supplies,
d) Environmental conditions,
e) Cross-section of conductors,
f) Type of wiring and methods of installations,
g) Protective equipment,
h) Emergency control,
j) Disconnecting devices, and
k) Preventing of mutual influence between electrical and non-electrical installations.

4.1 Protection for Safety

4.1.0 The requirements stated in **4.1.1** to **4.1.6** are intended to ensure the safety of persons, livestock and property against dangers and damage which may arise in the reasonable use of electrical installations.

NOTE — In electrical installations, two major types of risks exist.

a) Shock currents; and
b) Excessive temperatures likely to cause burns, fires and other injurious effects.

4.1.1 *Protection Against Direct Contact*

Persons and livestock shall be protected against danger that may arise from contact with live parts of the installation.

The protection can be achieved by one of the following methods:

a) Preventing a current from passing through the body of any person or any livestock, and

b) Limiting the current which can pass through a body to a value lower than the shock current.

4.1.2 *Protection Against Indirect Contact*

Persons and livestock shall be protected against dangers that may arise from contact with exposed conductive parts.

This protection can be achieved by one of the following methods:

a) Preventing a fault current from passing through the body of any person or any livestock.
b) Limiting the fault current which can pass through a body to a value lower than the shock current.
c) Automatic disconnection of the supply on the occurrence of a fault likely to cause a current to flow through a body in contact with exposed conductive parts, where the value of that current is equal to or greater than the shock current.

4.1.3 *Protection Against Thermal Effects in Normal Service*

The electrical installation shall be so arranged that there is no risk of ignition of flammable materials due to high temperature or electric arc. Also, during normal operation of the electrical equipment, there shall be no risk of persons or livestock suffering burns.

4.1.4 *Protection Against Overcurrent*

Persons or livestock shall be protected against injury, and property shall be protected against damage due to excessive temperatures or electromechanical stresses caused by any overcurrents likely to arise in live conductors.

This protection can be achieved by one of the following methods:

a) Automatic disconnection on the occurrence of an overcurrent before this overcurrent attains a dangerous value taking into account its duration, and
b) Limiting the maximum overcurrent to safe value and duration.

4.1.5 *Protection Against Overvoltage*

Persons or livestock shall be protected against injury and property shall be protected against any harmful effects of a fault between live parts of circuits supplied at different voltages.

Persons or livestock shall be protected against injury and property shall be protected against damage from any excessive voltages likely to arise due to other causes (for example, atmospheric phenomena or switching voltages).

4.1.6 *Methods for Protection for Safety*

While the general principles of protection against hazards in an electrical installation are given in **4.1.1** to **4.1.6** guidelines on the methods for achieving protection and the choice of a particular protective measure are under consideration.

4.2 Other Factors of Design

4.2.1 *Characteristics of the Available Supply or Supplies*

a) Nature of current: ac and/or dc,
b) Nature and number of conductors:
   1) For ac:
      i) phase conductors(s),
      ii) neutral conductor, and
      iii) protective conductor.
   2) For dc:
      i) conductors equivalent to those listed above.
c) Values and tolerances:
   1) voltage and voltage tolerances (*see* Part 1/Section 6),
   2) frequency and frequency tolerances (*see* Part 1/Section 6),
   3) maximum current allowable, and
   4) prospective short-circuit current (*see* Part 1/Section 13).
d) Protective measures inherent in the supply, for example, earthed (grounded) neutral or mid-wire.
e) Particular requirements of the supply undertaking.

4.2.2 *Nature of Demand*

The number and type of the circuits required for lighting, heating, power, control, signalling, telecommunication, etc, are to be determined by:

a) locations of points of power demand,
b) loads to be expected on the various circuits,
c) daily and yearly variation of demand,
d) any special conditions,
e) requirements for con trol, signaling, telecommunication, etc.

4.2.3 *Emergency Supply or Supplies* (*see also* Part 2 of the Code)

a) Source of supply (nature, characteristics), and
b) Circuits to be supplied by the emergency source.

4.2.4 *Environmental Conditions* (*see* Part 1/Section 8)

4.2.5 *Cross-section of Conductors*

The cross-section of conductors shall be determined according to:

a) their admissible maximum temperature,
b) the admissible voltage drop,
c) the electromechanical stresses likely to occur due to short-circuits,
d) other mechanical stresses to which the conductors may be exposed, and
e) the maximum impedance stresses to which the conductors of the short-circuit protection.

4.2.6 *Type of Wiring and Methods of Installations*

The choice of the type of wiring and the methods of installation depend on:

a) nature of the location,
b) nature of the walls or other parts of the building supporting the wire,
c) accessibility of wiring to persons and livestock,
d) voltage,
e) electromechanical stresses likely to occur due to short-circuits, and
f) other stresses to which the wiring may be exposed during the erection of the electrical installation or in service.

4.2.7 *Protective Equipment*

The characteristics of protective equipment shall be determined with respect to their function which may be, for example, protection against the effects of:

a) overcurrent (overload, short-circuit)
b) earth-fault current,
c) overvoltage, and
d) undervoltage and no-voltage.

The protective devices shall operate at values of current, voltage and time which are suitably related to the characteristics of the circuits and to the possibilities of danger.

4.2.8 *Emergency Control*

Where in case of danger, there is necessity for immediate interruption of supply, in interrupting device shall be installed in such a way that it can be easily recognized and effectively and rapidly operated.

4.2.9 *Disconnecting Devices*

Disconnecting devices shall be provided so as to permit disconnection of the electrical installation, circuits or individual items of apparatus as required for maintenance, testing, fault detection or repair.

4.2.10 *Prevention of Mutual Influence Between Electrical and Non-electrical Installations*

The electrical installation shall be arranged in such a way that no mutual detrimental influence will occur between the electrical installation and non-electrical installations of the building.

4.2.11 *Accessibility of Electrical Equipment*

The electrical equipment shall be arranged so as to afford as may be necessary:

a) sufficient space for the initial installation and later replacement of individual items of electrical equipment, and
b) accessibility for operation, testing, inspection, maintenance and repair.

SECTION 8 ASSESSMENT OF GENERAL CHARACTERISTICS OF BUILDINGS

0 FOREWORD

An assessment of the general characteristics of buildings is essential before planning for the needs of an electrical installation. This Part 1/Section 8 covers a checklist of various factors that require assessment.

This Part 1/Section 8 follows the internationally recommended method of identification of the external influences on the electrical installation such as environment, utilization and method of construction of the building. Out of these influences, those which are specifically important for specific occupancies are listed at the relevant Sections of the Code. However, it is hoped that this Section 8 would also enable understanding of installations not explicitly covered by the Code.

The contents of this Part 1/Section 8 are primarily intended for installations inside buildings though to the extent possible they could be utilized for outdoor sites. However more severe conditions may prevail at outdoor sites and these require special considerations.

1 SCOPE

This Part 1/Section 8 of the Code covers guidelines for assessing the characteristics of buildings and the electrical installation therein.

2 ASSESSMENT OF GENERAL CHARACTERISTICS OF BUILDINGS

An assessment of the general characteristics of buildings as enumerated below is essential from the point of view of design and protection for safety of the electrical installation. These characteristics when assessed shall also be taken into consideration in the selection and erection of equipment.

2.1 Identification of General Characteristics

2.1.1 *Purposes, Supplies and Structure*

The following shall be assessed:

a) Maximum demand and diversity from the point of view of economic and reliable design (*see* **3.2.2** of Part 1/Section 7).

b) Type of distribution system, which includes, types of systems of live conductors and types of system earthing.

   NOTE — For types of system earthing, *see* Part 1/Section 14.

c) Supply characteristics such as nature of current, nominal voltage, prospective short-circuit currents.

   NOTE — This assessment shall include those characteristics of main, standby and safety supply services.

d) Division of installation from the point of view of control, safe operation, testing and maintenance.

2.2 Identification of External Influences on the Electrical Installation

2.2.1 The characteristics of the following external influences shall be assessed:

a) *Environments*
   1) Ambient temperature,
   2) Atmospheric humidity,
   3) Altitude,
   4) Presence of water,
   5) Presence of foreign solid bodies,
   6) Presence of corrosive or polluting substances,
   7) Mechanical stresses,
   8) Presence of flora and/or mould growth,
   9) Presence of fauna,
   10) Electromagnetic, electrostatic or ionizing influences,
   11) Solar radiation,
   12) Seismic effects,
   13) Lighting, and
   14) Wind.

b) *Utilization*
   1) Capability of persons,
   2) Electrical resistance of human body,
   3) Contact of persons with earth potential,
   4) Conditions of evacuation in an emergency, and
   5) Nature of processed or stored material.

c) *Construction of Buildings*
   1) Constructional materials, and
   2) Building design.

2.2.2 Table 1 suggests the classification and codification of external influences which require assessment in the design and erection of electrical installation.

Table 1 Assessment of General Characteristics of Buildings
(*Clause* 2.2.2)

Sl No.	Class Designation	Characteristics	Application and Examples	Code
(1)	(2)	(3)	(4)	(5)
i)	**Environment**			
1)	Ambient temperature	The ambient temperature to be considered for the equipment is the temperature at the place where the equipment is to the installed resulting from the influence of all other equipment in the same location, when operating, not taking into account the thermal contribution of the equipment to be installed. Lower and upper limits of range of ambient temperature:		
		Lower Limits / *Upper Limits*		
		a) –60°C +5ºC		AA1
		b) –40°C +5ºC		AA2
		c) –25°C +5ºC		AA3
		d) –5°C +40ºC		AA4
		e) +5°C +40ºC		AA5
		f) –5°C +60ºC		AA6
		The average temperature over a 24 hour period must not exceed 5ºC below the upper limits. Combination of two ranges to define some environments may be necessary. Installation subject to temperatures outside the ranges require special consideration.		
2)	Atmospheric humidity	Under consideration		
3)	Altitude	≤ 2 000 m		AC1
		> 2 000 m		AC2
4)	Presence of water:			
	a) Negligible	Probability of presence of water is negligible	Locations in which the walls do not generally show traces of water but may do so for short periods, for example, in the form of vapour which good ventilation dries rapidly	AD1
	b) Free-falling drops	Possibility of vertically falling drops	Locations in which water vapour occasionally condenses as drops or where steam may occasionally be present	AD2
	c) Sprays	Possibility of water falling as spray at an angle up to 60ºC from the vertical	Locations in which sprayed water forms a continuous film on floors and/or walls	AD3
	d) Splashes	Possibility of splashes from any direction	Locations where equipment may be subjected to splashed water, this applies, for example, to certain external lighting fittings, construction site equipment, etc	AD4
	e) Jets	Possibility of jets of water from any direction	Locations where hosewater is used regularly (yards, car-washing bays)	AD5
	f) Waves	Possibility of water waves	Seashore locations such as piers, beaches quays, etc	AD6
	g) Immersion	Possibility of intermittent partial or total covering by water	Locations which may be flooded and or where water may be at least 150 mm above the highest point of equipment, the lowest part of equipment being not more than 1 m below the water surface	AD7
	h) Submersion	Possibility of permanent and total covering by water	Locations such as swimming pools where electrical equipment is permanently and totally covered with water under a pressure greater than 0.1 bar	AD8
5)	Presence of foreign solid bodies:			
	a) Negligible	The quantity of nature of dust or foreign solid bodies is not significant		AE1
	b) Small objects	Presence of foreign solid bodies where the smallest dimension is not less than 2.5 mm	Tools and small objects of which the smallest dimension is at least 2.5 mm	AE2
	c) Very small objects	Presence of foreign solid bodies where the smallest dimension is not less than 1 mm	Wires are examples of foreign solid bodies of which the smallest dimension is not less than 1 mm	AE3

Table 1 — (*Continued*)

Sl No.	Class Designation	Characteristics	Application and Examples	Code
(1)	(2)	(3)	(4)	(5)
		NOTE — In conditions AE1 and AE3, dust may be present but is not significant to operation of the electrical equipment		
	d) Dust	Presence of dust in significant quantity		AE4
6)	Presence of corrosive or polluting substances:			
	a) Negligible	The quantity or nature of corrosive or polluting substances is not significant		AF1
	b) Atmospheric	The presence of corrosive or polluting substance of atmospheric origin is significant	Installation situated by the sea or industrial zones producing serious atmospheric pollution, such as chemical works and cement works; this type of pollution arises especially in the production of abrasive, insulating or conductive dusts	AF2
	c) Intermittent or accidental	Intermittent or accidental subjection to corrosive or polluting chemical substances being used or produced	Location where some chemical products are handled in small quantities and where these products may come only accidentially into contact with electrical equipment; such conditions are found in factory, laboratories, other laboratories or in locations where hydro-carbons are used (boiler-rooms, garages, etc)	AF3
	d) Continuous	Continuously subject to corrosive or polluting chemical substances in substantial quantity	For example, chemical works	AF4
7)	Mechanical stresses:			
	a) Impact			
	Low severity		Household and similar conditions	AG1
	Medium severity		Usual industrial conditions	AG2
	High severity		Severe industrial conditions	AG3
		NOTE — Provisional classification. Quantitative expression of impact severities is under consideration.		
	b) Vibration			
	Low severity		Household and similar conditions where the effects of vibration are generally negligible	AH1
	Medium severity		Usual industrial conditions	AH2
	High severity		Industrial installations subject to severe conditions	AH3
		NOTE — Provisional classification. Quantitative expression of vibration severities is under consideration.		
	c) Other mechanical stresses		Under consideration	AJ
8)	Presence of fungus and/or mould growth:			
	a) No hazard	No hazard of fungus and/or mould growth		AK1
	b) Hazard	hazard of fungus and/or mould growth	The hazard depends on local conditions and the nature of fungus. Distinction should the made between harmful growth of vegetation or conditions for promotion of mould growth	AK2
9)	Presence of vermin:			
	a) No hazard	No hazard		AL1
	b) Hazard	Hazard from fauna (insects, birds, small animals)	The hazard depends on the nature of the vermin. Distinction should be made between: a) presence of insects in harmful quantity or of an aggressive nature. b) presence of small animals or birds in harmful quantity or of an aggressive nature	AL2
10)	Electro magnetic, electrostatic or ionizing influences:			

Table 1 — (*Continued*)

Sl No. (1)	Class Designation (2)	Characteristics (3)	Application and Examples (4)	Code (5)
	a) Negligible	No harmful effects from stay currents, electromagnetic radiation, electrostatic fields, ionizing radiation or induction		AM1
	b) Stray currents	Harmful hazards of stray currents		AM2
	c) Electromagnetics	Harmful presence of electromagnetic radiation		AM3
	d) Ionization	Harmful presence of ionizing radiation		AM4
	e) Electrostatics	Harmful presence of electrostatic fields		AM5
	f) Induction	Harmful presence of induced currents		AM6
11)	Solar radiation:			
	a) Negligible			AN1
	b) Significant	Solar radiation of harmful intensity and/or duration		AN2
12)	Seismic effects:			
	a) Negligible	Up to 30 gal (1 gal = 1 cm/s^2)		AP1
	b) Low severity	Over 30 up to and including 300 gal		AP2
	c) Medium severity	Over 300 up to and including 600 gal		AP3
	d) High severity	Greater than 600 gal	Vibration which may cause the destruction of the building is outside the classification. Frequency is not taken into account in the classification; however, if the seismic wave resonates with the building, seismic effects must be specially considered. In general, the frequency of seismic acceleration is between 0 and 10 Hz	AP4
13)	Lightning:			
	a) Negligible			AQ1
	b) Indirect exposure	Hazard from supply arrangements	Installations supplied by overhead lines.	AQ2
	c) Direct exposure	Hazard from exposure of equipment	Part of installations located outside buildings. The risks AQ2 and AQ3 relate to regions with a particularly high level of thunderstorm activity	AQ3
14)	Wind (Under consideration)			
ii)	**Utilization**			
1)	Capability of persons:			
	a) Ordinary	Uninstructed persons		BA1
	b) Children	Children in locations intended for their occupation. NOTE — This class does not necessarily apply to family dwellings	Nurseries	BA2
	c) Handicapped	Persons not in command of all their physical and intellectual abilities (sick persons, old persons)	Hospitals	BA3
	d) Instructed	Persons adequately advised or supervised by skilled persons to enable them to avoid dangers which electricity may create (operating and maintenance staff)	Electrical operating areas	BA4
	e) Skilled	Persons with technical knowledge or sufficient experience to enable them to avoid dangers which electricity may create (engineers and technicians)	Closed electrical operating areas	BA5
2)	Electrical resistance of the human body classification (Under consideration)			BB
3)	Contact of persons with earth potential:			
	a) None	Persons in non-conducting situations	Non-conducting locations	BC1
	b) Low	Persons do not in usual conditions make contact with extraneous conductive parts or stand on conducting surfaces		BC2
	c) Frequent	Persons are frequently in touch with extraneous conductive parts or stand on conducting surfaces	Locations with extraneous conductive parts, either numerous or of large area	BC3
	d) Continuous	Persons are in permanent contact with metallic surroundings and for whom the possibility of interrupting contact is limited	Metallic surroundings such as boilers and tanks	BC4

Table 1 — (*Concluded*)

Sl No.	Class Designation	Characteristics	Application and Examples	Code
(1)	(2)	(3)	(4)	(5)
4)	Conditions of evacuation in an emergency	Low density occupation, easy conditions of evacuation	Buildings of normal or low height used for habitation	BD1
		Low density occupation, difficult conditions of evacuation	High-rise buildings	BD2
		High density occupation, easy conditions of evacuation	Locations open to the public (theatres, cinemas)	BD3
		High density occupation, difficult conditions of evacuation	High-rise buildings open to the public (hotels, hospitals, etc)	BD4
5)	Nature of processed or stored materials			
	a) No significant risks			BE1
	b) Fire risks	Manufacture, processing or storage of flammable materials including presence of dust	Barns, wood-working shops, paper factories	BE2
	c) Explosion risk	Processing or storage of explosive or low flashpoint materials including presence of explosive dusts	Oil refineries, hydrocarbon stores	BE3
	d) Contamination risks	Presence of unprotected foodstuffs, pharma-ceutics, and similar products without protection	Foodstuff industries, kitchen NOTE — Certain precautions may be necessary in the event of fault, to prevent processed materials being contaminated by electrical equipment, for example, by broken lamps	
iii)	**Constructions of Building**			
1)	Constructional materials:			
	a) Non-combustible	—	—	CA1
	b) Combustible	Buildings mainly constructed of combustible materials	Wooden buildings	CA2
2)	Building Design:			
	a) Negligible risk	—	—	CB1
	b) Propagation of fire	Buildings of which the shape and dimensions facilitate the spread of fire (for example, chimney effects)	High-rise buildings, Forced ventilation systems	CB2
	c) Movement	Risks due to structural movement (for example, displacement between a building and the ground, or settlement of ground or building foundations)	Buildings of considerable length or erected on unstable ground. Contraction or expansion joints	CB3
	d) Flexible or unstable	Structures which are weak or subjects to movement (for example, oscillation)	Tents, air-support structures, false ceilings, removable partitions Flexible wiring, Installations needing support	CB4

NOTES

1 Each condition of external influence is designated by a code comprising a group of two capital letters and a number as follows:

The first letter relates to the general category of external influence

A = environment

B = utilization

C = construction of buildings

The second letter relates to the nature of the external influence

A …

B …

C …

The number relates to the class within each external influence

1 …

2 …

3 …

For example, the code AC2 signifies:

A = environment

AC = environment altitude, and

AC2 = environment altitude > 2 000 m.

The Code given here is not intended to be used for marking equipment.

2 The characteristics defined for electrical installations are those accepted by the IEC and as applicable for electrical installations in buildings. Influences on outdoor installations are separately defined in the respective parts of the Code.

For the time being, the characteristics of influences (Table 1, col 3) are given in descriptive language only. Codification for the same (*see* Note 1), as recommended by IEC are given at Table 1 col 5 for information.

2.3 Compatibility

An assessment shall be made of any characteristics of equipment likely to have harmful effects upon other electrical equipment or other services or likely to impair the supply. Those characteristics include, for example:

a) Transient overvoltages,
b) Rapidly fluctuating loads,
c) Starting currents,
d) Harmonic currents,
e) dc feedback,
f) High-frequency oscillations, and
g) Earth leakage currents.

2.4 Maintainability

An assessment shall be made of the frequency and quality of maintenance the installation can reasonably be expected to receive during its intended life. Where an authority is to be responsible for the operation of the installation, that authority shall be consulted. Those characteristics are to be taken into account in applying the requirements of this Code so that, having regard to the frequency and quality of maintenance expected,

a) Any periodic inspection and testing and maintenance and repairs likely to be necessary during the intended life can be readily and safely carried out,
b) Effectiveness of the protective measures for safety during the intended life is ensued, and
c) Reliability of equipment for proper functioning of the installation is appropriate to the intended life.

SECTION 9 WIRING INSTALLATIONS

0 FOREWORD

A major portion of fixed installation design in a building relates to wiring installation. This Section of the Code is primarily intended to cover guidelines on design and construction of wiring installations which are commonly applicable to all types of occupancies. The requirements specified in this Section are based on safety and reliability considerations.

The general design guidelines for wiring given in this Section have to be carefully considered while applying them to specific occupancies and a proper selection of the method is to be decided depending on local conditions. Guidance on such matters is covered in respective Sections of the Code.

Assistance for this Section has been derived from IEC 60364-5-52 (20001) 'Electrical installations of buildings — Part 5-52: Selection and erection of electrical equipment — Wiring systems'.

1 SCOPE

This Section 9 of the Code covers the essential design and constructional requirements for electrical wiring installations.

2 REFERENCES

A list of relevant Indian Standards on electrical wiring is given at Annex A.

3 TERMINOLOGY

For the purpose of this Part 1/Section 9, the definitions given in Part 1/Section 2 of this Code and the following shall apply.

3.1 Cable Ducting System — A system of closed enclosure of non-circular sections for insulated conductors, cable and cords in electrical installations, allowing them to be drawn in and replaced.

3.2 Conduit Fitting — A device designed to join or terminate one or more components of a conduit system, or change direction.

3.3 Conduit Joint — An interface between two or more components of a conduit system, or between a conduit system and other equipment.

3.4 Cable Trunking System — A system of closed enclosures comprising a base with a removable cover intended for the complete surrounding of insulated conductors, cables, cords and/or for the accommodation of other electrical equipment.

3.5 Conduit System — A closed wiring system consisting of conduits and conduit fittings for the protection and management of insulated conductors and/or cables in electrical or communication installations, allowing them to be drawn in and/or replaced, but not inserted laterally.

NOTE — Within the conduit system there shall be no sharp edges, burrs or surface projections which are likely to damage insulated conductors or cables or inflict injury to the installer or user. The manufacturer shall be responsible for providing guidelines to assist the safe installation of the conduit system.

3.6 Distribution Board — A unit comprising one or more protective devices against over current and ensuring the distribution of electrical energy to the circuits.

3.7 Luminaire — Apparatus which distributes, filters or transforms the light transmitted from one or more lamps and which includes all the 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.

4 GENERAL AND COMMON ASPECTS FOR SELECTION OF WIRING SYSTEMS

4.1 Cable and Conductors for Low/Medium Voltage

Every non-flexible cable cord for use at low/medium voltage, busbar trunking system, and every conductor other than a cable for use as an overhead line operating at low medium voltage shall comply with the appropriate Indian Standards.

Flexible cable or flexible cord shall be used for fixed wiring only where the relevant provisions of this Code are met.

4.1.1 *Cable for ac Circuits — Electromagnetic Effects*

Single-core cables armoured with steel wire or tape shall not be used for ac circuits. Conductors of ac circuits installed in ferromagnetic enclosure shall be arranged so that the conductors of all phases and the neutral conductor (if any) and the appropriate protective conductor of each circuit are contained in the same enclosure.

Where such conductors enter a ferrous enclosure they shall be arranged so that the conductors are not individually surrounded by a ferrous material, or other provision shall be made to prevent eddy (induced) currents.

4.1.2 *Electromechanical Stresses*

Every conductor or cable shall have adequate strength and be so installed as to withstand the electromechanical forces that may be caused by any current, including fault current it may have to carry in service.

4.2 Conduits and Conduit Fittings

A conduit or conduit fitting shall comply with the appropriate Indian Standard.

4.3 Trunking, Ducting and Fittings

Where applicable, trunking, ducting and their fittings shall comply with IS 14927. Where IS 14927 does not apply, non-metallic trunking, ducting and their fittings shall be of insulating material complying with the ignitability characteristic 'P' of relevant Indian Standard.

4.4 Lighting Track Systems

A lighting track system shall comply with relevant Indian Standard

4.5 Methods of Installation of Cables and Conductors

The methods of installation of a wiring system for which the Code specifically provides are at **6**. Other methods can be used provided that compliance with the Code is maintained.

A bare live conductor shall be installed on insulators. Non-sheathed cables for fixed wiring shall be enclosed in conduit, ducting or trunking. Where cables having different temperature ratings are installed in the same enclosure, all the cables shall be deemed to have the lowest temperature ratings.

4.6 Selection and Erection in Relation to External Influences

Table 1 of Part 1/Section 8 contains a concise list of external influences which need to be taken into account in the selection and erection of wiring systems.

4.6.1 *Ambient Temperature* (AA)

A wiring system shall be selected and erected so as to be suitable for the highest and lowest local ambient temperature likely to be encountered. The components of a wiring system, including cables and wiring enclosures shall be installed or handled only at temperatures within the limits stated in the relevant product specification or as recommended by the manufacturer.

4.6.2 *External Heat Sources*

To avoid the effects of heat from external sources one or more of the following methods, or an equally effective method, shall be used to-protect the wiring system:

a) shielding.
b) placing sufficiently far from the source of heat.
c) selecting a system with due regard for the additional temperature rise which may occur.
d) reducing the current-carrying capacity.
e) local reinforcement or substitution of insulating material.

NOTE — Heat from external sources may be radiated, convected or conducted, for example

a) from hot water systems,
b) from plant appliances and luminaires,
c) from manufacturing process,
e) through heat conducting materials,
f) from solar gain of the wiring system or its surrounding medium.

Parts of a cable or flexible cord within an accessory, appliance or luminaire shall be suitable for the temperatures likely to be encountered, or shall be provided with additional insulation suitable for those temperatures.

4.6.3 *Presence of Water* (AD) *or High Humidity* (AB)

A wiring system shall be selected and erected so that no damage is caused by high humidity or ingress of water during installation, use and maintenance. Where water may collect or condensation may form in a wiring system provision shall be made for its harmless escape through suitably located drainage points. Where a wiring system may be subjected to waves (AD6), protection against mechanical damage shall be afforded by one or more of the methods given in **4.6.6** to **4.6.8**.

4.6.4 *Presence of Solid Foreign Bodies* (AE)

A wiring system shall be selected and erected to minimize the ingress of solid foreign bodies during installation, use and maintenance. In a location where dust or other substance in significant quantity may be present (AE4: Light dust, AE5: Moderate dust or AE6: Heavy Dust) additional precautions shall be taken to prevent its accumulation in quantities which could adversely affect the heat dissipation from the wiring system.

4.6.5 *Presence of Corrosive or Polluting Substances* (AF)

Where the presence of corrosive or polluting substances is likely to give rise to corrosion or deterioration, parts of the wiring system likely to be affected shall be suitably protected or manufactured from materials resistant to such substances. Metals liable to initiate electrolytic action shall not be placed in contact with each other. Materials liable to cause mutual or individual deterioration or hazardous degradation shall not be placed in contact with each other.

4.6.6 *Impac*t (AG)

A wiring system shall be selected and erected so as to minimize mechanical damage. In a fixed installation where an impact of medium severity (AG2) or high severity (AG3) can occur, protection shall be afforded by:

a) the mechanical characteristics of the wiring system, or
b) the location selected, or
c) the provision of additional local or general mechanical protection,

or by any combination of the above.

Except where installed in a conduit or duct which provides equivalent mechanical protection, a cable buried in the ground shall be of a construction incorporating an armour or metal sheath or both, or be of insulated concentric construction. Such cable shall be marked by cable covers or a suitable marking tape or by suitable identification of the conduit or duct and be buried at a sufficient depth to avoid being damaged by any disturbance of the ground reasonably likely to occur.

A wiring system buried in a floor shall be sufficiently protected to prevent damage caused by the intended use of the floor.

Where a cable is installed under a floor or above a ceiling it shall be run in such a position that it is not liable to be damaged by contact with the floor or the ceiling or their fixings. Where a cable passes through a timber joist within a floor or ceiling construction or through a ceiling support (for example, under floorboards), the cable shall be at least 50 mm measured vertically from the top, or bottom as appropriate, of the joist or batten. Alternatively, cable shall incorporate an earthed metallic sheath suitable for use as a protective conductor or shall be protected by enclosure in earthed steel conduit securely supported, or by equivalent mechanical protection sufficient to prevent penetration of the cable by nails, screws, and the like.

Where a cable is to be concealed within a wall or partition at a depth of less than 50 mm from the surface its method of erection shall be that the cable shall be installed within 150 mm of the top of the wall or partition within 150 mm of an angle formed by two adjoining walls or partitions. Where the cable is connected to a point or accessory on the wall or partition, the cable may be installed outside these zones only in straight runs, either horizontally or vertically, to the point or accessory or switch gear.

Where compliance as above is impracticable, the concealed cable shall incorporate an earthed metallic covering which complies with the requirements of this Code for a protective conductor of the circuit concerned, or shall be enclosed in earthed conduit, trunking or ducting satisfying the requirements of this Code for a protective conductor, or by mechanical protection sufficient to prevent penetration of the cable by nails, screws and the like.

4.6.7 *Vibration* (AH)

A wiring system supported by, or fixed to, a structure or equipment subject to vibration of medium severity (AH2) or high severity (AH3) shall be suitable for the conditions and in particular shall employ cable with fixings and connections suitable for such a situation.

4.6.8 *Other Mechanical Stresses* (AJ)

A wiring system shall be selected and erected so as to minimize during installation, use and maintenance, damage to the sheath and insulation of cables and insulated conductors and their terminations.

Where the wiring system is designed to be withdrawable there shall be adequate means of access for drawing cable in or out and, if buried in the structure, a conduit or cable ducting system for each circuit shall be completely erected before cable is drawn in. The radius of every bend in a wiring system shall be such that conductors and cables shall not suffer damage. Where a conductor or a cable is not continuously supported it shall be supported by suitable means at appropriate intervals in such a manner that the conductor or cable does not suffer damage by its own weight. Every cable or conductor used as fixed wiring shall be supported in such a way that it is not exposed to undue mechanical strain and so that there is no appreciable mechanical strain on the terminations of the conductors, account being taken of mechanical strain imposed by the supported weight of the cable or conductor itself. A flexible wiring system shall be installed so that excessive tensile and torsional stresses to the conductors and connections are avoided.

4.6.9 *Presence of Flora and/or Mould Growth* (AK)

Where expected conditions constitute a hazard (AK2), the wiring system shall be selected accordingly or special protective measures shall be adopted.

4.6.10 *Presence of Fauna* (AL)

Where expected conditions constitute a hazard (AL2), the wiring system shall be selected accordingly or special protective measures shall be adopted.

4.6.11 *Solar Radiation* (AN)

Where significant solar radiation (AN2) is experienced or expected, a wiring system suitable for the conditions shall be selected and erected or adequate shielding shall be provided.

4.6.12 *Building Design* (CB)

Where structural movement (CB3) is experienced or expected, the cable support and protection system employed shall be capable of permitting relative movement so that conductors are not subjected to excessive mechanical stress.

For flexible or unstable structures (CB4) flexible wiring systems shall be used.

4.7 Current — Carrying Capacity of Conductors

The current to be carried by any conductor for sustained periods during normal operation shall be such that the appropriate temperature limit specified is not exceeded. *See* various parts of IS 3961 for details.

4.8 Voltage Drop in Consumer's Installations

Under normal service conditions the voltage at the terminals of any fixed current-using equipment shall be greater than the lower limit corresponding to the Indian Standard relevant to the equipment wherever existing. In the absence of such a standard, then the Voltage at the terminals shall be such as not to impair the safe functioning of the equipment.

The voltage drop between the origin of the installation (usually the supply terminal) and the fixed current-using equipment should not exceed 4 percent of the normal voltage of the supply.

A greater voltage drop maybe accepted for a motor during starting periods and for other equipment with high inrush currents provided it is verified that the voltage variations are within the limits specified in the relevant Indian Standards for the equipment or, in the absence of a Indian Standard, in accordance with the manufacturer's recommendations. Temporary conditions such as voltage transients and voltage variation due to abnormal operation may be disregarded.

4.9 Cross-sectional Areas of Conductors

4.9.1 *Phase Conductors in ac Circuits and Live Conductors in dc Circuits*

The nominal cross-sectional area of phase conductors in ac circuits and of live conductors in dc circuits shall be not less than the values specified in Table 1.

4.10 Neutral Conductors

For a polyphase circuit in which imbalance may occur in normal service, through significant inequality of loading or of power factor in the various phases, or through the presence of significant harmonic currents in the various phases, the neutral conductor shall have a cross-sectional area adequate to afford compliance with permissible conductor operating temperature for the maximum current likely to flow in it.

For a polyphase circuit in which serious imbalance is unlikely to occur in normal service, other than a

Table 1 Minimum Nominal Cross-sectional Area of Conductor

(*Clause* 4.9.1)

Sl No.	Type of Wiring System	Use of the Circuit	Conductor	
			Material	Minimum permissible nominal cross-sectional area mm^2
(1)	(2)	(3)	(4)	(5)
i)	Cables and insulated conductors	Lighting circuits	Cu	1.5
		Power Circuits	Cu	2.5
			Al	10 (*see* Note 1)
		Signalling and control circuits	Cu	0.5 (*see* Note 2)
ii)	Bare conductors	Power circuits	Cu	10
			Al	16
		Signalling and control circuits	Cu	4
iii)	Flexible connections with insulated conductors and cables	For a specific appliance	Cu	As specified in the relevant Indian Standard
		For any other application		0.5 (*see* Note 2)
		Extra low voltage circuits for special applications		0.5

NOTES

1 Connectors used to terminate aluminium conductors shall be tested and approved for this specific use.

2 In multicore 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 is permitted.

discharge lighting current, multi-core cables incorporating a reduced neutral conductor in accordance with the appropriate Indian Standard may be used. Where single — core cables are used in such circuits, the neutral conductor shall have a cross-sectional area appropriate to the expected value of the neutral current.

In a discharge lighting circuit the neutral conductor shall have a cross-sectional area not less than that of the phase conductor(s).

4.11 Electrical Connections

4.11.1 *Connections Between Conductors and Between a Conductor and Equipment*

Every connection between conductors and between a conductor and equipment shall provide durable electrical continuity and adequate mechanical strength (*see* **4.6.8**).

4.11.2 *Selection of Means of Connection*

The selection of the means of connection shall take account, as appropriate, of the following:

a) material of the conductor and its insulation.
b) number and shape of the wires forming the conductor.
c) cross-sectional area of the conductor.
d) number of conductors to be connected together.
e) temperature attained by the terminals in normal service such that the effectiveness of the insulation of the conductors connected to them is not impaired.
f) where a soldered connection is used the design shall take account of creep, mechanical stress and temperature rise under fault current conditions.
g) provision of adequate locking arrangements in situations subject to vibration or thermal cycling.

4.11.3 *Enclosed Connections*

Where a connection is made in an enclosure. The enclosure shall provide adequate mechanical protection and protection against relevant external influences. Every termination and joint in a live conductor or a PEN conductor shall be made within one of the following or a combination thereof:

a) a suitable accessory complying with the appropriate Indian Standard.
b) an equipment enclosure, complying with the appropriate Indian Standard.
c) a suitable enclosure of material complying with the relevant glow wire test requirements of IS 11000 (Part 2/Sec 1).
d) an enclosure formed or completed with building material considered to be non-combustible when tested appropriate Indian Standard relating to IS 3808.
e) an enclosure formed or completed by part of the building structure, having the ignitability characteristic 'P' as specified in appropriate Indian Standard.

Cores of sheathed cables from which the sheath has been removed and non-sheathed cables at the termination of conduit, ducting or trunking shall be enclosed as per specified enclosure at (b) above.

4.11.4 *Accessibility of Connections*

Except for the following, every connection and joint shall be accessible for inspection, test and maintenance:

a) a compound-filled or encapsulated joint.
b) a connection between a cold tail and a heating element (for example, a ceiling and floor heating system, a pipe trace-heating system).
c) a joint made by welding, soldering, brazing or compression tool.

4.12 Selection and Erection to Minimize the Spread of Fire

4.12.1 *Risk of Spread of Fire*

The risk of spread of fire shall be minimized by selection of an appropriate material and erection in accordance with this Code. The wiring system shall be installed so that the general building structural performance and fire safety are not materially reduced. A part of a wiring system which complies with the requirements of the relevant Indian Standard, which standard has no requirement for testing for resistance to the propagation of flame, shall be completely enclosed in non-combustible building material having the ignitability characteristic "P".

Where a wiring system passes through elements of building construction such as floors, walls, roofs, ceilings, partitions or cavity barriers, the openings remaining after passage of the wiring system shall be sealed according to the degree of fire resistance required of the element concerned (if any).

Where a wiring system such as conduit, cable ducting, cable trunking, busbar or busbar trunking penetrates elements of building construction having specified fire resistance it shall be internally sealed so as to maintain the degree of fire resistance of the respective element as well as being externally sealed to maintain the required fire resistance. A non-flame propagating wiring system having a maximum internal cross-section of 710 mm^2 need not be internally sealed.

Except for fire resistance over one hour, this requirement is satisfied if the sealing of the wiring system concerned has been type tested by the method specified in relevant Indian Standard.

Each sealing arrangement used as above shall comply with the following requirements:

a) It shall be compatible with the material of the wiring system with which it is in contact, and
b) It shall permit thermal movement of the wiring system without reduction of the sealing quality,
c) It shall be removable without damage to existing cable where space permits future extension to be made, and
d) It shall resist relevant external influences to the same degree as the wiring system with which it is used.

4.12.2 *Erection Conditions*

During the erection of a wiring system temporary sealing arrangements shall be provided as appropriate. During alteration work sealing which has been disturbed shall be reinstated as soon as practicable.

4.12.3 *Verification*

Each sealing arrangement shall be visually inspected at an appropriate time during erection to verify that it conforms to the manufacturer's erection instructions and the details shall be recorded.

4.13 Proximity to Other Services

4.13.1 *Proximity to Electrical Services*

4.13.1.1 Neither an extra-low voltage nor a low voltage circuit shall be contained within the same wiring system as a circuit of nominal voltage exceeding that of low voltage unless every cable is insulated for the highest voltage present or one of the following methods is adopted:

a) each conductor in a multicore cable is insulated for the highest voltage present in the cable, or is enclosed within an earthed metallic screen of current-carrying capacity equivalent to that of the largest conductor enclosed within the screen, or
b) the cables are insulated for the irrespective system voltages and installed in a separate compartment of a cable ducting or cable trunking system, or have an earthed metallic covering.

4.13.1.2 A low voltage circuit shall be separated from an extra-low voltage circuit.

4.13.1.3 Where an installation comprises circuits for telecommunication, fire-alarm or emergency lighting systems as well as circuits operating at low voltage and connected directly to a mains supply system, appropriate precautions shall be taken to prevent electrical contact between the cables of the various types of circuit.

4.13.1.4 Fire alarm and emergency lighting circuits shall be segregated from all other cables and from each other.

4.13.1.5 Where a common conduit, trunking, duct or ducting is used to contain cables of category 1 and category 2 circuits, all cables of category 1 circuits shall be effectively partitioned from the cables of category 2 circuits, or alternatively the latter cables shall be insulated in accordance with the requirements of the clauses for the highest voltage present in the category 1 circuits (*see also* **4.13.1.8**).

4.13.1.6 Where a category 3 circuit is installed in a channel or trunking containing a circuit of any other category, the circuits shall be segregated by a continuous partition such that the specified integrity of the category 3 circuit is not reduced. Partitions shall also be provided at any common outlets in a trunking system accommodating a category 3 circuit and a circuit of another category. Where mineral-insulated cable, or cable whose performance complies with appropriate Indian Standard relating to specification for performance requirements for cables required to maintain circuit integrity under fire conditions, is used for the category 3 circuit such a partition is not normally required.

4.13.1.7 In conduit, duct, ducting or trunking systems, where controls or outlets for category l and category 2 circuits are mounted in or on a common box, switchplate or block, the cables and connections of the two categories, of circuit shall be segregated by a partition which, if of metal, shall be earthed. .

4.13.1.8 Where cores of a category 1 and a category 2 circuit are contained in a common multicore cable, flexible cable or flexible cord, the cores of the category 2 circuit shall be insulated individually or collectively as a group, in accordance with the requirements of this Code, for the highest voltage present in the category 1 circuit, or alternatively shall be separated from the cores of the category 1 circuit by an earthed metal screen of equivalent current-carrying capacity to that of the cores of the category 1 circuit. Where terminations of the two categories of circuit are mounted in or on a common box, switchplate, or block, they shall be segregated in accordance with **4.13.1.7**.

4.13.2 *Proximity to Non-electrical Services*

4.13.2.1 Where a wiring system is located in close proximity to a non-electrical service both the following conditions shall be met:

a) the wiring system shall be suitably protected against the hazards likely to arise from the presence of the other service in normal use, and
b) protection against indirect contact shall be afforded in accordance with Part 1/Section 7 of this Code.

4.13.2.2 A wiring system shall not be installed in the vicinity of a service which produces heat, smoke or fume likely to be detrimental to the wiring, unless protected from harmful effects by shielding arranged so as not to affect the dissipation of heat from the wiring.

4.13.2.3 Where a wiring system is routed near a service liable to cause condensation (such as water, steam or gas services) precautions shall be taken to protect the wiring system from deleterious effects.

4.13.2.4 Where a wiring system is to be installed in proximity to a non-electrical service it shall be so arranged that any foreseeable operation carried out on either service will not cause damage to the other.

4.13.2.5 Any metal sheath or armour of a cable operating at low voltage, or metal conduit, duct, ducting and trunking or bare protective conductor associated with the cable which might make contact with fixed metalwork of other services shall be either segregated from it, or bonded to it.

4.13.2.6 No cable shall be run in a lift (or hoist) shaft unless it forms part of the lift installation as defined in the appropriate Indian Standard relating to Lifts and Service Lifts.

4.14 Selection and Erection in Relation to Maintainability, Including Cleaning

Where any protective measure must be removed in order to carry out maintenance, reinstatement of the protective measure shall be practicable without reducing the original degree of protection. Provision shall be made for safe and adequate access to all parts of the wiring system which may require maintenance.

5 MAINS INTAKE AND DISTRIBUTION OF ELECTRICAL ENERGY IN CONSUMERS' PREMISES

5.1 Distribution Board System

Distribution board system, also known as 'Distribution Fuse Board System' or 'Distribution Miniature Circuit Breaker (MCB) Board System' is most commonly adopted for distribution of electrical energy in a building. Appropriate protection shall be provided at distribution boards and at all levels of panels and switchboards 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 co-ordinated so as to afford selectivity in operation. Where circuit-breakers are used for protection of a main circuit and of the sub-circuits derived there from, 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. It is recommended to provide residual current device (RCD) of 300/500 mA rating as part of the main board at the entry of the building and of 30 mA rating as part of the sub-distribution board.

Where high rupturing capacity (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 therefrom, 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. 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 high rupturing capacity (HRC) fuses shall be used.

A fuse carrier shall not be fitted with a fuse element larger than that for which the carrier is designed. The current rating of a fuse shall not exceed the current rating of the smallest cable in the circuit protected by the fuse. 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.

In Fig. 1, the two copper strips (busbars) fixed in a distribution board of hard wood or metal or other non-metal insulating case are connected to the "supply mains" through a linked switch with fuse or linked circuit breaker on each live conductor, so that the installation can be switched off as whole from both

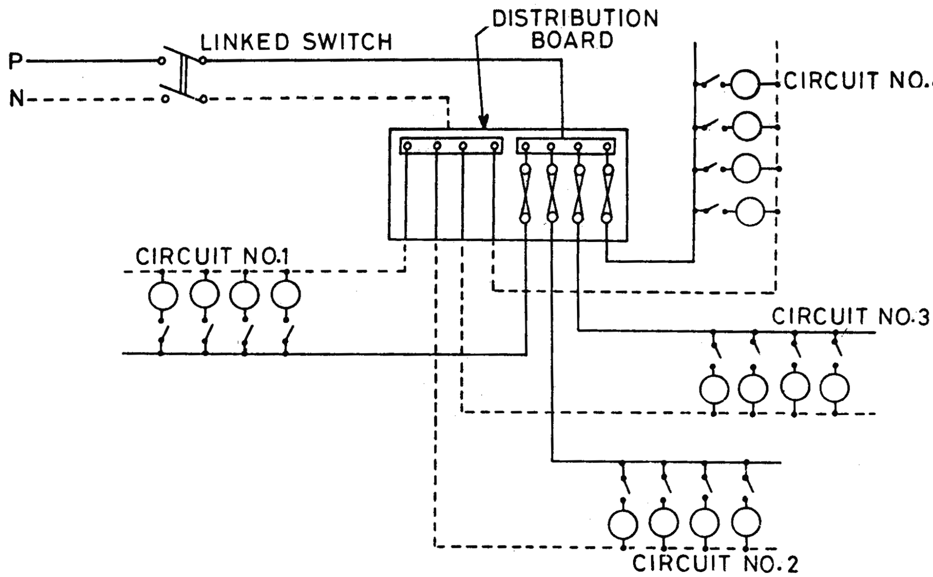


FIG. 1 A TYPICAL DISTRIBUTION BOARD SYSTEM

poles of the supply, if required. A fuse or MCB is inserted in the phase pole of each circuit, so that each circuit is connected up through its own particular fuse or MCB. The lamps, fans, socket outlets for other domestic appliances consisting each circuit need not necessarily be in the same room or even on the same floor in case of a small building and simply allocated to each circuit in such a way that the raceways or runs for connecting them is most convenient and economical. The distribution board has 4 ways for four circuits but the number of ways and the circuits can be more, provided the cable feeding the board is large enough to carry the total load current.

The practice in residential and similar commercial buildings is to restrict the maximum number of points of lights, fans and socket outlets in a final circuit. In order to ensure safety, in case more points are required to be connected to the supply, then it is to be done by having more than one final circuits.

5.1.1 *Main and Branch Distribution Board Systems*

5.1.1.1 The rating or setting of over-current protection devices shall be so chosen as to be suitable for protection of cables and conductors used in the circuit. 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. Main and branch distribution boards shall be provided, along with surge protective device and earth leakage protective device (incoming), with a fuse or a miniature circuit breaker or both of adequate rating/setting 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 overcurrent 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.

5.1.1.2 Functionally the residential installation wiring shall be separate for ceiling and higher levels in walls, portable or stationery plug in equipments. 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 ELCB protection in the sub-distribution board. 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 6A socket outlets. The load of such circuit shall be restricted to 800 W. 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 16A outlets on each sub-circuit. The circuits for lighting of common area shall be separate. For large halls 3-wire control with individual control and master control shall be made for effective conservation of energy.

5.1.1.3 In industrial and other similar installations requiring the use of group control for switching operation circuits for socket outlets may be kept separate from fans and lights. Normally, fans and lights may be wired on a common circuit, however, if need is felt separate circuits may be provided for the two. The load on any low voltage sub-circuit shall not exceed 3 000 W. In a case of new installation, all circuits and sub-circuits shall be designed by making a provision of 20 percent increase in load due to any future modification. Power sub-circuits shall be designed according to the load but in no case shall there be more than four outlets on each sub-circuit. In industrial installations the branch distribution board shall be totally segregated for single-phase distribution and wiring.

5.1.1.4 In wiring installations at special places like construction sites, stadium, shipyards, open yards in industrial plants, etc, where a large number of high wattage lamp 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.

5.1.1.5 In large buildings, however, if only one distribution board were used, some of the points would be at a considerable distance from it and in such cases it is advisable to employ sub-distribution boards (known as final circuit distribution boards) known as branch distribution boards either to save cable or to prevent too great voltage drop at the more distant points (lamps, fans or other appliances). In such cases, the main distribution board controls the distribution circuits to each sub-distribution board from which the final circuits to loads are taken as shown in Fig. 2.

5.1.1.6 The number of,

a) sub-main circuits (also called distribution circuits) from main distribution board to sub-distribution boards.

b) sub-distribution boards, also called branch distribution boards or final circuit distribution boards.

c) final circuits to loads, are decided as per the number of points to be wires and load to be connected per circuit and total load to be connected to the supply system.

5.1.1.7 For determination of load of an installation, the following ratings may be assumed, unless the values are known or specified:

Connected Device	*Rating for Calculating Connected Load*
Fluorescent lamp	40 W
Incandescent lamp, fan	60 W
6A socket outlet	100 W unless the actual value of loads are specified
16A socket outlet	1 000 W unless the actual value of loads are specified
Exhaust fans, fluorescent lamps other than single lamp, compact fluorescent lamps, HVMV lamps, HVSV lamps	according to their capacity, control gear losses shall be also considered as applicable

5.2 Distribution Boards

Distribution boards which provide plenty of wiring space having terminals of adequate size to accommodate the cables which will be connected to them should be selected. Very often it is necessary to install a cable which is larger than would normally be required, in order to limit voltage drop, and take

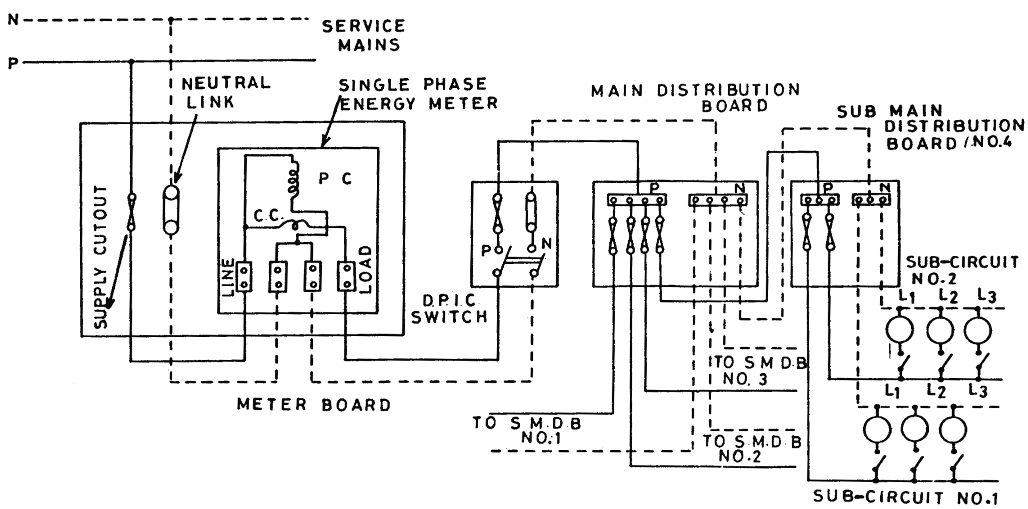


FIG. 2 TYPICAL HOUSE-WIRING CIRCUIT

account of the presence of harmonics, variation of voltage; and sometimes the main terminals are not of sufficient size to accommodate these larger cables. Therefore distribution boards should be selected with main terminals of sufficient size for these larger cables.

5.2.1 *Branch Distribution Boards*

Branch distribution boards shall be provided, along with surge protective device and earth leakage protective devices (incoming), with a fuse or a miniature circuit breaker or both of adequate rating / setting chosen in accordance with IS 732 on the live conductor of each sub-circuit and the earthed neutral conductor shall be connected to a common link and be capable 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 installation, 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.

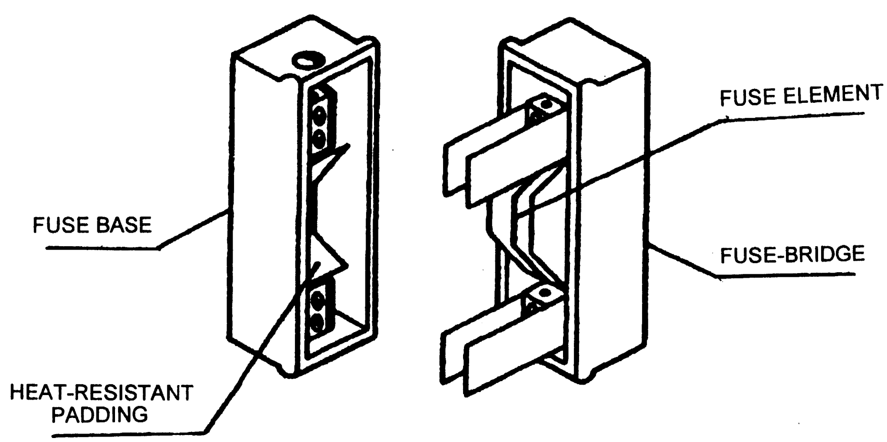
There are three types of distribution boards,

a) those fitted with rewirable fuse links;
b) those fitted with HBC fuse links; and
c) those fitted with circuit-breakers.

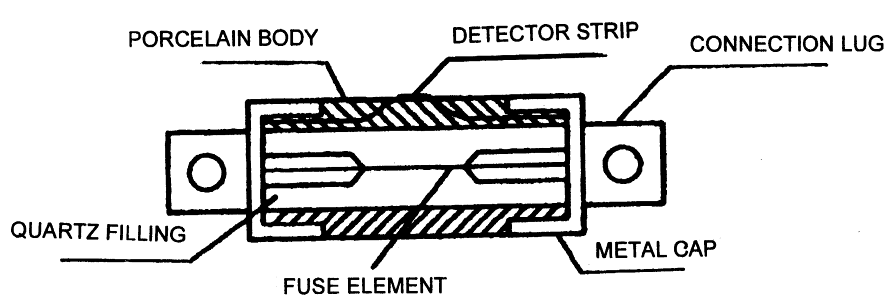
Refer to Fig. 3 for the above mantioned protective devices.

There are several reservations to the use of rewirable fuses. It is difficult to prevent the replacement of rewirable fuse link by a larger size fuse link than the fuse link chosen at the time of the installation. If the fuse links are not of appropriate size to match the current carrying capacity of the installed circuit, it would lead to short-circuit and earth fault.

Distribution boards can be fitted with MCBs or HBC fuse links. Distribution boards fitted with miniature circuit-breakers are more expensive in their first cost, but they have an advantage that they can incorporate an earth leakage trip. Miniature circuit-breakers are obtainable in ratings from 6 A to 63A, all of which are of the same physical size, and are therefore easily interchangeable. However, they must not be interchanged without first making sure that are of the correct rating for the circuits they protect. Another advantage of using MCBs is that they can easily be reset after operation.

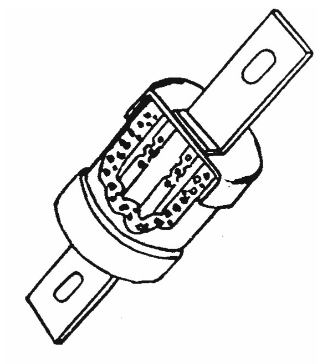


3A Semi-enclosed Rewirable Fuses

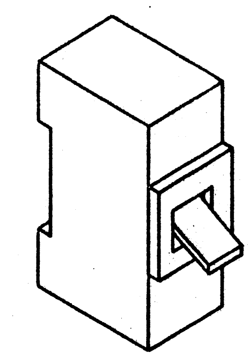


3B High Breaking Capacity (HBC) Fuse

FIG. 3 PROTECTIVE DEVICES (*Continued*)



3C High Breaking Capacity (HBC) Fuse



3D Miniature Circuit Breaker

FIG. 3 PROTECTIVE DEVICES

5.2.2 *Installation of Distribution Boards*

5.2.2.1 The distribution boards shall be located as near as possible to the centre of the load they are intended to control. The location should be convenient and economical for installation and use. Where two and/or more distribution fuse-boards feeding low voltage circuits are fed from a supply of medium voltage, these distribution boards shall be:

a) arranged so that it is not possible to open two at a time, namely, they are interlocked and the metal case is marked 'Danger 415 Volts' and identified with proper phase marking and danger marks; or
b) installed in a room or enclosure accessible to only authorized persons.

5.2.2.2 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. All low voltage distribution boards shall be marked 'Lighting' or 'Power' or 'Lighting and Power', as the case may be, and also marked with the voltage and number of phases of the supply. 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. If a distribution board is recessed into a wall which is constructed of combustible materials such as wood, the case must be of metal or other non-combustible material.

5.2.2.3 Distribution boards shall be of either metal-clad type, or air insulated type. But, if exposed to weather or damp situations, these shall be of the weatherproof type and, if installed where exposed to explosive dust, vapour or gas, these shall be of flameproof type in accordance with IS 5571. In corrosive atmospheres, these shall be treated with anti-corrosive preservative or covered with suitable plastic compound.

5.2.3 *Wiring of Distribution Boards*

5.2.3.1 The wiring shall be done on a distribution system through main and/or branch distribution boards. Main distribution board shall be controlled by a linked circuit-breaker or linked switch with fuse. Each outgoing distribution circuit or sub-main circuit from main distribution board to sub-distribution boards shall be provided with linked disconnector switch or linked MCB. Each outgoing final circuit from a main distribution board or branch distribution board shall be controlled by a miniature circuit-breaker (MCB) or a fuse on the phase or line conductor as in the case of single phase neutral (SPN) distribution board or three phase neutral distribution board. The branch distribution board shall be controlled by a linked switchfuse or linked circuit-breaker. Each outgoing circuit shall be provided with a fuse or miniature circuit breaker (MCB) of specified rating on the phase or live conductor.

5.2.3.2 Three pole neutral (TPN) distribution boards are not generally recommended to be used for single phase 2 wire final circuit distribution. However, the use of TPN fuse distribution boards or TPN MCB distribution boards for single phase 2 wire final circuit distribution have come to practice and the same is permissible, provided the size of the neutral conductor wire is carefully designed, taking the unbalanced load condition, harmonic generation of loads etc.

5.2.3.3 The neutral conductors (incoming and outgoing) shall be connected to a common link (multi-way connector) in the distribution board, and be capable of being disconnected individually for testing purposes. The wiring throughout the installation shall be such that there is no break in the neutral wire except in the form of a linked switchgear.

5.2.3.4 There shall be at least two ring circuits — one for light current (known as light power) 6A socket outlets and another for heavy current (known as heavy power) 16A socket outlets to connect heavy current domestic appliances. Similarly, heavy current wiring shall be kept separate and distinct from “light current” wiring, from the level of circuits, that is, beyond the branch distribution boards. Lights, fans and call bells shall be wired in the light current circuits.

5.2.3.5 Wiring shall be separate or essential loads, that is, those fed through standby supply and non essential loads throughout. Wiring for the safety services shall be separate and distinct. Unless and otherwise specified, wiring shall be done only by the “Looping System”. Phase or live conductors shall be looped at the switch boxes and neutral conductors at the point outlets. Where “joint box system” is specified for installation, all joints in the conductors shall be made by means of approved mechanical connector in suitable and approved junction boxes.

5.2.3.6 The balancing of circuits in three wire or poly phase installations shall be arranged before hand.

5.2.4 *Location of Distribution Boards*

5.2.4.1 Distribution boards should preferably be sited as near as possible to the centre of the loads they are intended to control. This will minimize the length and cost of final circuit cables, but this must be balanced against the cost of submain cables. Best location of distribution boards depends on the availability of suitable stanchions or walls, the case with which circuit wiring can be run to the position chosen, accessibility for replacement of fuselinks, and freedom from dampness and adverse conditions (if exposed to the weather or damp conditions, a distribution board must be of the weather proof type) The distribution boards shall not be more than 2 m above room floor level.

5.2.4.2 Where distribution boards (which are fed from a supply exceeding 230 V) feed circuits with a voltage not exceeding 230 V then precautions must be taken to avoid accidental shock at the higher voltage between the terminals of two lower voltage boards. Where the voltage exceeds 230 V, a clearly visible warning label must be provided, worded “400/415 V BETWEEN ADJACENT ENCLOSURES”. These warning notices should be fixed on the outside of busbar chambers, distribution boards or switchgear, whenever voltage exceeding 230 V exists.

5.2.5 *Feeding Distribution Board*

When more than one distribution board is fed from a single submain cable or from a rising bus bar trunking, it is advisable to provide local isolation near each distribution board (*see* Fig 4). It is also good practice to provide a local isolator for all distribution boards which are situated remote from the main switchboard (*see* Fig. 5). If the main or submain cables consist of bare or insulated conductors in metal trunking, it is very often convenient to fit the distribution board adjacent to the rising trunking, and to control each with fusible cutouts or switchfuse.

5.2.6 *Circuit Charts and Labelling*

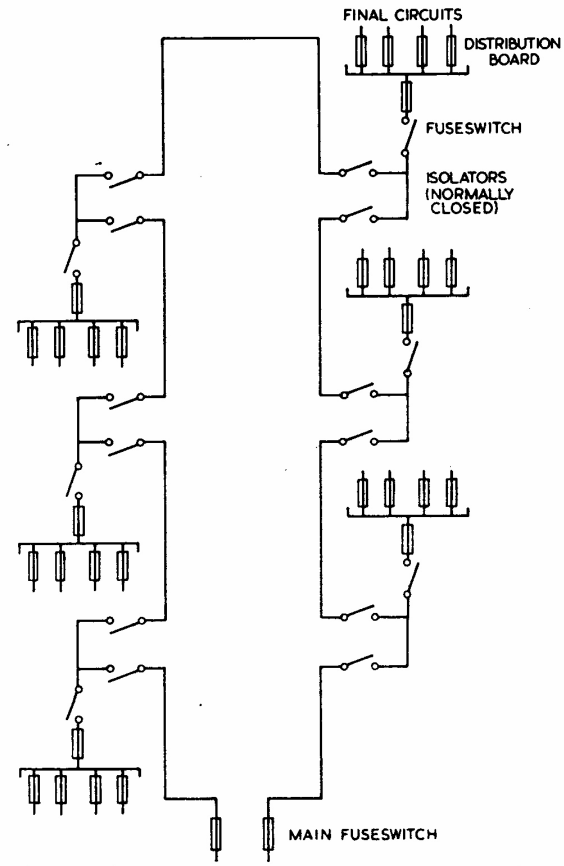
The diagrams, charts or tables shall be provided to indicate for each circuit:

a) The outlets served,
b) Size and type of cable, and
c) Rating of fuse or protective device.

These should be fixed in, or in the vicinity of the distribution board, and fitted in glazed frames or in plastic envelops for protection.

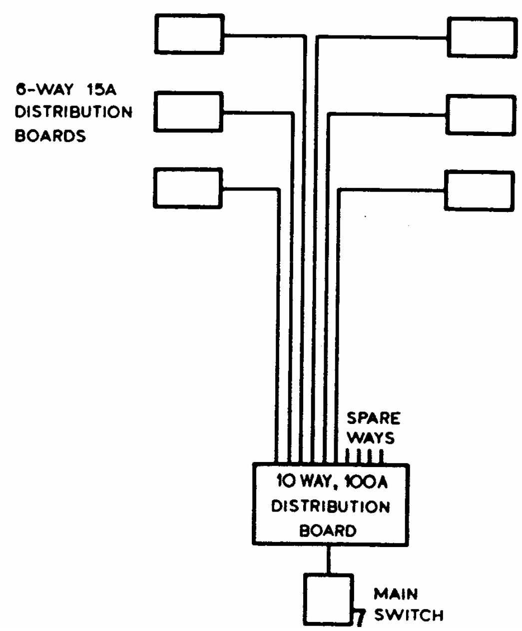
5.2.7 *Marking Distribution Boards*

a) All distribution boards should be marked with a letter or number, or both, preferably with the prefix ‘L’ for lighting, ‘S’ for socket and ‘P’ for power.
b) They should also be marked with the voltage and the type of supply, and if the supply exceeds 230V a DANGER notice must be fixed.
c) When planning an installation, a margin of spare fuseways should be provided usually about 20 percent of the total.



NOTE — The cables feeding the ring will share the load and may therefore be reduced accordingly. This arrangement enables the ring to be broken by one of the isolators in the event of a fault a one end of the ring, in which case the load must be reduced.

FIG. 4 SINGLE LINE DIAGRAM OF A TYPICAL RING MAIN FEEDING SIX DISTRIBUTION BOARDS



NOTE — It is recommended that distribution boards located remote from main switchgear be provided with local isolators.

FIG. 5 SINGLE LINE DIAGRAM SHOWING SIX FINAL DISTRIBUTION BOARDS FED BY RADIAL SUBMAINS FROM A MAIN DISTRIBUTION BOARD

d) Metal distribution boards should be provided with plugged holes to enable additional conduits or multicore cables to be easily connected in future.

5.3 Approximate Estimates of Allowable Voltage Drop in Different Parts of Wiring System of a Large Building

There is no hard and fast rule in this respect. Ordinarily, however, in a lighting circuit containing lights and fans, the total voltage drop is kept within 3 percent of the declared voltage. The maximum allowable voltage drop is 1 V from main fuse to main distribution board, 4.5 V from main distribution board to each sub-distribution board and 1.5 V in each final sub-circuit. The voltage drop in the connection line of a pump motor in a house may go up to 7.5 percent of the declared voltage, but as is the case with a lighting circuit, it is recommended to keep this drop within 3 percent, if possible.

5.4 Correct Estimation of Sizes of Cables

5.4.1 If the size of cable is determined on the basis of total load connected in the circuit, that is, on the basis of sum of wattage of all lamps, fans, wall-plugs, etc, the size will be very large. However, all lamps, fans, wall-plugs etc, may not be in use simultaneously at a given time, and it is possible that all the points are not loaded to their full capacity. For these reasons it is considered to be sufficiently accurate if an estimate is prepared according to **5.1.1.7** and the criteria of considering two-thirds of total wattage of the circuit, that is, the total wattage of every final sub-circuit is obtained by adding up the wattage of individual loads connected to that circuit and two-thirds of this total wattage should be taken into consideration for determining the size of cable to be used for this sub-circuit. But the current corresponding to this wattage must not be less than the current drawn by the single maximum wattage point. If a sub-circuit has only one point, cable suitable for full load current of that point is to be used. However, if a sub-circuit has three 6 A plug-sockets, the size of the cable can be determined on the basis of two-thirds of 180 W (that is, 120 W).

The above applies to ordinary dwelling-house, but not to all buildings. Three-fourths of the total wattage is to be considered for hotels, boarding houses etc, and nine-tenths for office etc. For the auditorium of cinema, theatre etc, cables suitable for full connected load are to used.

5.4.2 If in a house there is electric cooker or electric oven, full load up to 10 A and one-half of any extra load (in excess of 10 A) should be taken into account. The load of every sub-circuit is thus calculated, and the current drawn by a sub-distribution board is determined.

5.4.3 The load of wall-plug connected to a sub-distribution board in a dwelling house where there are wall-plugs of various sizes will be the full-load of the plug drawing maximum current plus four-tenths of all the remaining plugs. In hotels etc, three-fourths of the total load of all the remaining plugs have to be added to the full-load of the plug drawing maximum current.

a) At first currents for the sub-circuits are to be determined, one by one.
b) Sizes of fuse should be determined according to capacity to continuously carry the respective current.
c) The size of cable for each sub-circuit is determined according to the current drawn by that sub-circuit.
d) Finally, the sizes of flexible cord and wall-socket for the respective sub-circuit to be determined.

5.5 Diversity and Maximum Demand

In determining the maximum demand of an installation or parts thereof, diversity may be taken into account.

Table 2 gives guidance on diversity, but it is emphasized that the calculation of diversity would have to take into account several factors which would need special knowledge and experience. By consulting Table 2, a reasonable estimate can be obtained as to what the maximum load is likely to be, but it must be stressed that each installation must be dealt with on its own merits.

Table 2 Typical Allowances for Diversity

(*Clause* 5.5)

Sl No.	Purpose of Final Circuit Fed from Conductors or Switchgear to which Diversity Applies	Type of Premises		
		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	66 percent of total current demand	90 percent of total current demand	75 percent of total current demand

Table 2 — (*Concluded*)

(1)	(2)	(3)	(4)	(5)
ii)	Heating and power [*also see* Sl. No. (iii) to (iv) below]	100 percent of total current demand upto 10 A +50 percent of any current demand in excess of 10A	100 percent of full load of largest appliance +75 percent of remaining appliances	100 percent of full load of largest appliance +80 percent of second largest appliances +60 percent of remaining appliances
iii)	Cooking appliances	10A +30 percent of full load of connected cooking appliances in excess of 10 A + 6 A if socket-outlet incorporated in unit	100 percent of full load of largest appliance +80 percent of full load of second largest appliance +60 percent of full load of remaining appliances	100 percent of largest appliance +80 percent of full load 1 of second largest appliance +60 percent of full load of remaining appliances
iv)	Motors (other than lift motors which are subject to special consideration)		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.
v)	Water heater (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 heaters (thermostatically controlled)	No diversity allowable [2]	+25 percent of full load of remaining appliances	
vii)	floor warming installations	No diversity allowable [2]		
viii)	Water heaters thermal storage space heating installations	No diversity allowable [2]		
ix)	Standard arrangements of final circuits in accordance with IS 732	100 percent of current demand of largest circuit +40 percent of current demand of every other circuit	100 percent of current demand of largest circuit +50 percent of current demand of every other circuit	
x)	Socket outlets other than those included in Sl No. (ix) above and stationary equipment other than those listed above	100 percent of current demand of largest point +40 percent of current demand of every other point	100 percent of current demand of largest point +75 percent of current demand of every other point	100 percent of current demand of largest point +75 percent of current demand of every point in main rooms (dinning rooms, etc) +40 percent of 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.

An example of estimation of maximum demand for a domestic installation with a single tariff is given below:

Connected Load		*Expected Maximum Demand*	
Installed lighting—	10A	66 percent of installed load	= 6.6A
Installed fixed heating—	30A	100 percent of first 10 A plus 50 percent of excess of 10 A	= 20A
Installed general-purpose socket-outlet—	40A	100 percent current demand of largest circuit (20A) plus 40 percent current demand of other circuits (8A)	= 28A
Installed cooker—	45A	10A plus 30 percent of full load of remaining connected appliances plus 6A for socket in unit	= 22A
Total	**125A**		**76.6A**

In this case a 100A main switch should be provided. Unless it is anticipated to increase the load considerably in the foreseeable future, in which case a larger switch fuse should be installed.

However, for a small restaurant where electric lighting and heating is installed, it would be most likely that the whole load will be switched on at one time and therefore the main switchgear must be suitable for the total installed load.

5.6 MV/LV Busbar Chambers (400/230V)

Bus bar chambers which feed two or more circuits must be controlled by a main disconnector (TP and N), or isolating links, or (three) fuses and neutral link, to enable them to be disconnected from the supply.

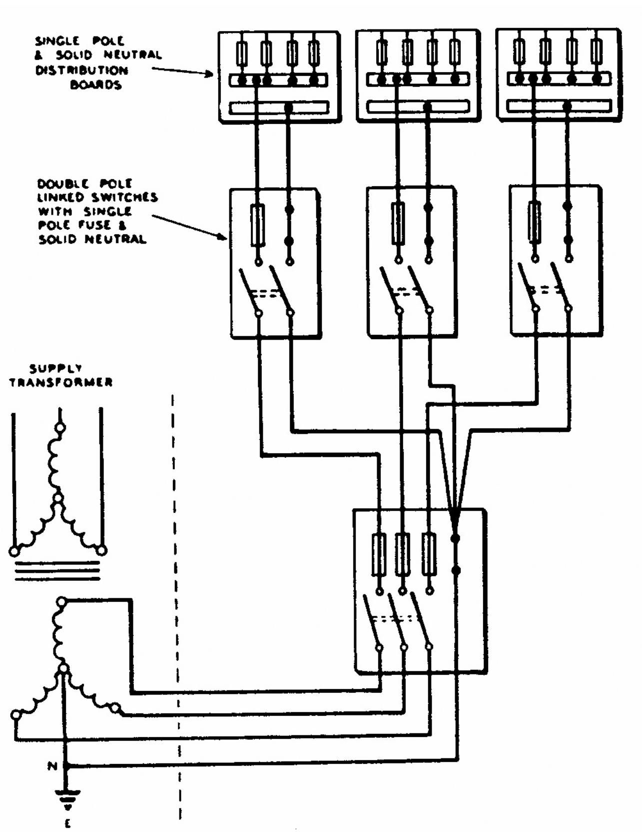
5.7 Earthed Neutrals

To comply with *Indian Electricity Rules*, 1956 no fuses or circuit-breakers other than a linked circuit-breaker shall be inserted in an earthed neutral conductor, and a linked switch or linked circuit-breaker shall be arranged to break all the related phase conductors. 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 (*see* Fig. 6). 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 must be arranged so that the neutral makes before, and breaks after the phases.

5.8 General Design of Feeder Circuit, Distribution Circuit and Final Circuit

5.8.1 Every distribution board must be connected to either a main switch fuse or a separate way on a main switch board. Every final circuit must be connected to either a switch fuse, or to one way of a distribution board. In either case the rating of the protective device must not exceed the current rating of the circuit cable.

5.8.2 The circuit which is connected to single-way of switch board/sub-switch board or fuse/MCB distribution board for supplying current to one or more load point known as 'final circuit'. In the case of domestic and commercial supply, the suppliers' line or cable comes to the energy meter through supplier's scaled cut-out and from the meter it goes to consumer's main switch. This line is called 'supply main' or 'main line'.



NOTE — When the neutral point of a supply or one pole of transformer on consumer's premises is earthed permanently, a fuse, non-linked switch or circuit-breaker is not permitted in the line connected to earth.

FIG. 6 SINGLE POLE FUSING

5.8.3 On account of heavy load in big factories of horizontal distribution, very often feeder line is drawn from the main incomer switch to busbar chamber of main switch board and the feeder line is called 'supply main' or 'main feeder'. If sub-switch board or distribution board is installed next in sequence to another sub-main switch, the feeder line upto sub-switch board or main distribution, the line from main switch board up to sub switch board or main distribution board is called 'sub-main feeder'. If main distribution board is installed next in sequence to sub-(main) switch board, the line upto main distribution board is called 'main distribution feeder' line. And from there line is drawn through different sub-busbar chambers of sub-switch boards to distribution boards, or from the main switch board and direct to main distribution boards.

5.8.4 Also on account of heavy load in large buildings of vertical distribution, very often main feeder line is drawn from the main incomer switch to main busbar chambers and from there upto different sub-busbar chambers and or main distribution boards, the feeder line from consumer's main switch to busbar chamber that rises from the ground floor upto the top most floor in multistoried building is known as 'main raising main'. If sub-(main) busbar chamber or main distribution board is installed next in sequence in different floors through another submain switch, feeder line upto sub-(main) busbars or main distribution boards is called 'sub-main raising bars' and considered sub-main feeder line. If main distribution is installed next in sequence to sub-main busbars, the line upto main distribution board is called 'distribution busbar' and considered main distribution feeder line. Circuit lines drawn from main distribution boards upto final circuit fuse districution boards /MCB distribution boards may be as 'sub-main distribution feeder'.

5.8.5 Every circuit line which runs from final circuit fuse distribution board towards load points is called 'final circuit'. Sometimes a circuit line may go to a load point from a main distribution board/main distribution busbar chamber, a sub-main switch board/ sub-main rising main, a main switch board /main rising main etc; in that case every line is regarded as a final circuit.

5.8.6 Every final circuit must come out of a separate way of a (final circuit) distribution board. Where there is only one final circuit, it may be connected directly to the main switch board.

5.8.7 Wiring of every final circuit will be completely separated from that of another final circuit which can be on or off with a single-pole switch. Care must be taken to see that every pair of live or neutral wires are kept together properly in order in the distribution board for the convenience of testing or disconnecting current flowing towards load points must not exceed the circuit-carrying capacity of wires used for final circuit.

5.8.8 *Use of Plug Point with Lamp Circuit*

In a house wiring, usually lamp, wall-plug etc., are connected to the same circuit. The actual limit of the current that the cables used in the wiring can safely carry should be known. Considering the final circuit which includes discharge lamps, the sum total of currents taken by all discharge lamps together must not exceed the current carrying capacity of the final circuit. If the lamps are lighted by means of only the normal circuit, current carrying capacity of the final circuit should be 1.256 times the total current of all the lamps together.

If in a final circuit both incandescent lamps and inductor-lighted discharge lamps are used,

$$\frac{(\text{Power taken by inductor-lighted discharge lamps} \times 2) + (\text{Power taken by incandescent lamps} \times 1)}{\text{Line voltage}}$$

Must not exceed the current carrying capacity of the final circuit.

5.8.9 *Exception in Case of Temporary Wiring*

In case of temporary load points where bayonet holders for lamps have been used, total power demand of load must not exceed 1 000 W per final circuit.

5.8.10 *Splitter Unit*

This kind of distribution board is very much in use now-a-days. This board can be installed anywhere and is known as 'splitter unit' or 'splitter box'. The unit is prepared by setting a pair of main switches as well as a pair of main fuses or a single fuse inside a cast iron box. An external handle is attached to the body of the box. It is so arranged that the cover of the box cannot be opened when the switch is in the on position or the switch cannot be switched on when the cover is open, that is the cover cannot by any means be opened unless the switch is off. It is for this arrangement that the unit is quite good from the point of view of safety. The box is also known as Iron-clad Switch-Fuse Box. The switch-fuse box is installed at a point where from consumer's zone starts. Cables are drawn from the switch and connected to the bus-bars of a fuse board. This is the main distribution board. Now-a-days iron-clad fuse-box is very much in use. A screw is attached to the body of this box. The risk of electric shock is avoided by connecting earth wires to that screw. The box is to be earthed by two separate and distinct earth connections.

5.8.11 *Lamps of the Same Room are Supplied from More Than One Final Circuit Distribution Boards*

When outlets from a sub-distribution board or a fuse board are divided into 'ways' and each final sub-circuit is connected to a separate way, the advantage is that in the event of a short-circuit in anyone sub-circuit, the other sub-circuits remain unaffected and continue to function normally. But if a fault occurs in a distribution board, all the sub-circuits coming out of it are affected. There are some places such as hospital, operation theatre; cash room in a bank, engine room, workshop etc, where the entire room cannot be allowed to be dark under any circumstance. A lot of risks may have to be faced if such places suddenly become totally dark. Wherever special attention must be paid to avoid any inconvenience in business, every room is equipped with more than one lamp and these are invariably taken from different ways. Even sometimes these lamps are supplied from fully separate distribution board. Suppose the wiring of a three-storeyed building is to be done in such a way that no room of that building shall be totally dark (except in the event of discontinuity of supply). In that case there must be a separate sub-distribution board in each floor. But it is not that the sub-distribution board will control the load points of that floor only. Depending on the convenience of a circuit, sub-distribution board in the lower floor will supply power to some lamps etc, of the lower floor and to some lamps etc, of the upper floor. Every room will be provided with two sets of cables — one set will be supplied from sub-distribution board of the upper floor and the other set will be supplied from sub-distribution board of the lower floor. With these arrangements if a fault develops in a sub-distribution board, there is no possibility of any room becoming totally dark. In such cases, operation theatre etc, are provided not only with connection from separate distribution boards but with alternative source of supply such as gas plant or charged battery.

5.8.12 *Pilot Lamp*

Arrangements should be made for fixing a bracket above each main board and for connecting a 20 W lamp on it. Cables connecting this lamp will come out directly from the bus bars of the board through a separate switch arid fuse. This lamp is called a Pilot Lamp**.** The purpose behind this arrangement is to keep the main board always illuminated so that fuse etc, can easily be changed.

5.8.13 *Arrangements for Taking Cable Connections from One House to Another*

If wiring is to be done to supply current from one house in which consumer's main switch has been installed to another house, whichever of the following arrangements is suitable (for a particular case) is to be adopted for the wiring and its protection:

If the distance between the house in which the main meter board has been installed and the other house (for example garage, servant's room etc) does not exceed 3 m and if there be no thoroughfare between the two houses, electric lines may be drawn from the former to the latter through a galvanized iron (G.I.) pipe of suitable dimensions at a height of at least 2.5 m above the ground level. Also the G.I. pipe has to be properly earthed. But in case the distance between the two houses exceeds 3 m or if there is a thoroughfare between them, a separate main or sub-main has to be drawn from one house to another by means of weather-proof cables tied up with G.I. bearer wire (*see* Fig. 7A).

If current is to be taken from one house to another by means of cleat wiring, the cable used in the wiring will be weather-proof. This is also known as H.S.O.S. (House Service Overhead System) cable. Use of cable with 'polychloroprine' sheath or PVC cable or cable with PVC sheath is also approved by many. This arrangement of drawing a supply line is allowed up to a distance of 3 m between two buildings. Using cables as described above and drawing these cables over a separate catenary wire or using those cables which have in-built bearer wires (at the time of manufacture), the supply line may be drawn.

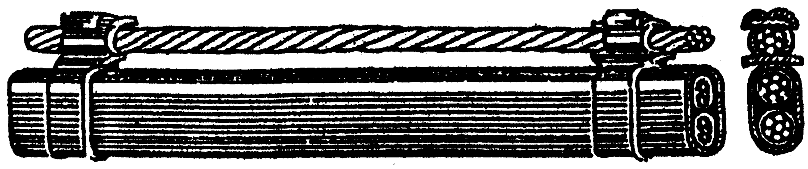
Other methods of drawing cables over bearer wires are also in use, one of these methods is shown in Fig. 7B. In this method a piece of leather strap loops a hard rubber-sheathed cable at certain intervals for hanging it, while the upper part of the strap is fastened to the catenary wire by means of wire hook. This is also an arrangement for taking a supply cable from one building to another. If such a cable, as has in-built bearer wire, is used, the limit of distance between two buildings will depend upon the load-bearing capacity of the bearer wire.

Besides these a cable may be drawn from one house to another as shown in Fig. 7C. Main earth pit should be at least 1.5 m away from the building.

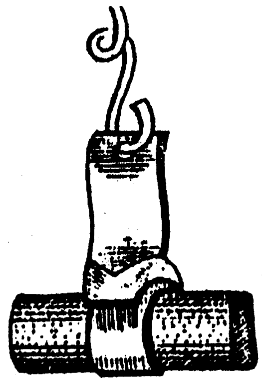
5.8.14 *Identification of Cables and Conductors*

IS 11353 gives guidance on uniform system of marking and identification of conductors and apparatus terminals (*see* Table 3). Colours of the cores shall be as per relevant Indian Standard for cables. The following shall be ensured:

a) *Non-Flexible Cables and Bare Conductors* — Every single core non-flexible cable, and every core of twin or multicore non-flexible cable used as fixed wiring shall be identifiable throughout its length by appropriate methods.

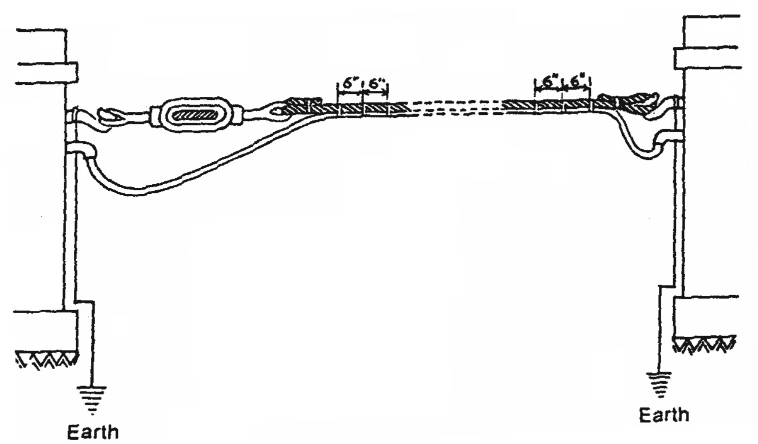


7A GI Bearer Wire Stretched Between Two Houses and Supply Cable Tied-Up with this Wire by Means of Link Clips



7B Leather Strap Loops for Hanging Hard Rubber-sheathed Cable at Intervals

NOTE — Leather strap loops are used for hanging hard rubber-sheathed cable at intervals while the upper part of the strap is fastened to the catenary wire by means of wire hook



7C Drawing of Supply Cable from One House to Another

FIG. 7 ARRANGEMENTS FOR TAKING CABLE CONNECTIONS FROM ONE HOUSE TO ANOTHER

b) *Rubber or PVC Insulated Cables* — Core colours to be in accordance with respective Indian Standard or colour sleeves at the termination of these cables.

c) *Multicore PVC Cables* — If colouring of cores is not used, then cores to be identified in accordance with relevant Indian Standards.

d) *M I Cables* — At the termination of these cables, sleeves shall be fitted.

e) *Bare Conductors* — To be fitted with sleeves or painted.

f) Colour coding of fixed wiring cables applies to all wiring up to the final distribution board, and also for circuit wiring, except that red may be used for any phase.

g) When wiring to motors the colours specified in Indian Standard should be used right up to the motor terminal box. For slipring motors the colours for the rotor cables should be the same as those for the phase cables, or could be all of one colour except black or green.

h) For star delta connections between the starter and the motor, use red for A1 and A0, yellow for B1 and B0, and blue for C1 and C0. The "1" cables should be marked to distinguish them from the "0" cables.

j) For 2-wire circuits, such as for lighting or sockets, the neutral of middle wire must always be black, and the phase or outer wire (whichever phase it is derived from) should be red.

k) For lighting the red wire will always feed the switch, and a red wire must be used from the switch to the lighting point.

For flexible cables and cords the distinctive colours are not the same as for fixed wiring, and the colours of these are given in Table 4.

5.8.15 *Sub-main Cables*

Sub-main (feeder) cables are those which connect between a switch fuse/MCCB feeding sub distribution boards of main switchboard, to incomer of subsidiary main switch board or direct to a main distribution board. The size of these cables will be determined by the total connected load which they supply, with due consideration for diversity and voltage drop, and the other factors described in Wiring Regulations. Sub-main cables may be arranged to feed more than one distribution board if desired; they may be arranged to form a ring circuit, looping from one main distribution board to another. Where a sub-main cable feeds more than one distribution board in a ring circuit, its size must not be reduced when feeding the second

Table 3 Colour Identification of Cores of Non-flexible Cables and Bare Conductors for Fixed Wiring
(*Clause* 5.8.14)

Sl No. (1)	Function (2)	Colour Identification of Core of Rubber or 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
ii)	Phase of ac single-phase circuit	Red [or yellow or blue (*see* Note 1)]
iii)	Neutral of ac single or three-phase circuit	Black
iv)	Phase R of 3-phase ac circuit	Red
v)	Phase Y of 3-phase ac circuit	Yellow
vi)	Phase B of 3-phase ac circuit	Blue
vii)	Positive of dc 2-wire circuit	Red
viii)	Negative of dc 2-wire circuit	Black
ix)	Outer (positive or negative) of dc 2-wire circuit derived from 3 wire system	Red
x)	Positive of 3-wire system (positive of 3-wire dc circuit)	Red
xi)	Middle wire of 3-wire dc circuit	Black
xii)	Negative of 3-wire dc circuit	Blue
xiii)	Functional earth-telecommunication	Cream

NOTES

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

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

Table 4 Colour, Identification of Cores of Flexible Cables and Flexible Cords
(*Clause* 5.8.14)

Sl No. (1)	Number of Cores (2)	Function of Core (3)	Colour(s) of Core (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.

or subsequent board, because the cable must have a current rating not less than the fuse or circuit breaker protecting the sub-main. If a fuse or circuit-breaker is inserted at the point where a reduction in the size of the cable is proposed, the reduced size of cable may be used, providing that the protective device is rated to protect the cable it controls.

5.8.16 *Protective Multiple Earthing (PME)*

5.8.16.1 Protective multiple earthing system uses the protective conductor as a combined earth/neutral conductor. It is sometimes used where there is overhead distribution, and where it is difficult to obtain a sufficiently low earth resistance from supply transformer to the consumer's terminal. In such a case the neutral conductor is also the earth conductor and it is bonded to earth, not only at the transformer position, but also at the consumer terminal position. The condition of approval for this system contain very stringent requirements. The wiring for consumers installations, including sub-mains and circuits wiring may (if approved) be carried out on the PME system. Some of the requirements for consumer's installation are as follows:

a) The supply undertaking shall be consulted to determine any special requirements concerning the size of protective conductors.
b) All precautions must be taken to avoid the possibility of an open circuit in the neutral conductor.
c) Bonding leads must be connected to the earthing terminals of all metal structures, metal pipes and other metal services that are (or may reasonably be expected to become) in electrical contact with the general mass of earth, and that are so situated that simultaneous contact may reasonably be expected to be made by any person with such structures, pipes or other metal work on the one hand, and with the exposed non-current-carrying metalwork of the consumer's installation, or any metal work in electrical contact therewith, on the other hand.
d) Earth electrodes shall be provided at points not less remote from the transformer than the most remote service line or connection point, and at such other points as will ensure that the resistance to earth in the neutral conductor is satisfactory and the protection system operative. The overall resistance shall not exceed 20 times.
e) There shall be a wire connection from the neutral earth conductor to both the neutral and the earth terminal of every socket outlet. Wiring from plugs or spur units to lamps and appliances shall be carried out by a phase conductor, a conductor and a separate earth conductor.
f) There shall be electrical continuity of the neutral earth sheathing of multicore armoured cables. All connections and joints shall be made in accordance with the recommendations of the cable manufacturer. At every joint in the outer conductor (that is neutral earth) and at terminations, the continuity of the conductor shall be ensured by bonding conductor additional to the means used for sealing and clamping the outer conductor.

5.8.16.2 The use of a PME system in petrol filling stations is specifically prohibited. The reason for the prohibition is to prevent the risk of electrical return currents flowing back to earth through the metallic parts of the underground supply pipes and storage tanks. Special armoured multicore cables may be used for the PME system. Such cables may be with XLPE (cross linked polyethylene) insulation, Aluminium conductors and sheath are used, and the cables have a PVC oversheath. The armouring in these cables is laid upon such a way that sufficient amount can be pulled away from the cable without the necessity of cutting it, to enable access to the phase conductor for the purpose of jointing. These special cables are only manufactured in minimum lengths of about 200 m, and it may not be economical to employ the PME system for sub-main cables when only short runs are involved.

5.8.16.3 *Circuit wiring*

a) Circuit ring for PME system may also use a common neutral earth (CEN) conductor, but in some instances this may not result in any cost savings.
b) For mineral-insulated copper sheathed systems the outside sheathing lends itself readily to the system, but special glands should be used to ensure satisfactory low impedance in the earth conductor.
c) For screwed-conduit systems it is sometimes difficult to guarantee satisfactory low impedance in the conduit system during the life of the installation, and it is recommended that a circuit protective conductor (CPC) neutral conductor be drawn into the conduit.
d) The same recommendation applies to wiring is steel trunking, because it is imperative that there be no risk during the life of the installation that an open circuit, or a high resistance joint, could occur.

e) Before planning any PME installation careful study must be made of the actual conditions of approval issued by the concerned regulatory authority.

5.9 Computer Data Transmission and Control System

Cables required for data transmission and control systems are those that are required between the computer and the outstations and those used between the machine and the associated peripheral equipment. Generally, the field wiring is multicore and may have screening applied to each core, to each pair or, simply, overall. There is a large range of cables used by different computer manufacturers. One of the commonly used cables for peripheral equipment is the ribbon form which is also produced as multicore cable, with and without screening and various types of insulation. Although ribbon cables are produced in widths upto approximately 80 mm and with over 60 cores, they are extremely thin and, therefore, flexible.

5.10 Multiplex Systems

One of the advantages gained by the use of electronic equipment is that the amount of field wiring required is far less, in both quantity and size, than for the earlier power circuitry entailed by mechanical relay systems. Even further improvements are made possible by the use of multiplexing systems, that is, the ability to convey a large number of signals each way along the same conductor, and these are, therefore, particularly suitable for installations requiring a large number of outstations, whether for data transmission or process control. Optical fibre cables provide further advantages for light-current installations of all types; they have low attenuation and high bandwidth, which reduces the necessity for repeaters, and are not subject to interference from heavy electrical equipment. In hazardous areas, optical fibres give even greater safety than intrinsically safe circuits as the form of energy transmitted is, of course, light waves and not current.

5.11 Domestic Systems

5.11.1 The smaller domestic type of installation is adequately catered for with twin and circuit protective conductor (CPC) PVC cables or single-core PVC cable in some form of enclosure; the installation of the first is less labour-intensive than conduit work although the second provides better mechanical protection. Due to the amount of space that is occasionally available between floorboards and ceilings (modern construction methods include solid floors) and in lofts, installation is relatively simple and protection is rarely necessary for horizontal runs. Where droppers are required for switches and wall-fittings, however, it is essential to provide oval conduit or capping over the cables. Although PVC has a much longer anticipated life than the previously used rubber covered cables, MICC is a suitable alternative which has an even longer life. It is not commonly used on very small installations except, possibly, for exterior lighting or feeds to remote buildings.

5.11.2 To avoid undue disruption and damage to existing floorboards, plastering, etc, a number of enclosed surface systems are available which incorporate mini-trunking, dado-trunking and cornice-trunking. For each system, accessories are available for accommodating different types of outlet and for negotiating corners, doorways, etc, a correctly designed installation is effective and relatively inconspicuous, although even where obvious, such as across ceilings, it presents an aesthetically pleasing appearance.

5.12 Telephone Cables

As the user finds it more convenient to install his own internal telephone systems, a large range of cables available for the purpose. The conventional type of multipair or multitriple cable consists of tinned copper conductors, PVC-insulated and sheathed with, in some cases, a non-metallic rip-cord laid under the sheath to simplify stripping while, for under-the-carpet installations or situations where the conventional round cables are inconvenient or too bulky, ribbon cables are again available with upto 50 ways. Where such cables may be subject to damage or heavy traffic, such as under floor coverings, ribbon cables insulated with cross-linked PVC (XLPVC) which is more robust than standard PVC may be used. XLPVC are different from XLPE-insulated cables which, among other advantages, have fire-retardant properties.

5.13 Cable Jointing and Termination

5.13.1 Although the methods employed for jointing and terminating cables of all types have been simplified, largely due to the use of improved materials for insulation and sheathing, the importance of utilizing correct techniques and methods cannot be too strongly emphasized. All joints and terminations introduce potentially dangerous points; in power circuits a faulty joint will lead to local hot-spots with ultimate failure of the cable, while in light-current installations for process control, data transmission and communications, a high resistance connection (dry joint) can prevent equipment from operating satisfactorily.

5.13.2 Multicore cables, whether for mains, voltages or light-current duty, generally present the greater problem as the crutch, that is, the point at which conductors are splayed out from the normal formation, constitutes a naturally weak area in which air may be trapped if a termination or joint is not correctly formed, leading to breakdown at a later stage.

5.13.3 Single-core cables should, preferably, never be jointed, but where this is essential it should be effected only in purpose-made joint boxes equipped with suitable mechanical or compression-type connectors. These may be of the ferrule type with pinching screws or, as with terminators, bolted clamps requiring the bare conductor to be either wound around the bolt between shaped washers or enclosed in crimped type terminals which are then threaded over the screw thread and clamped. It is essential with all types of stranded cable to ensure that every strand is included in the joint or termination and, particularly with aluminium conductors, to follow cable manufacturers' recommendations for tightening torques. Aluminium, although lighter in weight and less expensive than copper, unfortunately has a higher co-efficient of expansion and this has, at times, caused connections to slacken shortly after commissioning. It is therefore advisable for the installer of aluminium cables to recheck all clamp-type connections after electrical load has been applied. This does not imply, however, that a similar procedure is unnecessary with copper conductors but that it may not be so essential provided that connections are fully checked in the first instance.

5.13.4 Crimped terminals are quite adequate for the smaller, relatively lightly loaded cables but, otherwise, compression sleeves and lugs, provided that the recommended torques are applied, are unlikely to give rise to problems during the life of a cable under the most arduous circumstances.

5.14 Special Cabling Requirements

5.14.0 Although PVC insulated cables are suitable for most of the general wiring requirements in domestic, commercial and industrial situations, circumstances may dictate, either through technical necessity or statutory demands, that further precautions are necessary to prevent the possibility of danger or to give increased security, as detailed below.

5.14.1 *Lighting*

The two main areas of concern are related to heat build-up in luminaries and surges created by discharge lighting. In totally enclosed luminaries, high temperatures may arise due to the lack of ventilation. Though luminaires complying with the relevant Indian Standards take into account the temperature rise, however, during installation of luminaires it should ensured that wiring in proximity to the fittings is suitable. Discharge-type fittings may entail the use of higher current rated cables to avoid unnecessary temperature rises. The effects of high discharge currents during switching operations may have more drastic effects by causing a cable to disintegrate completely. Some cables are susceptible to current and voltage surges which may be avoided by the use of current limiting devices. Where electrical equipment in normal operation has a surface temperature sufficient to cause a risk of fire, suitable methods of protection should be adopted.

5.14.2 *Emergency Lighting*

Emergency lighting is very critical for at hospitals, theatres, hotels, factories, offices, shops, cinemas and certain specified places of entertainment and practically all types of premises excluding houses. Generally, the cable installation for an emergency lighting system should comply with Wiring Regulations but care must be taken to ensure that all wiring possesses inherently high resistance to attack by fire and adequate mechanical strength. This allows the use of various standard types of cable, provided that suitable means of protection are employed. When emergency luminaries are supplied from a remote source, the wiring system must be mechanically separated from other systems by rigid and continuous partitions of non-combustible materials. Consequently, multicompartment enclosures are suitable, also mineral insulated copper clad cables without further precautions. Segregation is not a requirement when self-contained luminaries are installed, as a failure of the supply will only cause them to operate. Precautions to be taken at the source of supply for an emergency lighting system are that cables between the source and a battery charger combination should be a fixed installation, which precludes plugs and sockets, while those cables from the battery to a protective device, that is the load circuit cables, must be separated from each other and not enclosed within metal conduit, ducting or trunking. Segregation must also be applied between the dc and any ac cables.

5.14.3 *Fire Alarms and Detection*

The requirements in the previous section regarding mechanical protection, high fire resistance and segregation, etc apply. Where high frequency circuits are installed, adequate screening is applied between the different circuits in order to avoid false alarms.

5.14.4 *Power System*

5.14.4.1 Some of the problems arising in the installation of power cables are high or low ambient temperatures, grouping, thermal insulation, type of protective device employed and voltage drop considerations. Under normal circumstances, correctly chosen protective devices are adequate to deal with disruptions such as overloads, short-circuits and earth-faults on low voltage systems but, on high voltage networks, transients may occur which create high stresses on cable insulation and therefore, it may be advisable to install screened cables which have the effect of grading such stresses between cores or between cores and earth.

5.14.4.2 The handling and installation of all types of cable is an important consideration. Some PVC cables, for instance, should not be installed during temperatures below 0°C as flexing will damage the insulation, while high temperatures will soften the PVC, causing it to strip if pulled into conduit, ducting, etc. Damage may also be caused to cables by drawing them into rough-edged enclosures, for example burred conduits, over stony surfaces or bending them tighter than the recommended radii. Large armoured cables are impressively strong, but even these, when being drawn into ducts, may be damaged if the correct type of grip-sleeve (or sock) and hauling equipment is not used, as too high a torque may stretch the cable cores or strip off the insulation and sheathing.

5.14.4.3 Particularly with the smaller armoured cables, if armouring is to be used as the protective conductor, the impedance must be checked to ensure that it complies with the relevant requirements; otherwise additional conductive material must be incorporated in the protective circuit.

5.14.5 *Control and Instrumentation*

Modern systems for control and instrumentation utilize electronic means (rather than power circuitry) which are more likely to be affected by low voltage systems, and precautions such as segregation and screening must be employed. Cables are available to suit all types of system but, as requirements vary between manufacturers of electronic equipment, advice should be sought at an early stage. The increasing use of multiplex systems and fibre-optics cables simplify installation work by reducing the number of cores required for the most complex systems and, in the case of the latter, eliminate completely the possibility of interference from other circuits.

5.14.6 *Hazardous Areas*

Danger in a hazardous area arises initially from the type of materials being processed rather than from the electrical installation, but a great degree of responsibility rests upon the designer to ensure that the installation does not contribute to the hazard by the introduction of flammable materials, high surface temperatures, arcs or sparks to the atmosphere. For these reasons, every care must be taken to avoid the overloading of cables or the inclusion of sheathing materials which easily burn and give off toxic gases.

See IS 5572 for classification of hazardous areas and IS 5571 for selection of equipment in hazardous areas. Different degrees of hazard exist and, consequently, these affect the type of electrical installation, particularly with regard to equipment. It is essential, therefore, to ascertain which zone is applicable before commencing the electrical design, this information generally being available from the process plant user. *See also* Part 7 of the Code.

6 WIRING SYSTEMS

6.0 General

6.0.1 The following systems are usually adopted for house wiring:

a) Cleat wiring;
b) Casing and capping wiring;
c) Metal sheathed wiring (for example lead-covered wiring);
d) Cab tyre sheathed (C.T.S.) or tough rubber sheathed (T.R.S.) wiring;
e) PVC sheathed wiring;
f) All insulated wiring — surface wiring and concealed wiring;
g) Enclosed wiring system — conduit wiring and cable trunking; and
h) Conduit wiring — steel, plastic and flexible.

A particular type of wiring is selected for a particular place on the basis of type of work, place and expenses involved. Insulated wires are used in all systems of wiring. These systems have been named according to either constructional details of wires or modes of fixing these wires on the wall. The voltage grade of wires depends on supply voltage of the circuit, that is, the voltage grade of wires must not be less than the highest root mean square or effective value of supply voltage. In case of house wiring where working voltage normally does not exceed 250 V, wires of 250 V grade can be used.

6.0.2 *Size of Wires*

The wire used should have such cross-sectional area that when the maximum current drawn by the circuit flows continuously through it, the voltage drop between main distribution board and the farthest point of the lighting circuit does not exceed 3 percent of the supply voltage (in a 230 V circuit this drop is $3/100 \times 230 = 6.9 \approx 7.0$ V). At the same time it should be ensured that the wire is not excessively heated when the maximum current flows continuously through it. Normally, the wire is not excessively heated when the amount of voltage drop remains within the limited value.

If the size of a wire in a circuit has to be increased with a view to reduce the drop of voltage, it may be noted that the wire will carry as much current as has been determined for the circuit to carry. Further, the size of a wire specified for a circuit must be suitable for continuous flow of current which is not less than the current-carrying capacity of the fuse of that circuit. Recommended current ratings for cables are as per IS 3961.

6.0.3 *Protection of Wiring from Damage*

V.I.R.(vulcanized rubber) wire, plastic-insulated wire with or without braided cotton cover, C.T.S. (or T.R.S.) wire normally need not be further covered with separate covering. But situations and circumstances have to be taken into account, and if necessary, the outermost insulation has to be protected from probable damage.

Where there is probability of conduit, duct, casing, etc, becoming hurtful, adequate arrangements have to be made to protect them. Where metal-sheathed wire or armoured cable is installed inside concrete or plaster, there is usually no need for further protection. However, depending upon site condition, sometimes additional arrangements may have to be made.

Wires used for lift, hoist (an electrically operated machine used for lifting goods), etc, must be metal-sheathed [*see also* IS 4289 (Part 1) and IS 4289 (Part 2]. Where the wiring will pass under the floor, the wire should be so installed that it will not be damaged as a result of coming in contact with the floor or some fitting.

Where a cable will enter the iron part of a house or the shed of a factory, every such entry should be provided with a bush in such a manner that the cable will not suffer abrasion from rubbing.

Where the sheath of a C.T.S. cable made of rubber or some compound mixed with rubber will be exposed to direct sunlight, arrangements must be made to cover it with some special covering. If the sunlight comes through glass panes of windows, it is not a direct sunlight. Wiring should be done in as dry a place as possible.

6.0.4 *Permissible Temperature Rise of Ordinary Insulated Wires and Flexible Cables*

Ordinary insulated cables and flexible cables, which are not specially manufactured for withstanding excessive heat, should not be used in places where the temperature may exceed the limit given in Table 5.

In cases where the temperature of lamp fittings and other accessories are excessively high, cables and flexible cords which are not specially made to withstand such high temperatures should not be brought near these fittings and accessories. Where there is probability of temperature exceeding 60°C, high temperature resisting cables like flexible cord, specially covered with conditioned asbestos, must be used. Further, they should be so connected that their temperatures do not exceed 85°C. If however, the flexible cord is connected with a portable heater with which there is not possibility of excessive rise of temperature, a temperature rise up to 66°C may be allowed, provided that the insulation of wires should remain covered with beads or insulating sleeves suitable for high temperature, and there is no dependence on rubber insulation of cable for the prevention of earth fault of cable conductors or short-circuit among them. These arrangements are to be specially provided for lamps rated 200 W or more and for immersion heater.

Where a cable with rubber, PVC or polythene insulation or a flexible cord remains connected with bare conductor or a busbar, the insulation of the cable or cord should be peeled off and wires should remain bare for a length of about 15 cm from the point of connection even when the temperature of the bare conductor or the bus bar is 90°C. But in places where this cannot be done, the current flowing through the bare conductor or the busbar should be so reduced as not to allow a rise of temperature above 90°C.

6.1 Cleated Wiring System

6.1.0 Cleat wiring is one of the most economical methods of wiring. The wires remain exposed to view, and these wires are drawn through cleats made of porcelain or plastic or some other approved material. Cleat wiring is most suitable for temporary wiring. The wiring can be completed quickly and the wiring materials can be recovered easily while dismantling.

Table 5 Permissible Maximum Temperature of Surrounding Space for Ordinary Insulated Cables

(*Clause* 6.0.4)

Sl No.	Types of Insulation		Maximum Temperature of Surrounding Space or Space Inside Conduit Pipes (°C)
	Cable	Flexible Cable	
(1)	(2)	(3)	(4)
i)	Rubber	Rubber	45
ii)	PVC	PVC	45
iii)	Polythene	—	45
iv)	Oil-soaked Paper	—	75
v)	Cloth impregnated with varnish	—	75
vi)	—	Rubber or cloth mixed with conditioned asbestos	80

Moreover, additions and alterations as well as inspection of wiring system can be easily made. Cleat wiring is not recommended for damp places and also for permanent wiring. After a certain period of installation the wires sag at some places, dust and dirt collect over them and the whole of the wiring system may look shabby.

6.1.1 The wires used are either vulcanized rubber insulated cables, single-core PVC or polyethylene cables, which can be used without further protection. Conductors should be visible all throughout a cleat wiring.

6.1.2 The cleats are made in two parts, called base and cap. The base is grooved to receive the wire and the cap is placed over it, and the whole of it is placed on a wooden plug which is fixed into the wall. The cleats are tightened up on wooden plugs by means of wooden screws which also tighten the grip of the wires between two halves of the cleat. The cleats are usually of two types having two or three grooves so as to receive two or three wires. These cleats are shown in Fig. 8.

6.1.3 *Installation of Cleats*

a) Wooden plugs are to be properly cemented in the wall or ceiling, and the distance between two adjacent plugs should be such that the cleats are not more than 60 cm apart horizontally or vertically.

b) Cleats shall be of such dimensions that for low voltage installation the distance between two wires shall not be less than 2.5 cm centre to centre for branch lines and 4 cm for sub-main lines.

c) In no case two wires shall be placed in the same groove of the cleats. Also the wires shall be laid stretched between the cleats so that they do not touch the wall.

d) Joint cut-outs or fuse cut-outs shall not be used in this type of wiring. Where joints become unavoidable, wooden junction boxes with porcelain connectors inside should be used.

e) Wiring should be enclosed in a conduit when passing through a wall or a floor. The wires should run through a conduit upto a height of 1.5 m level. In case of a metallic conduit, it should be properly earthed. Wooden bushings are to be provided at both ends of the conduit, otherwise insulation of the wires may be spoiled when drawn through it.

f) When two wires cross each other, they should be separated by an insulating bridge piece which should maintain a distance of atleast 1.3 cm between the wires.

g) The wires should not run near water or gas pipes or structural work.

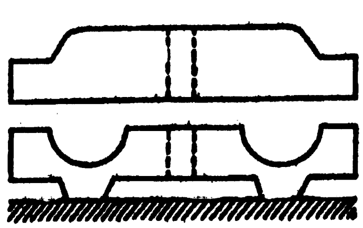
h) A special pattern of cleat may be used where conductors pass round corners, so that there may be no risk of the conductors touching the walls owing to sagging or stretching.

j) Cleats shall be fixed at distances not greater than 60 cm apart and at regular intervals.

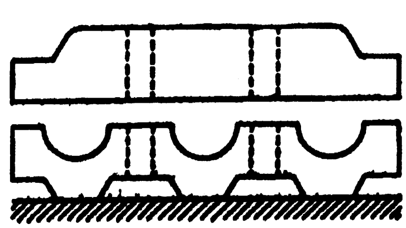
6.1.4 In temporary installations wiring is often done over bobbin or knob insulators in place of cleats. Whenever the wires pass through a floor or through a space where some damage is apprehended, they should be provided with an additional protection of a special strong covering upto a height of 1.5 m above the floor level. For this purpose, while the wiring passes through a wall or a partition, it should be taken inside a tube or a pipe or a conduit made of non-inflammable and non-hygroscopic material. Porcelain wall-pipe, lead wall-tube, iron conduit, etc, are the examples of this type of covering. Various components of cleat wiring are described below.

6.1.5 *Installation of Cleat Wiring*

6.1.5.1 Cleat wiring is installed along the wall below the beam. If there are wooden beams in a house, cleats may be directly fixed on the beam for drawing wires up to ceiling roses. But if there is an iron beam, then space permitting, a piece of wood may be tightly fitted on one side of the beam and cleat is fitted on this piece of wood. This is shown in Fig. 9. If space is not sufficient for fixing a piece of wood on the side of the



(i) Cleat with two grooves



(ii) Cleat with three grooves

FIG. 8 TYPES OF CLEAT

iron beam, at first pieces of wood are clamped at intervals to the bottom of the beam and then the cleats are fixed on these wood pieces. This is shown in Fig. 10. The spacing between two consecutive pieces of wood should be such that the wiring must not sag due to its own weight. If wiring is to be taken from one room into the next, a hole is drilled into the common wall and wiring is taken through porcelain or metal tube (wall-tube) set into the hole.

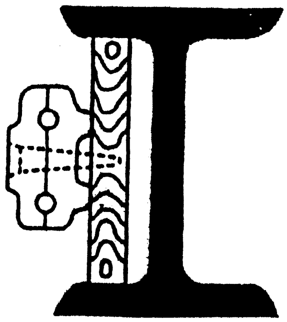


FIG. 9 CLEAT IS FIXED ON AN WOOD PIECE WHICH IS TIGHTLY ATTACHED ON ONE SIDE OF AN IRON BEAM

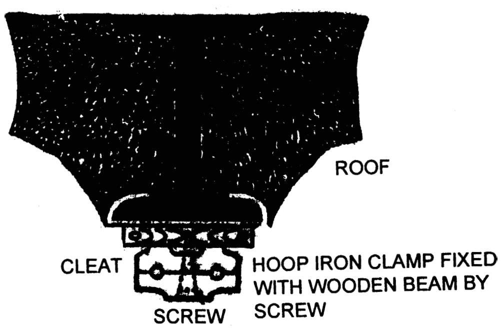


FIG. 10 ARRANGEMENT FOR DRAWING WIRES UNDER IRON BEAM

If the wires are to be drawn under the iron beam from one cleat to the next, arrangements are provided as shown in Fig. 11B using hoop iron or flat iron clamp. For heavy wiring or for lasting and durable job, two wrought iron clamps are used as shown in Fig. 11A.

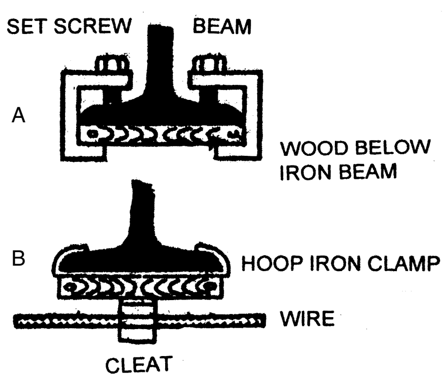


FIG. 11 USE OF CLAMPS

6.1.5.2 *Spacing between wires in cleat wiring*

The spacing between wires drawn through the cleats depends upon the line voltage, and the type of circuit as given at Table 6. An example of cleat wiring system is given at Fig. 12.

Table 6 Spacing of Wires in Cleat Wiring
(*Clause* 6.1.5.2)

Sl No.	Voltage	Type of Circuit	Centre to Centre Distance Between Two Adjacent Wires
(1)	(2)	(3)	(4)
i)	Not exceeding 250 V	Branch	Not less than 2.5 cm
		Sub-main	Not less than 4 cm
		Main	Not less than 7.0 cm
ii)	Exceeding 250 V	—	10.0 cm distance; 2.5 cm spacing all around

6.1.5.3 *Drawing a wire through wall*

Wall tube or pipe is usually set near the ceiling corner (*see* Fig. 13). The space within the pipe should be sufficient to accommodate with comfortable inter-space the maximum number of wires to be drawn through it. With too many number of wires more than one tube may be necessary. In that case pipes are set together at one place side by side. Such a tube may be made of porcelain or metal. Among metals lead, iron or steel is used. The pipe is set inside the wall by means of cement. If conduit is used, its two rough ends are properly filed and two bushes made of hard wood or ebonite are fitted at these ends. This eliminates the possibility of damage of the insulation of wires when drawn through the pipes. In case of ac wiring all the wires must be drawn through the same metal conduit. Where wires are drawn outside from a room, the outer end of the pipe should be a bit more widened. Also this end should have a downward bend so that rain water or water from other sources may not get inside the pipe along the wires.

6.1.5.4 *Drawing of wires through floors*

If the wires are to be drawn through a hole made in the floor, these must be drawn through a conduit pipe upto a height of 1.5 m above the floor level, and the lower end of the conduit should be flush with the ceiling below. As usual two ends of the conduit must be fitted with insulating bushes.

6.2 Casing Wiring

In this system of wiring narrow grooved planks of hard wood are fixed on wooden plugs grouted in the wall instead of cleats and wires drawn along the grooves. These narrow planks are called wood casing. Usually two long grooves are made in each casing, although three-grooved casing is also available. The top of the

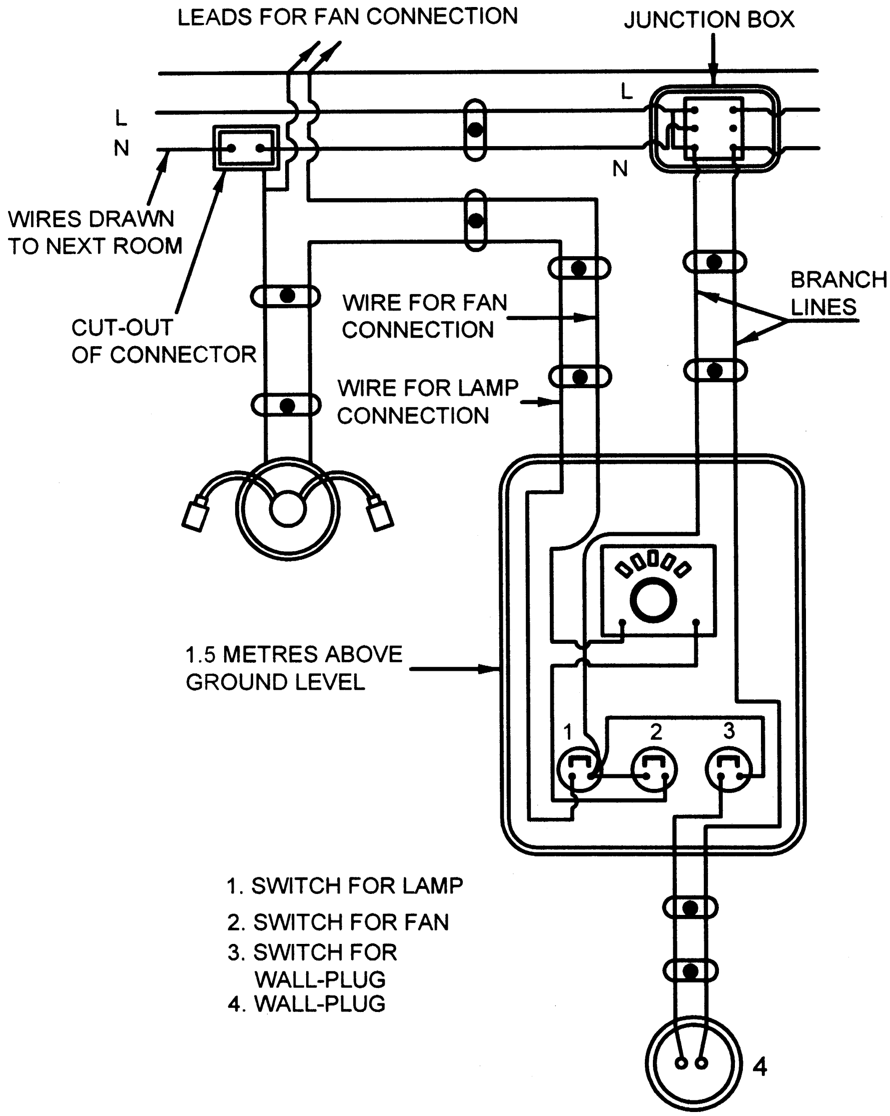


FIG. 12 AN EXAMPLE OF CLEAT WIRING SYSTEM

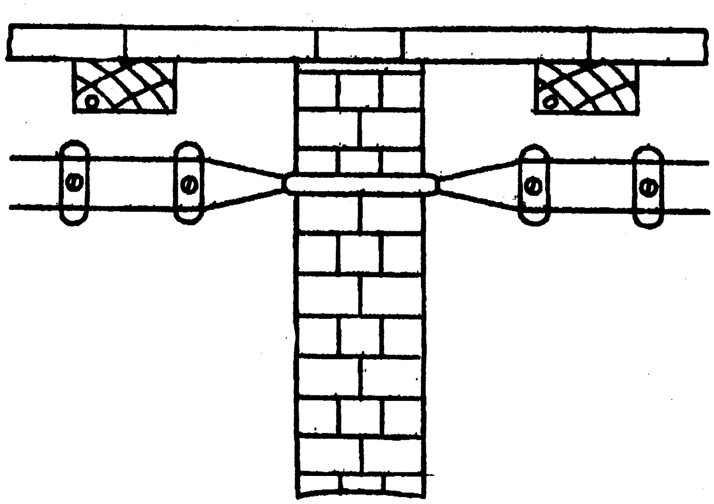


FIG. 13 USE OF WALL-TUBE FOR DRAWING WIRES FROM ONE ROOM INTO THE OTHER THROUGH PARTITION WALL

casing is covered by a rectangular strip of wood of the same width as that of casing. It is known as capping which remains screwed to the casing (*see* Fig. 14). On the surface of the capping a bouble bed is cut to show the position of wires so that the screws may not be driven through wrong position damaging the insulation of the cables laid under the capping. Casing wiring is generally adopted for low voltage installations such as office and residential buildings. This type of wiring is not suitable for places exposed to rain or sun or having dampness. It should not also be used in places where acids and alkalies are likely to be present.

6.2.1 The wood used for casing and capping must be first class seasoned teak wood or any other hard wood free from knots, shakes and saps. The sides should be well varnished both inside and outside with pure shellac varnish. The size of casing and capping depends upon the number of wires drawn through the grooves in a particular length of run.

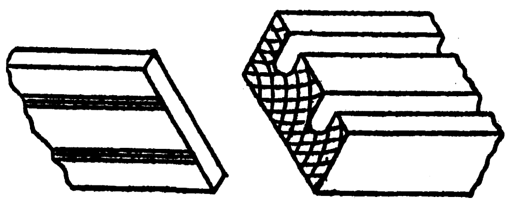


FIG.14 WOODEN CAPPING AND CASING

6.2.2 The size of wood casing and capping and number of cables that may be drawn in one groove of the casing is given in Table 2 of Part 1/Section 20 of this Code.

6.2.3 *Installation of Casing Wiring*

Casing generally used for installation is about 44 mm wide and 16 mm in thickness (height). However, for cables of higher sizes, 80-100 mm wide and proportionally higher in thickness casings are also in use. Casings may be 5.5 m to 6.0 m long, but smaller lengths are also available. Lengths of about 2.5 m to 3.0 m are convenient for handling. Very good workmanship is required to make the job perfect, and this results in costlier installation. There is also risk of fire from wood.

There are two grooves in each casing. The width of the strip of wood separating the two grooves should be carefully observed so that it is not less than 13 mm, and the portion of wood below each groove shall not be less than 7 mm in thickness. In case the cable has a large cross-section or a number of cables are to be drawn, the size of casing should increase accordingly. At the time of wiring the cables laid in the grooves are covered by a very thin and long strip of wood which is as wide as the casing. This is known as capping. The thickness of capping should be about 7 mm. The following precautions need to be taken:

a) Any number of wires of the same polarity may be laid in the same groove, but in no case wires of opposite polarities are laid in one groove.
b) Casing should be fixed on dry wall and ceiling. Casing shall not be embedded into cement or plaster. It shall neither be so set as to get contact with a water pipe, nor it shall be laid just below a water pipe. It shall not also be used in a place where moisture accumulates and drips.
c) A clear space of 3 mm shall be kept between wall or ceiling and the casing. This could be by means of porcelain insulators (spacing insulator) or cleats (either upper half or lower half).
d) Wooden plugs of approved sizes shall be fixed at a distance of 90 cm apart for casing of sizes upto 63.5 mm. For higher sizes of casing this distance shall not exceed 60 cm.
e) While passing through floors or walls, heavy gauge conduit of approved sizes shall be used. The conduit should be securely entered into casing, and it should be extended upto a height of 1.5 m above floor level.
f) All joints shall be made with good workmanship as per IS 732.
g) After the wires are laid in the grooves, the capping is attached to casing by brass screws in a proper way. The screws must not be so fixed as to pierce through the insulation of the wires.
h) Capping should be fixed on the casing only by screws. The screw used for fixing the casing must be long enough to pass through the casing, capping, central hole in the bobbin insulator or spacing insulator and the wooden plug in the wall. The capping is fixed on the casing by means of small screws. If the width of the casing is less than 50 mm, a series of screws are fixed on the central line of the capping, and in case the width is more, two rows (or columns) of screws are fixed on two sides of the capping. For this reason the width of the strips of wood on both sides of the casing shall not be less than 10 mm. Screws used for fixing the capping may be made of brass.
j) Provision must be there for easy insertion of cables into the casing. Before fixing the casing, it is necessary to smear its sides and back properly with two coats of shellac varnish. Further protection is provided by painting or varnishing the casing wiring once again on all sides after the wiring is finished.

k) Spacing insulators may be used at a place where the casing is passing below an iron beam. Preferred sizes of casings is given in Part 1/Section 20.

6.2.4 *Joints in Casing Wiring*

In casing wiring work starts from the farthest point of the load circuit, gradually proceeds towards the main board and finally ends there.

a) *Joint while fixing lamp* — The ceiling rose of the lamp bracket is set on a round wooden block. This block should have a thickness (height) of 4 cm with two coats of varnish applied on it. It has a saw-cut on one side in such a manner that the tip of the casing closely fits on to it (*see* Fig. 15).

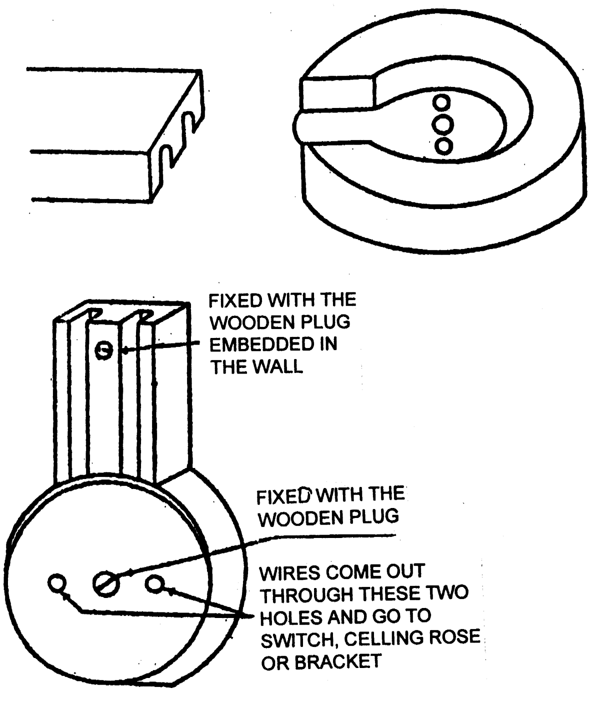
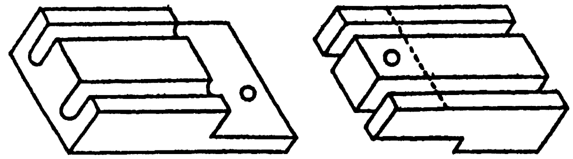


FIG. 15 JOINT FOR FIXING LAMP



16A Joint of Casing

16B Joint of a Caping with Another Caping Out in Oblique

FIG. 16 JOINTS FOR CASING/CAPPING

b) *Joints for casing/capping* — When two pieces of casing or of capping are to be joined together, the joint should be completed as shown in Fig. 16A (Lap Joint). The joint of capping shall be an oblique one (*see* Fig. 16B). Care must be taken to see that cappings are not joined together at a point where there is already a joint of casing, and also no screw for fixing the capping pierces any side wall of the casing.

1. *Joint at the corner* — The kind of joint necessary at the corner round is shown in Fig. 17. The two tips of casings that are to be joined together are placed on the floor, cut at an angle of 45° and finally screwed to each other. The corners of the grooves should be flush with each other so as to prevent any damage to the insulation of the cables. The general appearance of the joint where the casing is taken from one wall to another is at Fig. 18 or somewhat similar. The shape of such a joint should be such that the radius of curvature of the joint should not be less than 75 mm so that the insulation of cables is not damaged due to twist etc. For a corner joints, the piece of casing can be abtained as shown in Fig. 19.

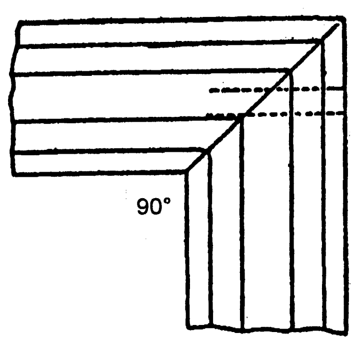


FIG. 17 JOINT AT A CORNER

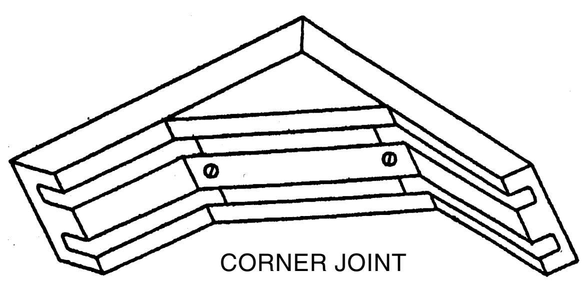


FIG. 18 SHAPE OF JOINT AT A CORNER

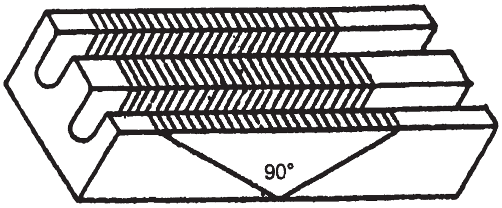


FIG. 19 HOW A SMALL PIECE OF CASING IS OBTAINED FOR A CORNER JOINT

2) *Bending on cables* — To bend a VIR or PVC cable, the internal radius of bend shall be atleast four times the diameter of the cable. Where the casing will go from one wall to another on the external side, the joint should be as per Fig. 20.

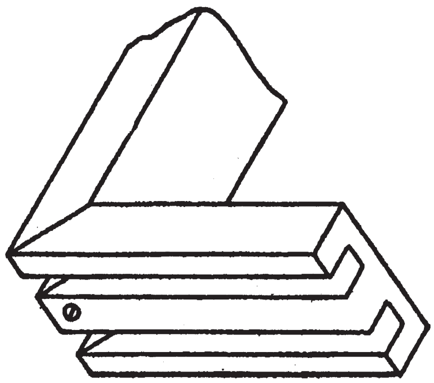


FIG. 20 JOINT OF CASING ON THE EXTERNAL SIDES OF WALLS

3) *T-Joint* — From a point in the continuous run of the casing, sometimes connection is to be taken out for lamp point, fan point, etc, through a joint of the casing, known as T-Joint. Where such a joint is to be adopted, a V-shaped piece of casing is to be cut off upto the middle of the casing used in the continuous run.

Later, the tip of another casing to be joined to it is cut off in the shape of V and is made flush with the V-groove of the former casing as shown in Fig. 21.

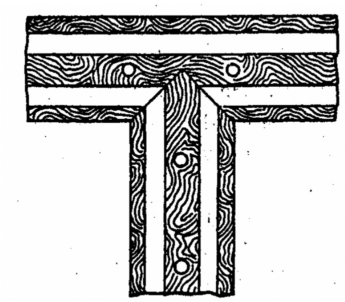


FIG. 21 T-JOINT

4) *Bridge* — When it is required to draw one circuit over another, a small piece of casing, named 'bridge', is used so that the cable of one circuit does not come in touch with that of another. At first the bridge is fixed on the casing and then the second cable is drawn over it. Where a T-joint is necessary, a one-half bridge is fixed there along with a full bridge. This additional one-half portion is known as 'half-bridge'. A bridge is also used where cable of one circuit crosses that of another circuit. Figure 22 depicts 'half bridge' and 'bridge'. The joint of casings at this point is called 'cross joint'. T-joint and cross-joint of casings are shown in Fig. 23 and Fig. 24 respectively.

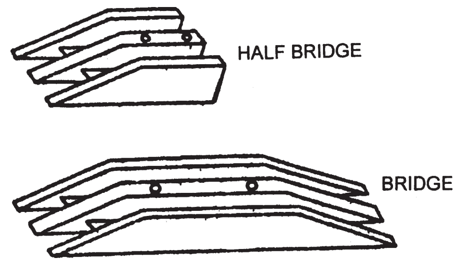


FIG. 22 HALF BRIDGE AND BRIDGE

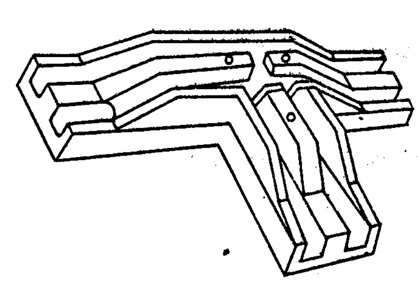


FIG. 23 T-JOINT OF CASING WITH BRIDGES

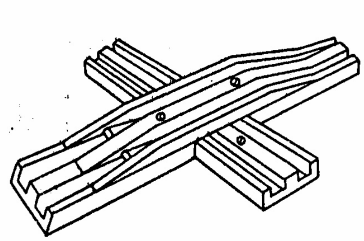


FIG. 24 CROSS-JOINT OF CASINGS WITH BRIDGE

6.2.5 *Installation of Wiring*

a) *Leading a cable from one room to another* — When leading from one room to another, a cable may be drawn either through a casing or through a wall-tube. If casing is used, the hole in the wall must be large enough to leave a clearance of at least 25 mm all around the casing. The purpose of this clearance is to keep the casing dry through ventilation of air. If a wall-tube is to be used, the two ends of the tube project a little from the wall. The partition wall between the grooves at the end of casing remaining in contact with the wall-tube must be cut off to the same extent as the amount of projection of the tube from the wall (*see* Fig. 25). This will keep the wall-tube properly fitted with the casing. But in case the diameter of the tube is larger than the height of the casing or where more than one wall-tubes are used, it will not be possible to fix the capping over the casing. In such cases, the height of the casing is increased with the help of a half bridge.

For continuous earthing system a single galvanized iron wire is drawn continuously outside the casing along with the cables and finally earthed. This is called 'Earth continuity conductor'. The outer metallic covers of fan regulator iron-clad distribution box, earth terminal of the wall socket etc, remain connected with this wire. Usually a separate wall-tube is used for leading earth continuity conductor through the wall. For this work a half bridge on the casing near the wall is indispensable.

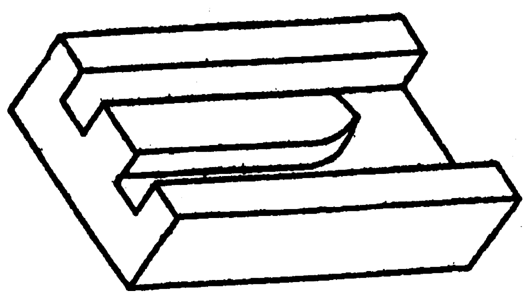


FIG. 25 CUTTING OFF A PORTION OF CASING IN ORDER TO FIT IT WITH A WALL-TUBE

There should be three sockets instead of two in every wall socket and three pins instead of two with every wall plug. Also the flexible cables used in this system must have three lengths of insulated wires instead of two.

b) *Leading a cable through the floor* — In the casing wiring if cables are to be drawn from a lower floor to a upper floor, a piece of conduit is pushed through a hole made in the floor. The sizes of wires of all the circuits to be drawn from lower to upper floor are calculated at first, and then the size and number of conduits are determined accordingly. If continuous earthing system is adopted, another extra conduit is to be provided for drawing earth continuity conductor. At the ceiling of the lower floor all conduits must project atleast 25 mm. At both ends of a conduit insulating bushes are to be fitted. In the upper floor conduit will rise up to a height of 1.5 m above the floor level. At this end of the conduit one end of a casing should remain properly fitted. For proper fitting the lower end of the casing is cut to size as shown in Fig. 26. If necessary, the spacing of the casing from the wall may be increased by using a half bridge. Besides, every piece of conduit should remain well-earthed.

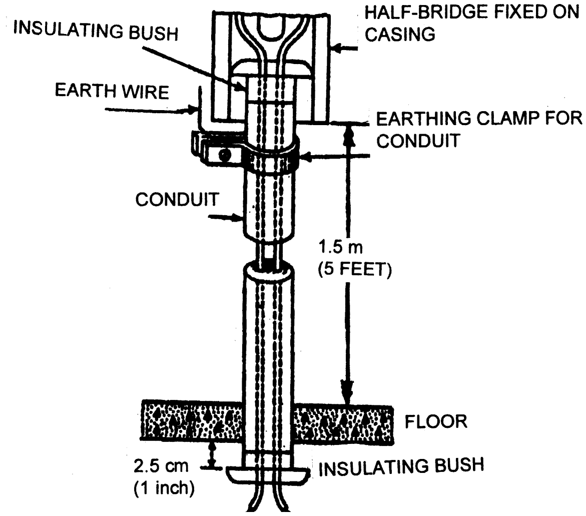


FIG. 26 LEADING OF CABLE THROUGH THE FLOOR

c) *Utility of looping-in-system* — Like cleat wiring, casing wiring can also be done by means of connectors inside junction boxes as well as by looping-in-system. Loop wiring has many advantages. No joint is necessary and the insulation resistance is better retained by this system than any other system of wiring. The reason for no joint is that, one piece of cable is joined with another piece only through brass screws of switches and ceiling roses. What is meant by jointing of cables does not at all happen in this system. Its main disadvantage, however, is that the length of cable required for wiring is somewhat more.

6.3 Metal-sheathed Wiring

6.3.1 The wiring system completed with wires having metallic (for example lead) covering over rubber insulation is known as 'metal-sheathed' or 'lead-covered' wiring. Here the conductors are rubber insulated and covered with an outer sheath of lead alloy containing about 95 percent lead which provides protection against mechanical injury. Lead sheath should be properly earthed.

6.3.2 The cables may remain exposed to sun or rain, but it should not be used where acids and alkalies are likely to be present. The cables are laid on wooden battens and remain fixed on it by means of brass or aluminium link clips spaced at intervals not exceeding 10 cm horizontally and 15 cm vertically. The thickness of the batten should not be less than 10 mm.

6.3.3 *Installation of Metal Sheath*

a) Sharp bends should be avoided. A round bend of radius not less than 10 cm may be adopted for a change of direction.
b) Supporting clips used for the cables must not set up any chemical reaction with the metal sheath.
c) Lead sheath must be electrically continuous and properly earthed. For maintaining electrical continuity, bonding of sheaths is necessary at joint-boxes and switch boards.
d) When passing through a floor or crossing a wall, the cable must be drawn through conduits. Conduits should go up to a height of 1.5 m above the floor level. Both ends of the conduit should be fitted with ebonite, plastic or hard rubber bushings in order to protect metal sheath and rubber insulation of cables from being damaged.

6.3.4 *Joints for Metal Sheathed Wiring*

a) *Connectors* — Some special types of connector are used for jointing wires or for a T-joint to lead a cable to switch board etc. These types of connector are more or less the same for almost all types of wiring. As per requirement two, three or four holes are provided in small pieces of porcelain or plastic, and inside those holes there are connectors in the form of brass tubes. At the two ends of the connector there are brass screws for fixing the wires. The porcelain or plastic portion acts as insulators. When only one piece of wire is to be joined with another piece, the smallest size connector with a single piece of brass tube is used. For jointing twin-wire (2-core) from a single cable, a connector with two pieces of brass tubes is needed. In place of junction cut-outs connector is used even in cleat and casing wirings. There are holes on the top of all connectors with screws to connect wires with the connector (the left hand one shows single-joint connector).

   Sometimes the outer cover of a connector is made of PVC or bakelite in place of porcelain. But as an insulator the use of porcelain is better than PVC or bakelite.
b) *Thimbles* — Thimble is made of porcelain or plastic and looks like a cap as shown in Fig. 27. A thimble is threaded inside and it becomes pointed towards the upper end. Where two or more wires are to be connected together, about 6.4 mm of end insulation of each wire is taken off and all the ends are then twisted together. The combination is then put inside a thimble which is turned like a screw driver. As a result the thimble pulls the combination of twisted ends in by means of threads and thus holds it tightly.

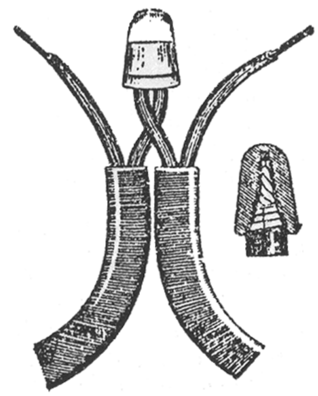


FIG. 27 WIRES CONNECTED WITH THIMBLE

c) *T-Joint* — Where T-connection is taken for a point, connectors used there and the mode of connection are shown in Fig. 28. A small box, called 'joint-box', is used to cover the joint. The box may be made of metal or wood. The box shall prevent access of insects, dust or lime-water (during white washing). The advantage of a metal box is that the speciality of a lead-sheathed wiring to maintain electrical continuity of metal sheath of the cables everywhere beginning from the main board upto the farthest point of the load circuit is automatically retained in it, whereas in case of a wooden box it is not so. If a wooden box is to be used, an additional bonding clamp must be provided in the box and the lead sheaths of all the cables taken in for connection shall remain fixed with this clamp so that electrical continuity is established among them. If metal sheath of the cable is to be used as an earth continuity conductor, then in case of non-metal box, a strip of metal is to be used for maintaining continuity of metal sheath, and the resistance of such metal strip shall be negligible in comparison to that of the largest size of cable coming into the box (*see* Fig. 29). Joint-box must not be installed in a damp place due to possibility of leakage of current in the joint-box installed in a damp place. Arrangement for maintaining continuity between wires near a ceiling rose is shown in Fig. 30. In this way, maintaining continuity and electrical connections among lead sheaths, finally the sheath is connected to earth at the main distribution board. If this is not done, the insulation of the cable gets damaged in a very short time in metal-sheathed wiring. If two or more lead-covered wires are laid side by side and one wire has leakage and its sheath is not well-bonded, there will be sparking between them, causing damage to the cable. In metal-sheathed wiring, electrical continuity of sheath must be maintained, and this sheath must not only be well-earthed, but the earth connection must also be well-maintained.

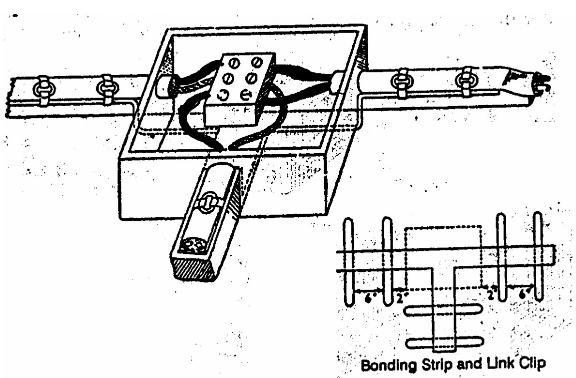


FIG. 28 HOW WIRES ARE DRAWN AND HOW THESE ARE CONNECTED IN A T-JOINT

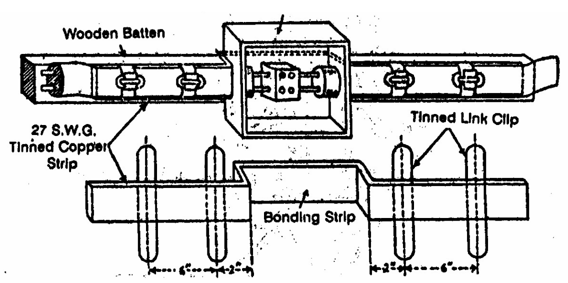


FIG. 29 USE OF BONDING METAL STRIP IN A WOODEN JOINT-BOX

d) *Lead-sheathed cables with earth wire* — Continuous earthing system ensures safety of circuits. According to this system metallic covers of table fan, electric iron, electric heater, table lamp etc, are to be earthed. In case of cleat or casing wiring a single G.I. wire is to be drawn as the earth wire along with the wiring throughout the house. Use of cables having a single earth wire provided along with insulated copper wire or wires within the same lead sheath can be made. While jointing two or more wires, a separate connector should also joint all related earth wires. If the outer cover and inner lever is made of metal, the switch should also be earthed as per rule. In such cases lead-sheathed cables with earth wire inside is used. Connection of earth wire of a circuit with earth in the distribution board is shown in Fig. 31. Descriptions of different methods and systems of wiring (for example cleat or casing wiring) are also applicable to metal-sheathed system. Looping-in-system of wiring may also be adopted with lead-sheathed cables where necessary.

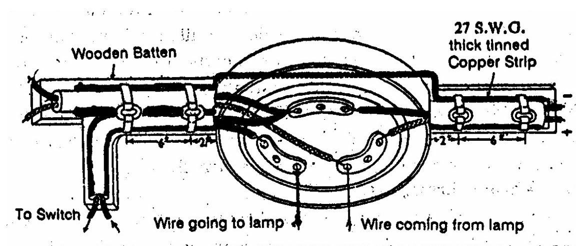


FIG. 30 MAINTENANCE OF CONTINUITY OF WIRES NEAR A CEILING ROSE

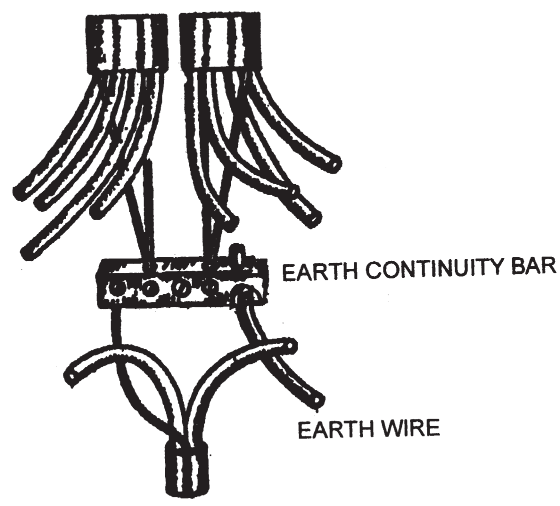


FIG. 31 EARTH CONTINUITY BAR AND ARRANGEMENT FOR CONNECTION OF EARTH WIRES OF DIFFERENT CIRCUITS

6.3.5 *Installation of Wiring*

a) *Drawing of Cables through the Floor* — The lead-sheathed cable should be drawn through a heavy gauze conduit pipe when the cable is drawn from lower floor to upper floor. The conduit length shall remain extended upto a height of 1.5 m above the floor level in the upper floor, while the lower end of the conduit shall remain flush with the ceiling of the lower floor. Both ends of the conduit should be fitted with bushes made of wood or ebonite or some other insulating material.

b) *Drawing of cables through partition wall between two adjacent rooms* — Like other systems of wiring metal-sheathed cable should also be drawn through porcelain wall-tube or steel conduit or hard PVC conduit as straight as possible.

c) *Concealed wiring through the wall* — Lead-sheathed cable cannot be laid direct under plaster. For concealed wiring it should be either drawn through conduit pipe or by some other means after which the whole thing is covered with plaster.

6.4 Cab-Tyre Sheathed (C.T.S.) or Tough Rubber-Sheathed (T.R.S.) Wiring

6.4.0 This type of wiring is adopted only for low voltage circuits. C.T.S. wiring is used in open space in place of drawing bare conductors. This system of wiring is very useful in workshops or places where fumes are generated continuously from acids etc, which may damage the insulation of ordinary cables or wear out conduits etc, or corrode the lead sheath of cables. No other insulation is applied on the conductor except hard rubber sheath, and in the wiring system cable may not be drawn through conduit, casing etc. The advantages of this system is that wiring can be done very easily and quickly. As a result wiring is economical on the whole, although the cable may cost more. C.T.S. wiring can be used with a variety of fittings and also in case of concealed wiring. The T.R.S. (C.T.S.) system has however, now become almost obsolete; as it has been replaced by the PVC insulated and sheathed system.

6.4.1 *Installation of C.T.S. Wiring*

When the sheath of C.T.S. cable made of rubber or some other compound mixed with rubber remains exposed to direct sunlight, arrangement must be provided to cover it up properly. It should, however, be noted that when sunlight comes through the glass of a window, it is not regarded as direct sunlight. Where weather proof or lead-sheathed cable is to be drawn with the help of catenary wire, either the cable should be taken by binding it continuously with the catenary wire or it should remain fixed with catenary wire by means of link clips at intervals of about 15 cm. C.T.S. cable is drawn over the wall in the same way as lead-sheathed cable. At first wooden plugs are grouted or cemented in the wall at intervals of about 75 cm and polished thin batten of teak wood as wide as or a little wider than the cable is screwed to these plugs. Tinned brass or aluminium link clips are then fixed on this batten with the help of iron pins at intervals not exceeding 10 cm horizontally and 15 cm vertically. For the sake of convenience of work, sometimes clips are fixed on the batten at equal intervals in a straight line first and then the batten is screwed to the wooden plugs. Finally the cable is laid neatly on the clips which are then folded. In some cases a batten with clipped cable is screwed to the wooden plugs. A single clip may be used to fix upto two twin-core, 0.019 4 cm^2 cables. If the cross-section of the cable is greater than this, a single clip may hold only one cable. Where there are fumes from acids etc, clips are made of lead strips cut out from then lead sheets and iron pins are already painted with acid-proof paint. This prevents the iron pins being rusted when in contact with acid fumes. For a neat and clean look of C.T.S. wiring or for saving it from mechanical injury, the wiring may be covered by wooden channeling or any other suitable cover. Also C.T.S. cables may be drawn through conduit pipes, if necessary. During installation of C.T.S. wiring the following points are to be kept in mind:

a) C.T.S. cables should be laid on well seasoned, well varnished and perfectly straight hard wood of thickness 10 mm and width sufficient enough to carry the required number of cables.

b) Wooden batten should remain fixed to rawl or phil plugs grouted in the wall or ceiling by means of wood screws at an interval not exceeding 75 cm.

c) C.T.S. cables shall never be turned at right angles. Wherever there is a bend, the radius of curvature shall not be less than six times the outer diameter of the cable. While passing through wall or floor, cable must be drawn through conduit pipes. Metal conduit should be properly earthed.

d) C.T.S. cables shall never be buried under plaster. These should be drawn through conduit or wooden channeling.

e) While taking through a floor, the cable shall be drawn through a heavy conduit. The two ends of the conduit should be fitted with bushes made of wood or rubber or any other suitable insulating material. The bottom of the conduit should be flush with the ceiling of the lower floor, while its top must rise upto a height of 1.5 m above the floor level of the upper floor. Porcelain tubes may also be used when the cables are drawn through a wall.

6.5 Polyvinyl Chloride (PVC) Sheathed Wiring

6.5.0 PVC sheathed cable is used extensively in house wiring. This cable is available in single-core, twin-core or three-core, and its cost is comparatively less than that of other wires. PVC cable may be used for wiring in open space in place of bare conductor or C.T.S. cable. The rubber sheath of C.T.S. cable deteriorates quickly in places where there is oil, but PVC insulation is highly suitable in such places. PVC insulation can withstand acid, alkali, ozone and also direct sunlight. Owing to gaps in the sheath it does not dry up, harden and crack like rubber. But at higher temperatures PVC softens because of which it should not be used at places where it is expected to get excessively heated. Also, PVC insulation becomes brittle in very cold atmosphere therefore it should not be used in places where there is ice or snow fall. Wiring systems of PVC wire is similar to that of C.T.S. wiring. However, as the PVC wire is comparatively lighter than C.T.S. wire, link clips are to be fixed on wooden battens at comparatively closer intervals. The distance between two adjacent link clips should be 6 cm horizontally and 7.5 cm vertically. For conduit wiring as well as for concealed wiring, PVC cables are drawn through conduit pipes in place of V.I.R. wires. The first all-insulated wiring system consisted of vulcanized insulated conductors with a tough cables sheath (T.R.S.). When first introduced the system was known as “cab-type” system (C.T.S.). The T.R.S. (C.T.S.) system has now become almost obsolete; as it has been replaced by the PVC insulated and sheathed system. PVC and similar sheathed cables if exposed to direct sunlight shall be of a type resistant to damage by ultraviolet light. PVC cable should not be exposed to contact with oil, creosote and similar hydrocarbons, or should be of a type capable of withstanding such exposure. The cables may be installed without further protection, except where exposed to mechanical damage, in which case they must be suitably protected. The all-insulated wiring system is used extensively for lighting and socket installation in small dwellings, and is one of the most economical methods of wiring for this type of work. *See* IS 14772 for joint boxes and IS 371 for ceiling roses. An alternative method for wiring with PVC sheathed cables for lighting is to use 2-core and circuit protective conductor cables with 3 plate ceiling roses instead of joint boxes. At the positions of joint boxes, switches, sockets and luminaries the sheathing must terminate inside the box or enclosure, or could be partly enclosed by the building structure if constructed of combustible material.

6.5.1 *Installation of PVC Wiring*

a) *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.

b) *Keeping cables away from pipework* — Insulated cables must not be allowed to come into direct contact with gas pipes or non-earthed metal work, and very special care must be exercised to ensure they are kept away from hot water pipes.

c) *Precautions for cables passing through walls, ceiling, etc* — Where the cables pass through walls, floors, ceilings, partitions, etc, the holes shall be made good with incombustible material to prevent the spread of fire. It is advisable to provide a short length of pipe or sleeving suitable bushed at these positions and the space left inside the sleeve should be plugged with incombustible material. Where the cables pass through holes in structural steelwork, the holes must be bushed so as to prevent abrasion of the cable. Where run under wood floors, the cables should be fixed to the side of the joists, and if across joists, should be threaded through holes drilled through the joists in such a position as to avoid floorboard nails and screws. In any case, screwed ‘traps’ should be left over all joint boxes and other positions where access may be necessary.

d) *Fixing cables by suspension on catenary wires* — Cables can be taken across a lofty building, or outside between buildings, if protected against direct sunlight by suspending them on catenary wires. Galvanized steel wires should be strained tight and the cables clipped to the wire with wiring clips. Alternatively, they can be suspended from the wire with ‘rawhide’ hangers; this provides better insulation although not so neat as the former method. The catenary wire must be bonded to earth.

e) Multicore cables have cores of distinctive colours, the red should be connected to phase terminals, the black to neutral or common return and the protective conductor to the earth terminal. Clips are much neater than saddles, but when more than two cables are run together it is generally best to use large saddles. If a number of cables have to be run together on concrete or otherwise where the fixings are difficult to obtain, it is advisable to fix a wood batten and then to clip or saddle the cables to the batten. Cable runs should be planned so as to avoid cables having to cross one another, and additional saddles should be provided where there is change in directions.

PVC sheathed cables should not be used for any systems where the normal voltage exceed 1 000 V.

f) *Wiring to socket outlets* — When PVC cables is used for wiring to socket outlets of other outlets demanding an earth connection, it is usual to provide 2-core and circuit protective conductor cables. These consist of two insulated conductors and one uninsulated conductor, the whole being enclosed in the PVC sheathing. The protective conductor shall comply with IS 3043. When wiring to 16-amps standard domestic sockets, the cable will have to be taken into standard box which is designed for these sockets and which includes an earth terminal.

6.6 All-Insulated Wiring

The first all-insulated wiring system consisted of vulcanized insulated conductors with a tough cables sheath (T.R.S.). The system was initially know as "cab-type" system (C.T.S.). The T.R.S. (C.T.S.) system has now become almost obsolete; as it has been replaced by the PVC insulated and sheathed system. The PVC system has many advantages over the old T.R.S. system because it is not so inflammable, and will stand up better to direct sunlight and chemical action. The cables may be installed without further protection, except where exposed to mechanical damage, when they must be suitably protected. This all-insulated wiring system is used extensively for lighting and socket installation in small dwellings, and is probably the most economical method of wiring for this type of work. It is customary to use 2 and 3-core cables with an integral protective or 4-terminal ceiling roses for making the necessary connections.

An alternative method for wiring with PVC sheathed cables for lighting is to use 2-core and CPC cables with 3 plate ceiling roses instead of joint boxes. Terminations of joints in these cables must be enclosed in non-ignitable material, such as a box complying with IS 14772.

NOTE — An accessory is a device, other than current using equipment associated with such equipment or with the wiring of installation.

At the positions of joint boxes, switches, sockets and luminaries the sheathing must terminate inside the box or enclosure, or could be partly enclosed by the building structure if constructed of combustible material.

6.6.1 *Surface Wiring*

When cables are run on the surface, a box is not necessary at outlet positions providing the outer sheathing is brought into the accessory or luminaries, or into a block or recess lined with incombustible materials, or into a plastic patress. For vertical-run cables which are installed in accessible positions and unlikely to be disturbed, support shall be provided at the top of the cable, and then at intervals of not less than 5 m. For horizontal runs the cables may rest without fixing in positions which are in accessible and are not likely to be disturbed, provided that the surface is dry, reasonably smooth and free from sharp edges. For cables installed in accessible portions the fixing space for cable is 100 to 250 mm for horizontal runs and 150 to 400 mm for vertical runs.

Link clips for electrical wiring shall be used for fixing the cables installed in accessible positions. Link clips shall be so arranged that one single clip shall not hold more than two twin-core T.R.S. or PVC-sheathed cables up to 1.5 mm^2 above which single clips shall hold a single twin-core cable. The clips shall be fixed on varnished wood battens with any rust resisting pins or screws. For the wiring and runs of mains exposed to heat and rain, clip specially made for outdoor use from a durable metal, resistant to weather and atmospheric corrosion shall be used (*see* IS 2412 for link clips).

6.6.2 *Concealed Wiring*

PVC wiring, concealed in ceiling partition, is an effective method of providing a satisfactory installation where appearance is of prime importance as in domestic, display or office situations. Where it is impractical to run concealed wiring at these locations, special precautions are necessary, appropriate protection must be provided. This may take the form of a cable incorporating an earthed metal sheath, or by enclosing the cables in earthed metallic conduit, trunking or ducting. PVC sheathed cables shall not be buried direct in cement or plaster. The disadvantage is that cables once buried in cement or plaster cannot be withdrawn should any defect occur. It is better to provide a plastic conduit to the switch or outlet positions, so that the PVC cables can be drawn into the conduit, and withdrawn should the need arise. Such an arrangement must also comply with the location constraints. Whichever construction is employed, it is necessary to provide a box at all light, switch and socket outlet position. The boxes must be provided with earthing terminals to which the protective conductor in the cable must be connected. If the protective conductor is a bare wire in multicore cable, a green/yellow sheath must be applied where the cable enters the box.

6.7 Enclosed Wiring System

6.7.0 Many of the original installations consisted of single-core cable supported in cleats. With increasing awareness of the possibility of hazard, the necessity for greater protection created the demand for enclosures such as conduit and, later, trunking of which there are many different types now available to suit different situations.

6.7.1 *Conduit Wiring Systems*

6.7.1.0 Wiring done by insulated wires drawn through iron or steel pipes is known as conduit wiring. Conduit systems, when assembled in accordance with the manufacturer's instructions, shall have adequate resistance to external influences according to the classification declared by the manufacturers with a minimum requirement of IP 30. A conduit system which conforms to IS 14930 (Part 1) is deemed safe for use. To ensure safety in electrical installations, use of metallic conduits as earth continuity conductor is not permitted.

NOTES

1 Certain conduit systems may also be suitable for use in hazardous atmosphere. Regard should be taken for the extra requirement necessary for equipment to be installed in such condition.

2 Earthing conductors may or may not be insulated. Earthing conductors may or may not be insulated if laid outside, but invariably be insulated.

See IS 14930 (Part 2) for requirements and tests for conduit systems buried underground, including conduits and conduit fittings for the protection and management of insulated conductors and/or cables in electrical installations in communication systems and IS 9537 (various parts) for conduits. Conduit diameters shall be preferably according to Table 7 and points of support in accordance with Table 8. Classification coding of conduit systems is given at Annex B.

6.7.1.1 *Types of Conduits*

a) *Steel conduit system* — IS 9537 (Part 2) specifies the requirement of rigid steel conduits. The screwed steel conduit system is used extensively for permanent wiring installations, especially for modern commercial and industrial buildings (*see* Fig. 32). Its advantages are that it affords the conductors good mechanical protection, permits easy rewiring when necessary and minimizes fire risks. The disadvantages are that it is expensive compared with other systems, is difficult to install under wood floors in houses and flats, and is liable to corrosion when subjected to acid, alkali and other fumes. Moreover, under certain conditions, moisture due to condensation may form inside the conduit. Solid drawn conduit is much more expensive than welded conduit, due to which its use is generally restricted to gas-tight and explosion-proof installation work. Welded screwed conduit is, therefore, generally used for most installation.

b) *Copper conduit* — At some places, copper conduit is used as it resists corrosion and provides excellent continuity. However, the

Table 7 Outside Diameters — Preferred Values

(*Clause* 6.7.1.0)

Sl No. (1)	Nominal Size (2)	Outside Diameter mm (3)	Tolerance mm (4)	Inside Diameter, *Min* Mm (5)
i)	25	25	+0.5	18
ii)	32	32	+0.6	24
iii)	40	40	+0.8	30
iv)	50	50	+1.0	37
v)	63	63	+1.2	47
vi)	75	75	+1.4	56
vii)	90	90	+1.7	67
viii)	110	110	+2.0	82
ix)	120	120	+2.2	90
x)	125	125	+2.3	94
xi)	140	140	+2.6	106
xii)	160	160	+2.9	120
xiii)	180	180	+3.3	135
xiv)	200	200	+3.6	150
xv)	225	225	+4.1	170
xvi)	250	250	+4.5	188

NOTES

1 Tolerance on outside diameters are given as follows:

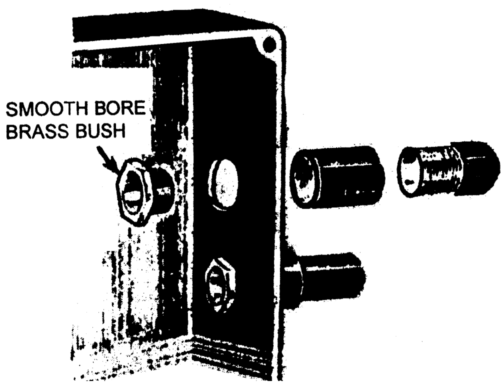
a) Outside diameter specified are nominal dimensions.

b) Outside diameter maximum is nominal outside diameter + (0.018 × nominal outside diameter values) rounded off to + 0.1 mm.

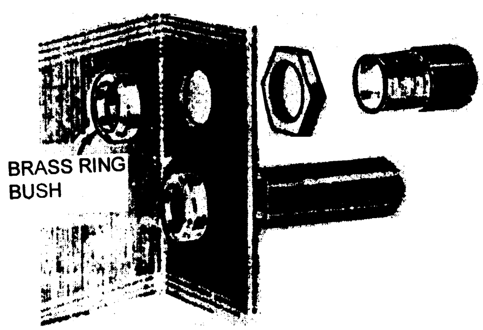
c) Minimum inside diameter is nominal outside diameter divided by 1.33.

2 Any other sizes other than those mentioned in Table 7 shall be as per the agreement between the buyer and the seller.

use is limited because the cost could prove to be prohibitive. Copper conduit can be screwed in the same manner as steel conduit although the screwing of copper is more difficult than mild steel. Connections are generally made by soldering. Bronze junction boxes should preferably be used.



32A With Smooth Bore Bush and Coupling



32B With Brass Ring Bush and Back Nut

FIG. 32 METHODS OF FIXING SCREWED CONDUIT AT CLEARANCE ENTRIES IN METAL CASING OR BOXES

c) *PVC conduit* — When first introduced, such conduits had many disadvantages compared to steel — the material was mechanically weak, greatly affected by changes in temperature, did not retain sets, maintained combustion (and emitted toxic fumes) and tended to separate at joints. These problems have now been overcome and, in some respects, plastics conduits have many advantages over steel. It is much lighter and, therefore, easier to handle and install, provides a smoother surface for the drawing of the cables, is not subject to corrosion and rusting, and the super high impact materials now used make it suitable for most applications.

d) *Flexible conduit* — Several different types of flexible conduit are available, ranging from convoluted plastics to reinforced corrugated steel covered both internally and externally with self-extinguishing plastics, the latter being the most appropriate for general use. It is particularly useful for final connections to machinery subject to vibration in place of the alternative methods of flexible cable or coiled mineral insulated copper cables (MICCs). Flexible conduit shall conform to relevant Indian Standard.

6.7.1.2 *Cables in conduits*

The types of cables which may be installed in conduits are PVC single-core insulated, butyl or silicone rubber insulated, with copper or aluminium conductors. PVC insulated and sheathed cables are sometimes installed in conduits when the extra insulation and protection is desirable. Under no circumstances may ordinary flexible cords be drawn into conduit.

6.7.1.3 *Selection of correct size of conduit*

After selection of the correct size of cables for a given electrical load is made, the selection of the appropriate size of conduit to accommodate these cables is to be done. The number of cables which may be drawn into any conduit must be such that it allows easy drawing

Table 8 Spacing of Supports for Conduits

(*Clause* 6.7.1.0)

Sl No.	Nominal Size of Conduit mm	Maximum Distance between Supports					
		Rigid Metal		Rigid Insulation		Pliable	
		Horizontal m	Vertical m	Horizontal m	Vertical m	Horizontal m	Vertical m
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	Not exceeding 16	0.75	1.0	0.75	1.0	0.3	0.5
ii)	Exceeding 16 and not exceeding 25	1.75	2.0	1.5	1.75	0.4	0.6
iii)	Exceeding 25 and not exceeding 40	2.0	2.25	1.75	2.0	0.6	0.8
iv)	Exceeding 40	2.25	2.5	2.0	2.0	0.8	1.0

NOTE — A flexible conduit is not normally required to be supported in its run.

in, and in no circumstances may it be in excess of the maximum given in Part 1/Section 20 of this Code. For larger cables it is preferable to install cables in trunking. As the number of cables or circuits in a given conduit or trunking increase, the current-carrying capacities of the cables decrease. Therefore it is advisable not to increase the size of the conduit or trunking in order to accommodate more cables, but to use two or more conduits. The conduit installation must be complete before cables are drawn in. This is to ensure that subsequent wiring can be carried out just as readily as the original. Also the installation must be arranged so that cables are not drawn round more than two rigid-angle bends. This conduit is complete and ready for wiring, and will be concealed when the wall panels are fitted.

6.7.1.4 *Conduit system*

There are two distinct conduit systems, the surface system, and the concealed system.

6.7.1.4.1 *Surface system*

a) *Choice of runs* — The most suitable 'run' should be chosen for the conduits. When there are several conduits running in parallel, they must be arranged to avoid crossing at the point where they take different directions. The routes should be chosen so as to keep the conduits as straight as possible, only deviating if the fixings are not good. The 'runs' should also be kept away from gas and water pipes and obstructions which might prove difficult to negotiate. Locations where they might become exposed to dampness or other adverse conditions should be avoided.

b) *Conduit fittings* — Bends, inspection tees and elbows, made in accordance with relevant Indian Standards may be used. However, bends can be made by setting the conduit, and where there are several conduits running in parallel which change direction, it is necessary for these bends to be made so that the conduits follow each other symmetrically which is not possible if manufactured bends are used. The use of inspection elbows and tees is not good practice, as there is insufficient room for drawing in cables and, in addition, the installation presents a shoddy appearance. Round boxes in accordance with relevant Indian Standards may, instead be used. These boxes have a much better appearance, provide plenty of room for drawing in cables, and can accommodate some slack cable which should be stowed in all draw-in points. For conduits up to 25 mm diameter, the small circular boxes should be used. Circular boxes are not suitable for conduits larger than 32 mm, and for these larger sizes rectangular boxes should be used to suit the size of cables to be installed. The inspection sleeve is a very useful draw-in fitting, because its length permits the easy drawing in of cables and its restricted width enable conduits to be run in close proximity without the need to 'set' the conduits at draw-in points. Where two or more conduits run in parallel, it is a good practice to provide at draw-in points an adaptable box which embraces all of the conduits. This presents a much better appearance than providing separate draw-in boxes and has the advantage of providing junctions in the conduit system which might prove useful if alterations have to be made at a later date. Where two or more conduits are run in parallel, it is good practice to embrace all conduits with an adaptable box as shown in Fig. 35. An advantage of the conduit system is that the cables can be renewed or altered easily at any time. It is, therefore, necessary that all draw-in boxes should be readily accessible, and subsequently nothing should be fixed over or in front of them so as to render them inaccessible. The need for the conduit system to be complete for each circuit, before cables are drawn in, is to ensure that subsequent wring can be carried out just as readily as the original; it prevents cables becoming damaged where they protrude from sharp ends of conduit, and avoids the possibility of drawing the conduit over the cables during the course of erection.

c) *Radius of conduit bends* — Facilities such as draw-in boxes, must be provided so that cables are not drawn round more than two right-angle bends or their equivalent. The radius of bends must not be less than the standard normal bend *(see also* Fig. 36 and Table 9).

d) *Methods of fixing conduit* — There are several methods of fixing conduit, and the one chosen generally depends upon what the conduit has to be fixed to.

   1) *Conduit clips* — Conduit clips take the form a half saddle, and have only one fixing lug. The reason for using clips instead of saddles is to save an additional fixing screw. They are not satisfactory if the conduit is subjected to any strain.

   2) *Ordinary saddles* — Ordinary saddles provide a very secure fixing (*see* Fig. 37). They should be fixed by means of two

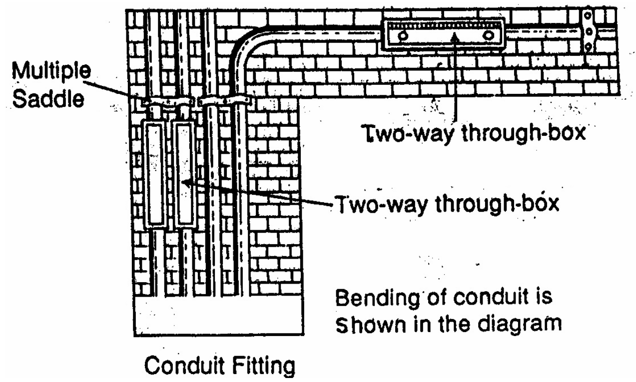


FIG. 33 BENDING OF CONDUIT

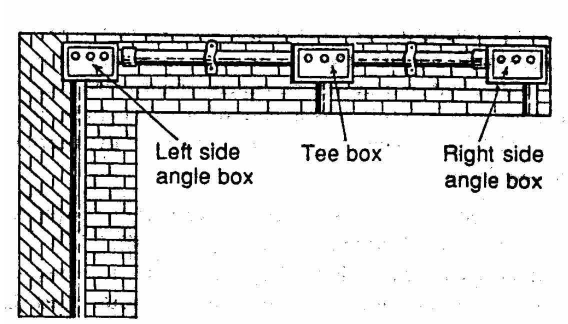
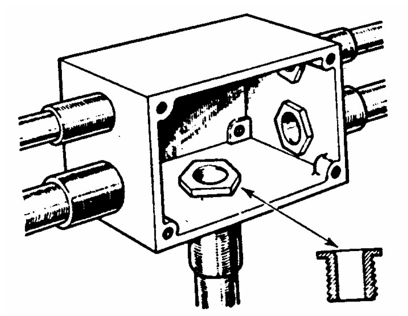
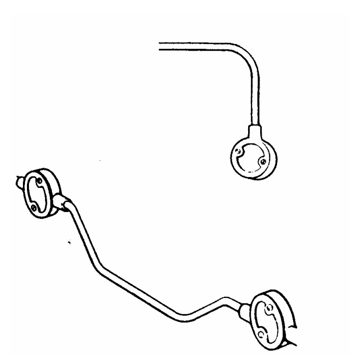


FIG. 34 FITTINGS OF CONDUITS



NOTE — Where two or more conduits are run in parallel it is good practice to embrace all conduits with an adaptable box.

FIG. 35 CONDUITS RUN IN PARALLEL



NOTE — Cable must not be drawn round more than two right angle bends or their equivalent. The four bends in the lower diagram are each 45° making a total of 180° in all.

FIG. 36 DRAWING OF CABLES IN BENDS

Table 9 Minimum Internal Radii of Bends in Cables for Fixed Wiring
[*Clause* 6.7.1.4.1 (c)]

Sl No.	Insulation	Finish	Overall Diameter	Factor to be Applied to Overall Diameter[1] of Cable to Determine Minimum Internal Radius of Bend
(1)	(2)	(3)	(4)	(5)
i)	XLPE, PVC or rubber (circular, or circular stranded copper or aluminium conductors)	Non-armoured	Not exceeding 10 mm	3(2)[2]
			Not exceeding 25 mm	4(3) [2]
			Exceeding 25 mm	6
		Armoured	Any	6
ii)	XLPE, PVC or rubber (solid aluminium or shaped copper conductors)	Armoured or non-armoured	Any	8
iii)	Mineral	Copper of aluminium sheath with or without PVC overing		6

[1] For flat cables the factor is to be applied to the major axis.

[2] The figure in brackets relates to single-core circular conductors of stranded construction installed in conduit, ducting or trunking.

screws and should be spaced not more than 1.3 m apart. Nails must not be used for fixing (*see* Fig. 37). The conduit boxes to which luminaries are to be fixed should be drilled at the back and fixed, otherwise a saddle should be provided close to each side of the box (*see* Fig. 38).

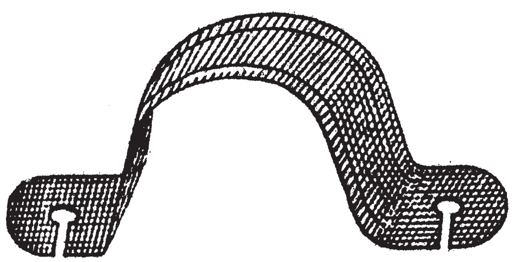


FIG. 37 SPACING SADDLES WITH OVAL HOLES

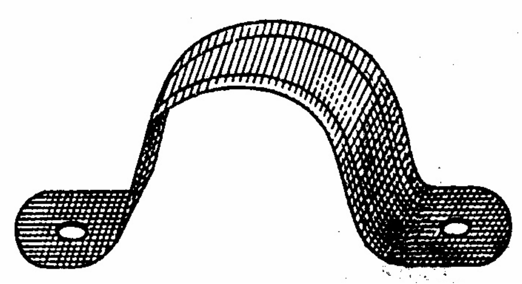


FIG. 38 SADDLE

3) *Spacer bar saddles* — Spacer bar saddles are ordinary saddles mounted on a spacing plate. This spacing plate is approximately the same thickness as the sockets and other conduit fittings and, therefore, serves to keep the conduit straight where it leaves these fittings as well as to prevent the conduit from making intimate contact with damp plaster and cement walls and ceilings which would result in corrosion of the conduit and discoloration of the decorations. When conduit is fixed to concrete a high percentage of the installation time is spent in plugging for fixing, and the use of the spacer-bar saddle which has only a one-hole fixing in its centre has an advantage over the ordinary saddle. Some types of spacer bar saddles are provided with saddles having slots instead of holes. The idea is that the small fixing screws need only be loosened to enable the saddle to be removed, slipped over the conduit and replaced (*see* Fig. 31 and 40). This advantage is offset by the fact that when the saddle is fixed under tension there is tendency for it to slip sideways clear of its fixing screws, and there is always a risk of this happening during the life of the installation if a screw should be come slightly loose. For this reason holes rather than slots are generally more satisfactory in these saddles. When selecting the larger sizes of spacer-bar saddles it is important to make sure that the slotted hole which accommodates the counter-sunk fixing screw is properly proportioned.

4) *Distance saddles* — These are designed to space conduits approximately 10 mm from the wall or ceiling. Distance saddles are generally made of malleable cast iron. They are much more substantial than other types of saddles, and as they space the conduit from the fixing surface they provide better protection against

corrosion. The use of this type of saddle eliminates the possibility of dust and dirt collecting behind and near the top of the conduit where it is generally inaccessible. For this reason distance saddles are usually specified for hospitals, kitchens, and other situation where dust traps must be avoided.

5) *Multiple saddles* — Where two or more conduits follow the same route it is generally an advantage to use multiple saddles as it saves a considerable amount of fixing time because only two screws are required, and also all conduits are properly and evenly spaced (*see* Fig. 39 and 42).

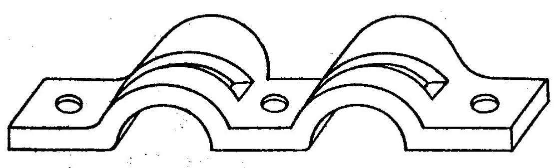


FIG. 39 MULTIPLE SADDLE

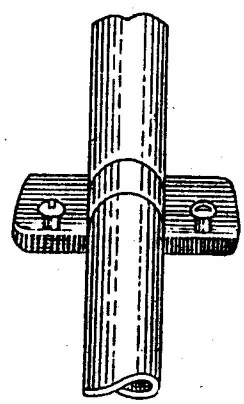


FIG. 40 INSTALLATION OF CONDUIT WITH SPACING SADDLE

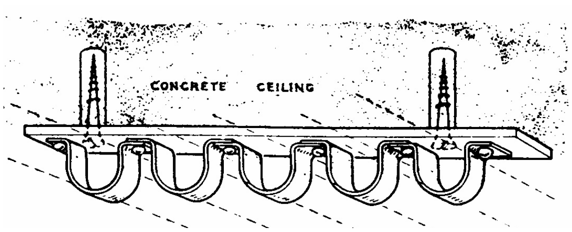


FIG. 41 MULTIPLE SADDLE

6) *Girder clips* — Where conduits are run along or across girders, trusses or other steel frame work, standard spring clips may be used for be quick and easy fitting. Other methods include a range of bolt-on devices and if it is intended to run number of conduits on a particular route and standard clips are not suitable, it may be advisable to make these to suit site conditions, multiple girder clips can be made to take a number of conduits run in parallel. As an alternative to girder clips, multiple saddles can be welded to steelwork, or the steelwork could be drilled in case there is no adverse effect on its structural properties.

When conduits are suspended across trusses or steel work there is a possibility of sagging, especially if luminaries are suspended from the conduit between the trusses. These conduits should either be of sufficient size to prevent sagging, or be supported between the trusses. They can sometimes be supported by iron rods from the roof above (*see* Fig. 42 and 43). If the trusses are spaced 3 mm or more apart it is not very satisfactory to attempt to run any conduit across them, unless there is additional means of support. It is far better to take the extra trouble and run the conduit at roof level where a firm fixing may be found.

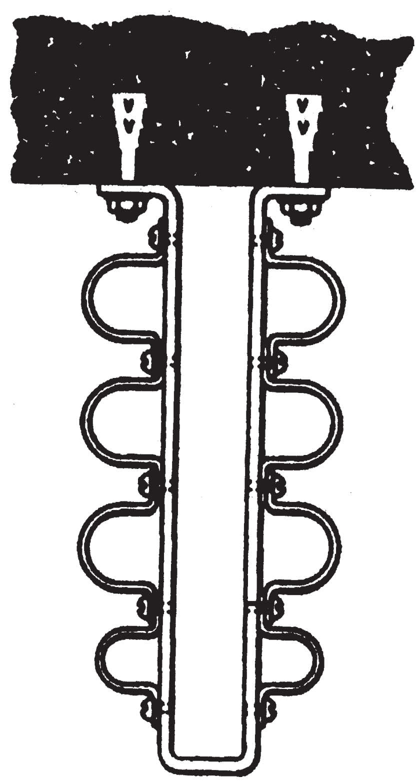


FIG. 42 A U-SECTION FASTENED TO A CONCRETE CEILING WITH RAG-BOLTS USED TO CARRY A NUMBER OF SADDLES OF THE REQUIRED SIZE

e) *Avoidance of gas, water and other pipes* — All conduits must be kept clear of gas and water pipes, either by spacing or insulation. They must also be kept clear of cables and pipes which feed telephones, bells and other services, unless these are wired to the same standard as lighting, heating or power circuits. One exemption to this is that conduits may be fitted to electrically operated gas valves, and the like, if they are constantly under electrically skilled supervision. Another is that conduits may make contact with water pipes if they are intentionally bonded to them. They must not make casual contact with water pipes. If conduits have to be run near gas or water pipes and there is a risk of their making contact, they should be spaced apart with wood or other insulating material. If the conduit system reaches a high potential due to defective cables in the conduit and ineffective earth continuity, and this conduit makes casual contact with a gas or water pipe, either of which would be at earth potential, then arcing would take place between the conduit and the other pipe. This might result in puncturing the gas pipe and igniting the gas. There is greater likelihood of this happening if the gas or water pipe is of lead.

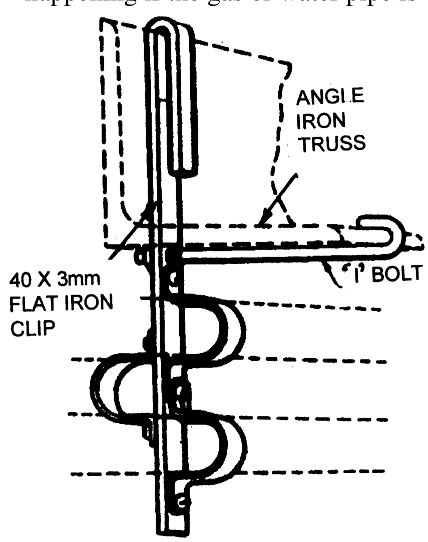
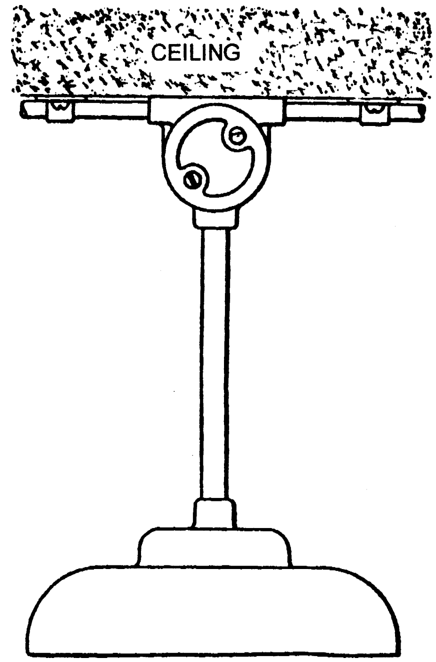


FIG. 43 SUPPORTING SEVERAL CONDUITS FROM ANGLE IRON TRUSS

f) *Protection of conduits* — Although heavy gauge conduit affords excellent mechanical protection to the cables it encloses, it is possible for the conduit itself to become damaged if stuck by heavy objects. Such damage is liable to occur in workshops where the conduit is fixed near the floor level and may be struck by trolley or heavy equipment being moved or slung into position. Protection can be afforded by threading a water pipe over the conduit during erection, or by screening it with sheet steel or channel iron. Another method of protection is, of course, to fix the conduit behind the surface of the wall.



NOTE — The conduit is fixed to the ceiling with spacer bar saddles.

FIG. 44 A SUPPORTING FITTING FROM TANGENT TEE BOX

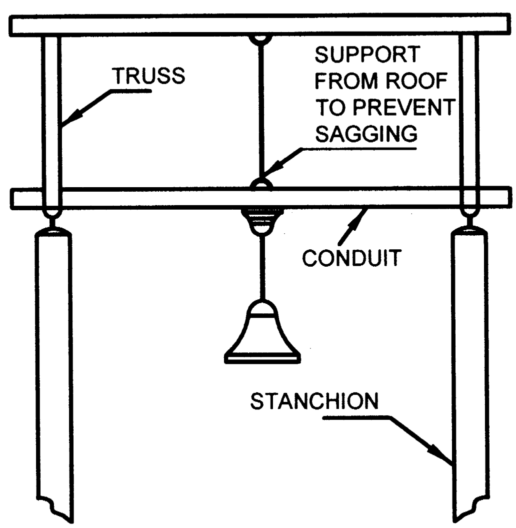
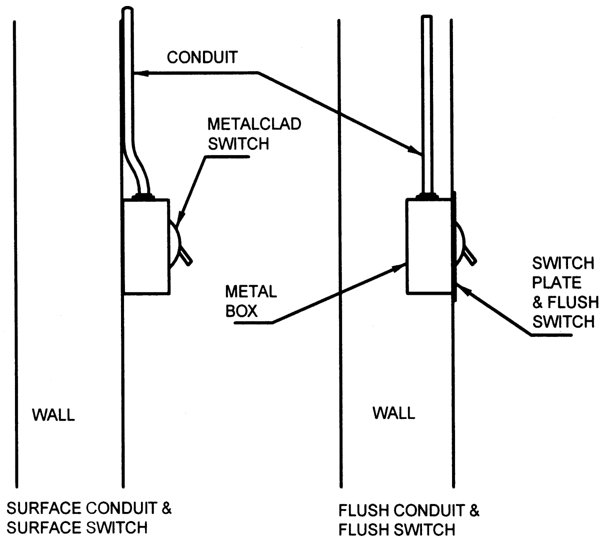


FIG. 45 A CONDUIT SUSPENDED ACROSS ROOF TRUSSES

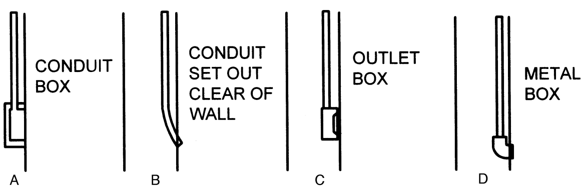
g) *Termination of conduit at switch positions* — At switch positions the conduit must terminate with a metal box or into an accessory or recess lined with incombustible material.

h) *Termination of conduit at other than switch positions* — Where conduit terminates a ceiling or wall points other than at switch positions, it must terminate with a meal box, or recess, or a block of incombustible material.



NOTE — At switch positions, conduit must terminate with metal box or other suitable enclosure.

FIG. 46 TYPICAL METHODS OF TERMINATING SURFACE AND CONCEALED SYSTEMS



NOTE — A box or suitable enclosure must be fitted at all outlet positions. Terminations as shown at B, C and D are not permitted.

FIG. 47 OUTLET POSITIONS

j) *Removal of burrs from ends of conduit* — When steel conduit is cut by a hacksaw, a burr is formed upon the inner bore of the conduit. If this burr were not removed it would cause considerable damage to the insulation of the cables drawn into the conduit. Ends of lengths of conduit should be free from burrs, and where they terminate at boxes, trunking and accessories not fitted with spout entries, should be treated so as to eliminate damage to cables.

k) *Conduit Installed in damp conditions* — If metallic conduits are installed externally or in damp situations, they should either be galvanized, sherardized, or be made of copper, and all clips and fixings (including fixing screws) shall be of corrosion-resisting material and should be free from burrs. When there is a danger of condensation forming inside conduit (for example, where there may be changes of temperature) suitable precautions should be taken. Holes may be drilled at the lowest points of the conduit system or, alternatively, conduit boxes with drainage holes should be fitted. Drainage outlets should be provided where condensed water might otherwise collect. When ever possible conduit runs should designed so as to avoid traps for moisture.

m) *Continuity of the conduit system* — A screwed conduit system must be mechanically and electrically continuous across all joints so that the electrical resistance of the conduit, together with the resistance of the earthing lead, measured from the earth electrode to any position in the conduit system shall be sufficiently low so that the earth fault current operates the protective device. To achieve this it is necessary to ensure that all conduit connections are tight and that the enamel is removed form adaptable boxes and other conduit fittings where screwed entries are not provided. To ensure the continuity of the protective conductor throughout the life of the installation, a separate circuit protective conductor is drawn into the conduit for each circuit in the conduit._Conduits must always be taken direct into distribution boards, switchfuses, switches, isolators, starters, motor terminal boxes, etc, and must be electrically and mechanically continuous throughout. Conduits must not be terminated with a bush and unprotected cables taken into

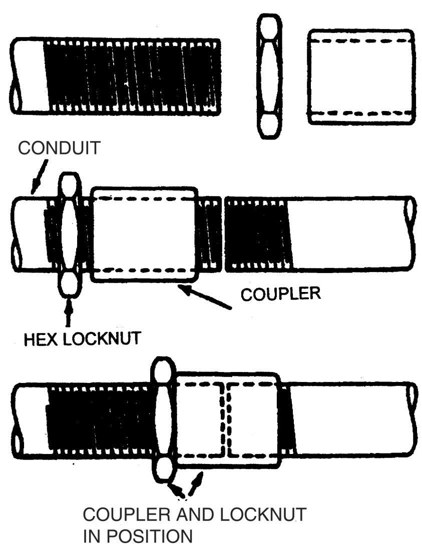
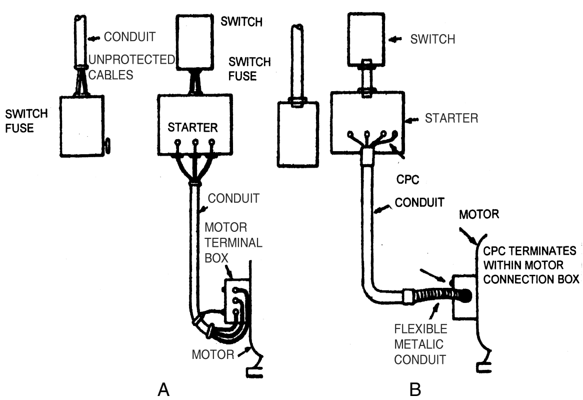


FIG. 48 CONNECTING TWO LENGTHS OF CONDUIT NEITHER OF WHICH CAN BE TURNED, BY USE OF COUPLER AND LOCKOUT

switchgear and other equipment. The switchgear must be connected mechanically either with solid conduits, or with flexible metallic conduits.

n) *Flexible metallic conduit* — Flexible metallic conduits are used for final connections to motors so as to provide for the movement of the motor if fixed on slide rails. It also prevents any noise or vibration being transmitted from the motor, or the machine to which it may be coupled, to other parts of the building through the conduit system (*see* Fig. 49). These flexible conduits should preferably be of the watertight pattern and should be connected to the conduit by means of brass adaptors. These adaptors are made to screw on to the flexible tubing and also into the conduit. It is good practice to braze the adaptor to the metallic tubing, otherwise it is likely to become detached and expose the cables to mechanical damage. The use of flexible metallic tubing which is covered with PVC sleevings is recommended as this outer protection prevents oil from causing damage to the rubber insertion in the joints of the tubing.



NOTE — Figure 49A shows the wrong method, which is frequently adopted because proper conduit outlets are not always provided on starters and motors. The lengths of unprotected cable are subject to mechanical damage which may lead to electrical breakdown. Figure 49B illustrates the right method. Conduit is either taken direct into the equipment or terminated with flexible metallic conduit and a suitable c.p.c.

FIG. 49 TERMINATION CONDUIT AT SWITCH AND STARTER

p) *Surface conduit feeding luminaires and clocks* — When surface conduit run to feed wall or ceiling accessory like luminaries/clock etc which are fixed direct to the wall or ceiling, it is advisable, if possible, to set the conduit into the wall a short distance from the position of the accessory as shown in Fig. 50.

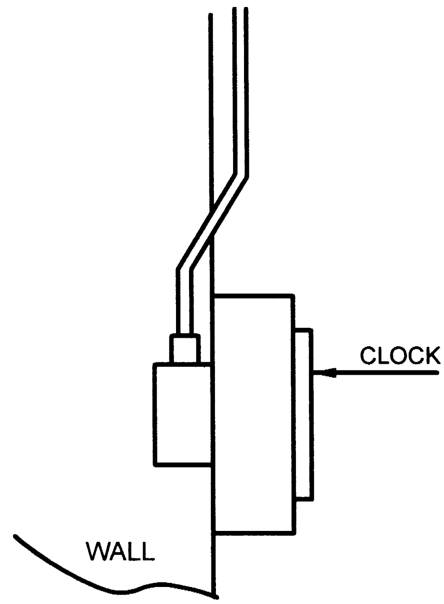


FIG. 50 SURFACE CONDUIT SYSTEM WHEN FITTING/ ACCESSORY MUST BE FLUSH ON WALL OR CEILING

q) *Drawing cables into conduits*

1) Cables must not be drawn in to conduits until the conduit system for the circuit concerned is complete, except for prefabricated flexible conduit systems which are not wired *in-situ.*
2) When drawing in cables they must first of all be run off the reels or drums, or the reels must be arranged to revolve freely, otherwise if the cables are allowed to spiral off the reels they will become twisted, and this would cause damage to the insulation. If only a limited quantity of cable is to be used it may be more convenient to dispense it direct from one of the boxed reels which are now on the market.
3) Cable must not be allowed to spiral off reels or it will become twisted and the insulation damaged.
4) If a number of cables are being drawn into conduit at the same time, the cable reels should be arranged on a stand or support so as to allow them to revolve freely.
5) In new buildings and in damp situations the cable should not be drawn into conduits until it has been made certain that the interiors of the conduits are dry and free from moisture. If in doubt, a draw wire with a swab at the end should be drawn through the conduit so as to

remove any moisture that may have accumulated due to exposure or building operations.

6) It is usual to commence drawing in cables from a mid-point in the conduit system so as to minimize the length of cable which has to be drawn in. A draw-in tape should be used from one draw-in point to another and the ends of the cables attached. The ends of the cables must be bared for a distance of approximately 50 mm and threaded through a loop in the draw tape. When drawing in a number of cables they must be fed in very carefully at the delivery end whilst some one pulls them at the receiving end.
7) The cables should be fed into the conduit in such a manner as to prevent any cables crossing, and also to avoid them being pulled against the sides of the opening of the draw-in box. In hot weather or under hot conditions, the drawing-in can be assisted by rubbing French chalk on the cables. Always leave some slack cable in all draw-in boxes and make sure that cables are fed into the conduit so as not to finish up with twisted cable at the draw-in point.
8) This operation needs care and there must be synchronization between the person who is feeding and the person who is pulling. If in sight of each other this can be achieved by a movement of the head, and if with in speaking distance by word of command given by person feeding the cables. If the two persons are not with in earshot, then the process is somewhat more difficult. A good plan is for the individual feeding the cables to give pre-arranged signals by tapping the conduit with a pair of pliers.
9) In some cases, it may be necessary for a third person to be stationed midway between the tow positions to relay the necessary instructions from the person feeding to the person pulling. Otherwise cables may become crossed and this might result in the cables becoming jammed inside the conduit.
10) The number of cables drawn into a particular size conduit should be such that no damage is caused to either the cables or to their enclosure during installation. It will be necessary, after deciding the number and size of cables to be placed in a particular conduit run, to determine the size of conduit to be used. Each cable and conduit size is allocated a factor and by summing the factors for all the cables to be run in a conduit route, the appropriate conduit size to use can be determined.

6.7.1.4.2 *Concealed conduit system*

6.7.1.4.2.1 Screwed metal conduit is particularly suitable for concealed wiring. The conduit can be installed during building operations and can be safely buried in floors and walls whether the floors or walls are constructed of wood, brick, hollow tiles or solid concrete, in such a manner that the cables can be drawn in at any time after the completion of the building. The conduit system, if property installed, can be relied upon adequately to protect the cables and allows them to be replaced at any time if desired. Most modern buildings, including blocks of flats, are constructed with solid floors and solid walls and it is necessary for the conduit (if concealed) to be erected during the construction of the building. In other types of building where there are wooden joists and plaster ceilings, conduit will have to be run between and across the joists.

a) *Running conduit in wooden floors* — Where conduit is run across the joists, they will have to be slotted to enable the conduit to be kept below the level of the floor boards. When slots are cut in wooden joists they must be kept as near as possible to the bearings supporting the joists, and the slots should not be deeper than absolutely necessary, otherwise the joists will be unduly weakened (*see* Fig. 51). The slots should be arranged so as to be in the centre of any floorboards, if they are near the edge there is the possibility of nails being driven through the conduit. The slots cut in the joists should be no deeper than necessary and kept as near as possible to the bearing of the joints so as not to weaken them unduly. 'Traps' should be left at the position of all junction boxes. These traps should consist of a short length of floor board, screwed down and suitably marked.

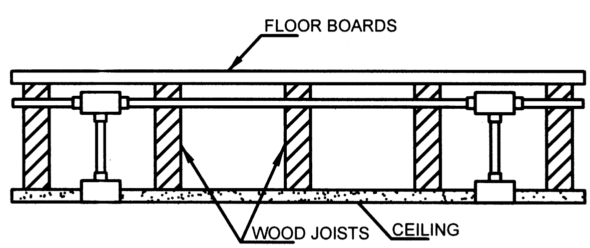


Fig. 51 Running Conduit in Wood Floors to Feed Lighting Points

b) *Running conduits in solid floors* — Where there are solid floors, it is impossible to leave junction boxes in the floors, unless there is a cavity above the top of the floor slab, in which case the conduits may be run in the cavity and inspection boxes arranged so as to be accessible below the floor boards. Otherwise the conduit needs to be arranged so that cables can be drawn in through ceiling or wall points. This methods is known as the' looping-in system', and it is shown in Fig. 52 and Fig. 53 and conduit boxes are provided with holes at the back to enable the conduit to be looped from one box to another. These boxes are made with two, three or four holes so that it is possible also to tee off to switches and adjacent ceiling or wall points. If the floors are of reinforced concrete, it may be necessary to erect the conduit system on the shuttering and to secure it in position before the concrete is poured. Wherever conduit is to be buried by concrete, special care must be taken to ensure that all joints are tight, otherwise liquid cement may enter the conduit and form a solid block inside. Preferably the joints should be painted with bitumastic paint, and the conduit itself should also be painted where the enamel has been removed during threading of setting. Sometimes the conduits can be run in chases cut into concrete floors; these should be arranged so as to avoid traps in the conduit where condensation may collect and damage the cables.

c) *Conduit runs to outlets in walls* — Sockets near skirting level should preferably be fed from the floor above rather than the floor below, because in the latter case it would be difficult to avoid traps in the conduit (Fig. 54). When the conduit is run to switch and other positions in walls it is usually run in a chases in the wall. These chases must be deep enough to allow at least 10 mm of cement and plaster covering; otherwise rust from the conduit may come through to the surface. Conduits buried in plaster should be given a coat of protective paint, or should be galvanised. The plaster should be finished neatly round the outside edges of flush switch and socket boxes, otherwise the cover plates may not conceal any deficiencies in the plaster finish. When installing flush boxes before plastering, it is advisable to stuff the boxes with paper to prevent their being filled with plaster.

d) *Ceiling points* — At ceiling points the conduit boxes will be flush with the finish of the concrete ceiling. If the ceiling is to have a plaster rendering, this will leave the front of the boxes recessed above the plaster finish. To overcome this it is possible to use extension rings for standard conduit boxes. At the position of ceiling points pit is usual top provide a standard found conduit box, with an earth terminal, but any metal box or incombustible enclosure may be used, although an earth terminal must be provided.

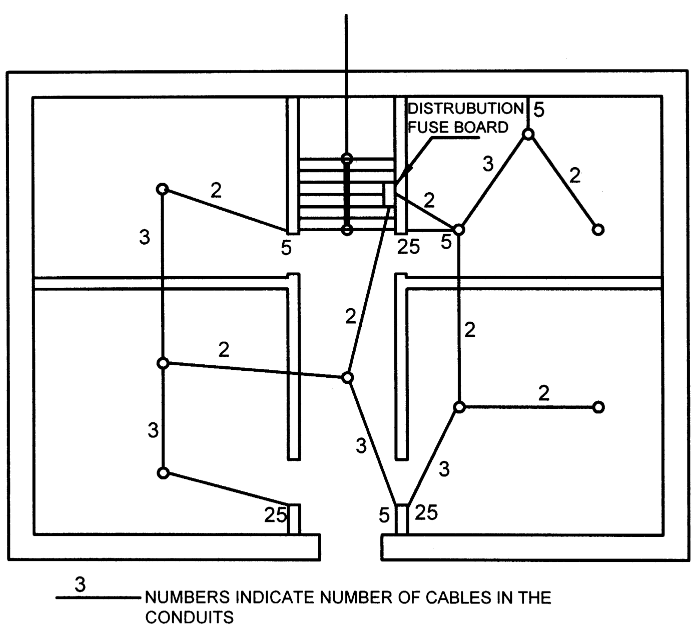


FIG. 52 TYPICAL ARRANGEMENT OF CONCEALED CONDUITS FEEDING LIGHTING POINTS BY LOOPING THE CONDUIT INTO THE BACK OF OUTLET BOXES

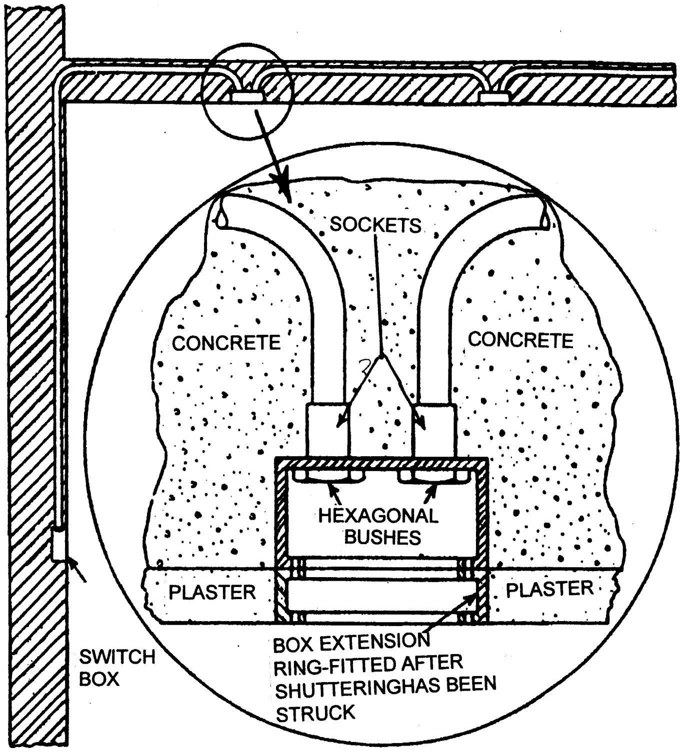
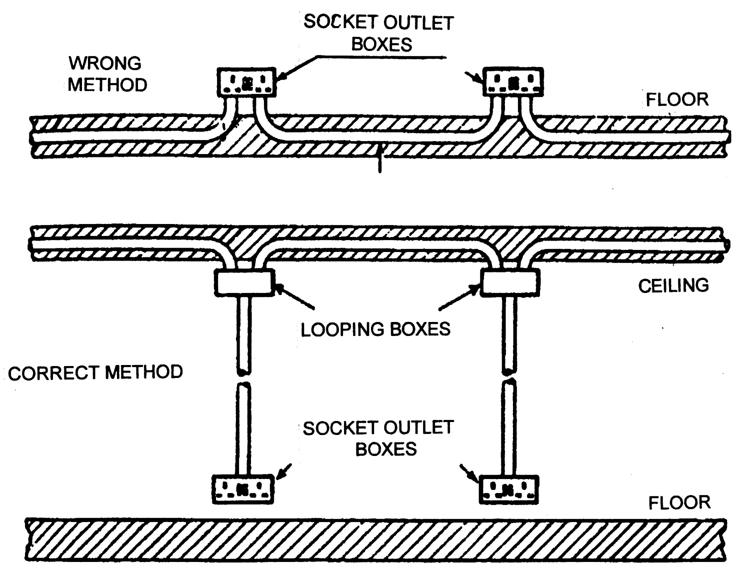


FIG. 53 DETAILS OF CONDUIT BOX AND METHOD OF HASTENING CONDUIT



NOTE — If the sockets are fed from the floor below, it is difficult to avoid a trap for moisture.

FIG. 54 RIGHT AND WRONG METHODS OF FEEDING SOCKET NEAR SKIRTING LEVEL

e) *Running sunk conduits to surface distribution boards* — Where surface mounted distribution boards are used with a sunk conduit, the problems arises as to the best method of terminating flush conduits into the surface boards. One method is to 'set' the conduits out to the required distance into the surface boards but this is not recommended. A better method is to fit a flush adaptable box in the wall behind the distribution board and to take the flush conduits directly into it. Holes can be drilled in the back of the distribution board and bushed. Spare holes should be provided for future conduits. Alternatively, an adaptable box can be fitted at the top of the distribution board, partly sunk into the wall to receive the flush conduits, and partly on the surface to bolt on the top of the distribution board. Distribution boards must be bonded to the adaptable boxes.

f) *Before wiring sunk conduit* — Before wiring, the conduits for each circuit must be erected complete. Not only should they be complete but they must be clean and dry inside otherwise the cables may suffer damage. No attempt should be made to wire conduits which are buried in cement until the building has dried out and then the conduits should be swabbed to remove any moisture or obstruction which may have entered them.

g) *The light mechanical stress unscrewed conduit system* — The light mechanical stress conduit system consists of conduits, the walls of which are not of sufficient thickness to allow them to be threaded. Instead of screwed sockets and fittings grip type fittings are used.

h) *Insulated conduit system* — Non-metallic conduits are now being increasingly used for all types of installation work, both for commercial and house wiring. The PVC rigid conduit is made in various sizes and there are various types of conduit fittings, including boxes available for use with this conduit. The type of universal conduit box is made of a plastic material, and fitted with special sockets, and enable the conduit to be merely slipped into position, and secured by locking ring. No cement is required, except that it is recommended in damp situations. The advantage of the insulated conduit system is that it can be installed much more quickly than steel conduit, it is non-corrosive, impervious to most chemicals, weatherproof, and it will not support combustion. The disadvantages are that it is not suitable for temperatures below –5°C or above 60°C, and where luminaries are suspended from PVC conduit boxes, precautions must be taken to ensure that the heat from the lamp does not result in the PVC box reaching a temperature exceeding 60°C. For surface installations it is recommended that saddles be fitted at intervals of 800 mm for 20 mm diameter conduit, and intervals of 1 600 mm to 2 000 mm for larger sizes. The special sockets and saddles for this type of conduit must have provision to allow for longitudinal expansion that may take place with variations in ambient temperature. It is necessary to provide a circuit protective conductor in all insulated conduit, and this must be connected to the earth terminal in all boxes for switches, sockets and luminaries. The only exception is in connection with Class 2 equipment, that is, equipment having double insulation. In this case a protective conductor must not be provided. Flexible PVC conduits are also available, and these can be used with advantage where there are awkward bends, or under floorboards where rigid conduits would be difficult to install.

6.7.1.4.2.2 *Installation of plastic conduit*

Plastic conduits and fittings can be obtained from a number of different manufacturers and the techniques needed to install these are not difficult to apply. Care is however needed to assemble a neat installation and the points given below should be borne in mind. As with any other installation good workmanship and the use of good quality materials is essential.

It should be noted that the thermal expansion of plastic conduit is about six times that of steel, and so whenever surface installation of straight runs exceeding 6 m is to be employed, some arrangement must be made for expansion. The saddles used have clearance to allow the conduit to expand. Joints should be made with an expansion coupler, which is attached with solvent cement to one of the lengths of tube, but allowed to move in the other.

Cutting the conduit can be carried out with a fine tooth saw or using the special tool. As with steel conduit, it is necessary to remove any burrs and roughness at the end of the cut length.

Bending the small sizes of plastic conduit up to 25 mm diameter can be carried out cold. A bending spring is inserted so as to retain the cross sectional shape of the tube. It is important to use the correct size of bending spring for the type of tube being employed. With cold bending, the tube should initially be bent to about double the required angle, and then returned to the angle required, as this reduces the tendency of the tube to return to its straight form. To bend larger sizes of tube, 32 mm diameter and above, judicious application of heat is needed. This may be applied by blowlamp, electric fire or boiling water. If a naked flame is used, extreme care must be taken to avoid overheating the conduit. Once warm, insert a bending spring and bend the tube round a suitable former. A bucket is suitable, but do not use a bending machine former, as this conduits away the heat too rapidly. The formed tube should as soon as possible be saddled after bending.

Joints are made using solvent adhesives, which can be obtained specifically for the purpose. These adhesives are usually highly flammable and care is needed in handling and use. Good ventilation is essential, and it is important not to inhale any fumes given off. The manufacturers' instructions for use of the solvent adhesive should be strictly followed. If sealing is needed to waterproof the joint, use a special non-setting adhesive or grease. Threaded adaptors are available for use when it is required. Drawing in cables is carried out by making use of a nylon draw-in tape. The smooth bore of the plastic tube aids the pulling in operation. Liquid soap or French chalk maybe used to provide lubrication to help the pulling in process. Capacities of plastic conduits maybe calculated in a similar way to that used for steel systems. Each type of cable is allocated a factor, and corresponding factors are allocated for various sizes of conduit. Table 10 and Table 11 give the factors applicable to cables and conduits. This requires that when cables are drawn into conduit damage to both cables and conduit is avoided. The use of plastic conduit is suitable when cable runs require to be located in pre-cast concrete. As will be appreciated it is essential that sound joints are made so that when the concrete is cast, the conduit runs do not separate. The maximum permissible number of 1.1 kV grade cables that can be drawn into rigid steel conduits are given at Table 3 of Part 1/Section 20 of this Code. The maximum permissible number of 1.1 kV grade single-core cables that may be drawn into rigid non-metallic conduits are given in Table 4 of Part 1/Section 20 of this Code. Table 1 of Part 1/ Section 20 gives diameter and maximum allowable resistance of fusewires of tinned copper.

6.7.2 *Cable Trunking and Ducting Systems*

6.7.2.0 *General*

Cable trunking and cable ducting systems are used for the accommodation, and where necessary for the segregation of conductors, cables or cords and/or other electrical equipment in electrical installations (*see* Fig. 55). The systems are mounted directly on walls or ceilings , flush or semi-flush or indirectly on walls or ceilings, or on structures away from on walls or ceilings. *See* IS 14927 (Part 1) for general requirements of the cable trunking and ducting systems. For general use, cable trunking is now available in various materials such as steel, PVC, aluminium and phenylene oxide (Noryl), in a wide range of sizes of both square and rectangular cross-section. Steel cable trunking is supplied in various standard lengths with provision for slotting together and bolting to maintain electrical continuity for bonding. If required, trunking is available with pin supports at regular intervals for separating circuits and, where it is essential to completely segregate wiring, such as safety services and extra-low voltage, continuous barriers are provided.

Where a large number of cables has to be run together, it is often convenient to put them in trunking. Trunking for electrical purposes is generally made of 1.2 mm sheet steel, and is available is size ranging from 50 mm × 50 mm to 600 mm × 150 mm, common sizes being 50 mm × 50 mm, 75 mm × 100 mm, 150 mm × 75 mm and 150 mm × 150 mm although 50 mm × 100 mm and 100 mm × 100 mm are also available. *See* Table 12 for spacing of supports for trunking and Table 13 for preferred dimensions of cable trunking and ducting.

6.7.2.1 *Types of trunking*

a) *Metallic trunking* — Trunking for industrial and commercial installations is often used in place of the larger sizes of conduit. It can be used with advantage in conjunction with 16 mm to 32 mm conduits, the trunking forming the background or framework of the system with conduits running from the trunking to lighting or socket outlet points. For example, in a large office building, trunking can be run above the suspended ceiling along the corridors to feed corridor points, and rooms on either side can be fed from this trunking by conduit.

   In multistoreyed buildings trunking of suitable capacity, and with the necessary number of compartments, is to be provided and run vertically in the riser ducts and connected to distribution boards; it can also accommodate circuit wiring, control wiring, also cables feeding fire alarms, telephones, emergency lighting and other services associated with a modern building.

   Cables feeding fire alarms and emergency circuits need to be segregated by fire-resisting barriers from those feeding low-voltage circuits (that is 50 V to 1 000 V ac). It is usual for telecommunications companies to insist that their cables are completely segregated from all other wiring systems. It may therefore be necessary to install 3 or 4 compartment trunking to ensure the requirements for data and telecommunications circuits are complied with. Cables feeing emergency lighting and fire alarm must also be segregated from the wiring of any other circuits by means of rigid and continuous partitions of non-combustible material.

b) *Non-metallic trunking* — A number of versatile plastic trunking systems have been developed in recent years and these are often suitable for installation work in domestic or commercial premises, particularly where rewiring of existing buildings is required.

Table 10 Conduit Factors for Runs Incorporating Bends

(*Clause* 6.7.1.4.2.2)

Sl No.	Length of Run	Straight				One Bend				Two Bends				Three Bends				Four Bends			
	m	16	20	25	32	16	20	25	32	16	20	25	32	16	20	25	32	16	20	25	32
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
i)	1					188	303	543	947	177	286	514	900	158	256	463	818	130	213	388	692
ii)	1.5					182	294	528	923	167	270	487	857	143	233	422	750	111	182	333	600
iii)	2					177	286	514	900	158	256	463	818	130	213	388	692	97	159	292	529
iv)	2.5					171	278	500	878	150	244	442	783	120	196	358	643	86	141	260	474
v)	3					167	270	487	857	143	233	422	750	111	182	333	600				
vi)	3.5	179	290	521	911	162	263	475	837	136	222	404	720	103	169	311	563				
vii)	4	177	286	514	900	158	256	463	818	130	213	388	692	97	159	292	529				
viii)	4.5	174	282	507	889	154	250	452	800	125	204	373	667	91	149	275	500				
ix)	5	171	278	500	878	150	244	442	783	120	196	358	643	86	141	260	474				
x)	6	167	270	487	857	143	233	422	750	111	182	333	600								
xi)	7	162	263	475	837	136	222	404	720	103	169	311	563								
xii)	8	158	256	463	818	130	213	388	692	97	159	292	529								
xiii)	9	154	250	452	800	125	204	373	667	91	149	275	500								
xiv)	10	150	244	442	783	120	196	358	643	86	141	260	474								

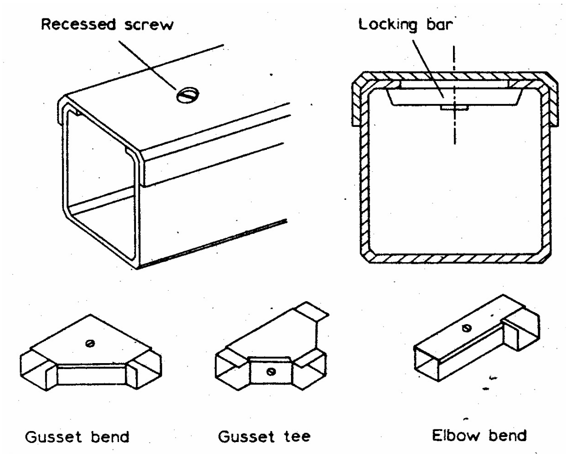


FIG. 55 CABLE TRUNKING

Table 11 Cable Factors for Long Straight Runs, or Runs Incorporating Bends in Conduit
(*Clause* 6.7.1.4.2.2)

Type of Conductor	Conductor, Cross-Sectional Area	Factor
	1.0	16
Solid or stranded	1.5	22
	2.5	30
	4.0	43
	6.0	58
	10.0	105

c) *Mini trunking* — For domestic or similar small installations, mini-trunking systems similar in form to cable trunking but of less obstructive cross-section, ranging from 16 mm to 75 mm wide by 12 mm to 30 mm deep can be used. There are numerous accessories for bends, junctions and outlets and, with the exception of the outlets which are usually surface mounted. A complete installation can be made quite inconspicuously by close fitting to skirtings, picture rails and door architraves. Because of the small section, runs on walls or across ceilings can be used without spoiling the aesthetics of an area.

Mini-trunking and cove-trunking are particularly suitable for areas which may be subject to changes of layouts, or for rewiring, to avoid major unheavals in addition to new installations. The simplicity of installations and the degree of accessibility provided by these systems can reduce labour costs tremendously.

d) *Lighting trunking system* — Steel or alloy lighting trunking was originally designed to span trusses other supports in order to provide an easy an economical method of supporting luminaries in industrial premises at high level.

e) *Underfloor trunking system/Floor distribution system* — Open plan office and other types of commercial buildings may well need power and data wiring to outlets at various points in the floor area. The most appropriate way of providing this is by one of the underfloor wiring systems now available. Both steel and plastic construction trunking can be obtained, and if required 'power poles' can be inserted at appropriate locations to bring the socket outlets to a convenient hand height. With the increasing use being made of computers, and

Table 12 Spacing of Supports for Trunking
(*Clause* 6.7.2.0)

Sl No.	Cross-sectional Area, mm^2	Maximum Distance Between Supports			
		Metal		Insulating	
		Horizontal m	Vertical m	Horizontal m	Vertical m
(1)	(2)	(3)	(4)	(5)	(6)
i)	Exceeding 300 and not exceeding 700	0.75	1.0	0.5	0.5
ii)	Exceeding 700 and not exceeding 1 500	1.25	1.5	0.5	0.5
iii)	Exceeding 1 500 and not exceeding 2 500	1.75	2.0	1.25	1.25
iv)	Exceeding 2 500 and not exceeding 5 000	3.0	3.0	1.5	2.0
v)	Exceeding 5 000	3.0	3.0	1.75	2.0

other electronic data transmission systems, the flexibility of the underfloor wiring can be used to good advantage.

f) *Steel floor trunking* — Under floor trunking made of steel is used extensively in commercial and similar buildings, and it can be obtained in very shallow sections with depth of only 22 mm, which is very useful where the thickness of the floor screed is limited.

g) *Plastic underfloor trunking* — Plastic materials are now often used instead of their metal counterparts for the enclosures of underfloor systems. Under floor trunking systems made with this material can be divided into two main types, these being raised floor systems and underfloor systems.

h) *Carpet trunking system* — A carpet trunking is provided for fixing to a finished floor, which has a total depth of 9.6 mm. It is complete with a snap on overlapping lid which, when it place, forms a retainer for abutting carpet.

NOTE — There are many different designs, the particular requirements of which are covered in other parts of IS 14927.

6.7.2.2 Trunking and ducting systems shall be so designed and constructed that where required they ensure reliable mechanical protection to the conductors and/or cables contained therein. Where required, the system shall also provide adequate electrical protection. In addition, the system components shall withstand the stresses likely to occur during transport, storage, recommended installation practice and usage. System Components are parts used within the system, which include lengths of trunking or ducting, trunking or ducting fittings, fixing devices, apparatus mounting devices, and other accessories.

NOTE — The above mentioned components may not necessarily be included all together in a system. Different combinations of components may be used.

In addition, for cable trunking and ducting systems intended for mounting on walls or ceilings, the manufacturer's instruction on classification of the CT/DS and on installation of the system should be followed. If the system is intended for the suspension of loads, the manufacturers on the maximum load and method of suspension should be followed.

The sizes of the cable trunking and ducting other than those specified are also acceptable as per the agreement between the purchasers and the manufacturers provided that the height and width are from the combination of the following dimensions having tolerances of ±0.2 mm on both height and width dimensions. 12 mm, 16 mm, 20 mm, 25 mm, 32 mm, 38 mm, 50 mm, 75 mm and 100 mm.

Wall thickness for cable trunking and ducting for any type of combination with respect to height and width as given in clause shall be as follows:

a) Any combination where size is up to 32 mm the wall thickness shall be at least 1.20 mm.
b) Any combination where size is up to 38 mm, the wall thickness shall be at least 1.30 mm.
c) Any combination where size is up to 50 mm the wall thickness shall be atleast 1.50 mm.
d) Any combination where size is above 50 mm the wall thickness shall be at least 1.80 mm.

6.7.2.3 *Access to live parts*

Trunking/ducting systems shall be so designed that when they are installed and fitted with insulated conductors and apparatus in normal use, parts are not accessible.

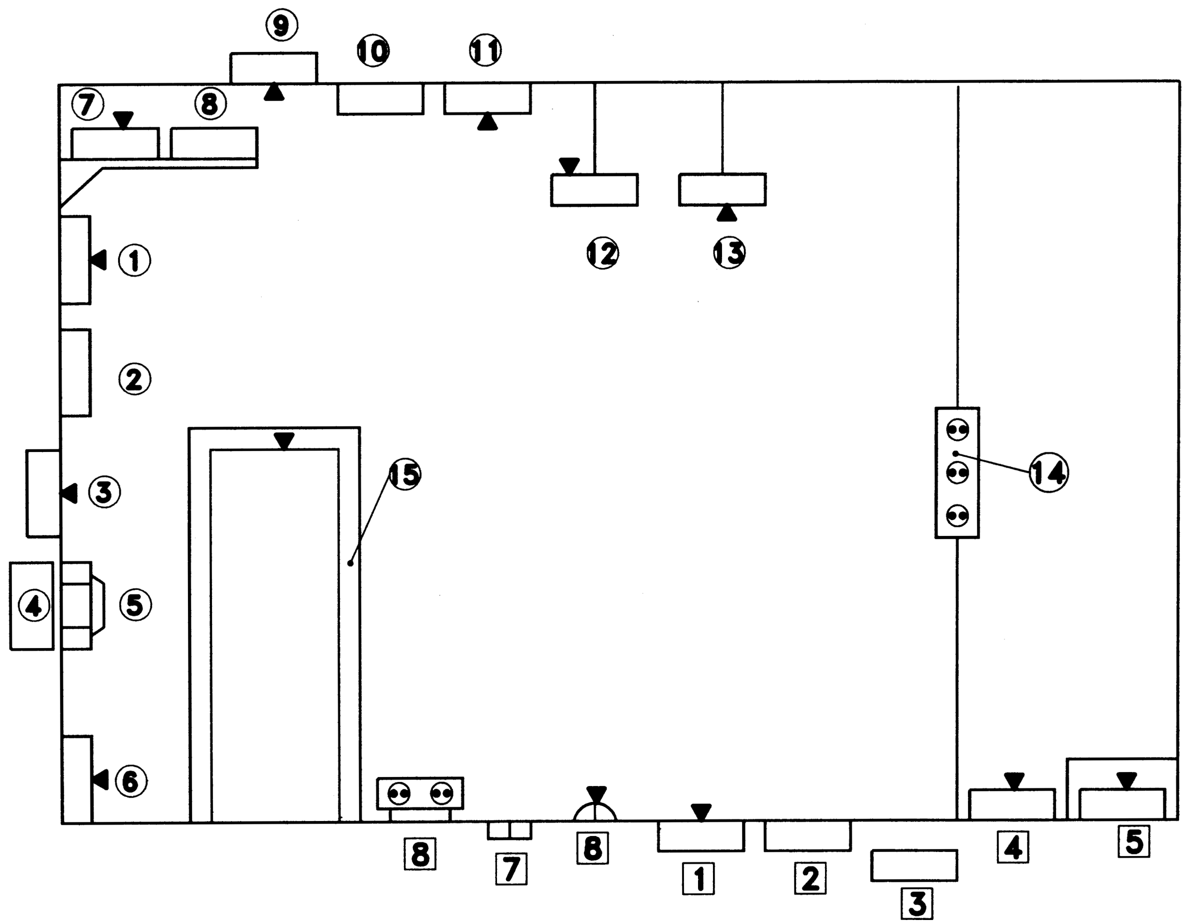
6.7.2.4 *Designs of conduit system*

A schematic of trunking and ducting systems for wall, ceiling installation and floor installation is given at Fig. 56.

Table 13 Preferred Dimensions of Cable Trunking and Ducting

(*Clause* 6.7.2.0)

Size mm (1)	Approximate Internal Cross-Sectional mm^2 (2)	Outer Width mm (3)	Outer Height mm (4)	Wall Thickness *Min* mm (5)
12 × 12	119.50	12.0 ± 0.2	12.0 ± 0.2	1.20
16 × 12	153.00	16.0 ± 0.2	12.0 ± 0.2	1.20
16 × 16	196.00	16.0 ± 0.2	16.0 ± 0.2	1.20
25 × 12	239.10	25.0 ± 0.2	12.0 ± 0.2	1.20
25 × 16	307.40	25.0 ± 0.2	16.0 ± 0.2	1.20
25 × 25	510.80	25.0 ± 0.2	25.0 ± 0.2	1.20
38 × 16	474.40	38.0 ± 0.2	16.0 ± 0.2	1.30
38 × 25	793.00	38.0 ± 0.2	25.0 ± 0.2	1.30
50 × 16	611.00	50.0 ± 0.2	16.0 ± 0.2	1.50
50 × 50	2 209.00	50.0 ± 0.2	50.0 ± 0.2	1.50
75 × 75	5 098.00	75.0 ± 0.2	75.0 ± 0.2	1.80
100 × 50	4 473.00	100.0 ± 0.2	50.0 ± 0.2	1.80



NOTE — No. 5 represents an apparatus in a trunking system.

a) Types and Application of Trunking and Ducting System for Wall and Ceiling Installation

No. on Fig. 56	Definition	For	Mounting
(1)	(2)	(3)	(4)
1 7 11 12 13 15	Trunking and accessories	Insulated conductors, cables, cords	Surface on wall and ceiling, on walls mounted horizontally or vertically, ceiling suspended
3 9	Trunking and accessories	Insulated conductors, cables, cords	Flush in wall and ceiling, in walls mounted horizontally or vertically
5	Trunking and accessories	Insulated conductors, cables, cords, mounting devices for apparatus (switches, socket-outlets, circuit-breakers, etc	Surface on wall and ceiling, on walls mounted horizontally or vertically
2 10 8	Ducting and accessories	Insulated conductors, cables, cords	Surface on wall and ceiling, on walls mounted horizontally or vertically, ceiling suspended
4	Ducting and accessories	Insulated conductors, cables, cords	Embedded in wall and ceiling, in walls mounted horizontally or vertically

b) Trunking and Ducting Systems for Floor Installation

No. on Fig. 56 (1)	Definition (2)	For (3)	Mounting (4)
1	Trunking and accessories	Insulated conductors, cables, cords	Flush floor
1 5 6	Trunking and accessories	Insulated conductors, cables, cords	Surface on floor
2	Ducting and accessories	Insulated conductors, cables, cords,	Flush floor
3 7	Ducting and accessories Electrical service unit	Insulated conductors, cables, cords Apparatus	In floor (embedded) Flush floor
8	Electrical service unit Skirting systems	Apparatus	Surface on floor
6 15	Skirting trunking and accessories	Insulated conductors, cables, cords	Surface on wall and ceiling
Not shown	Skirting trunking and accessories	Insulated conductors, cables, cords, counting devices for apparatus	Surface on wall and ceiling
Not shown	Socket plinth	Mounting apparatus (socket-outlets)	Surface on wall

FIG. 56 TYPES OF TRUNKING AND DUCTING SYSTEMS

7 EQUIPMENT, FITTINGS AND ACCESSORIES

7.0 An important stage of electrical installation work is the fixing of accessories, such as ceiling roses, holders, switches, socket outlets and luminaries. This work requires experience and a thorough knowledge of the regulations which are applicable, because danger from shock frequently results from the use of incorrect accessories or accessories being wrongly connected.

All equipment shall be suitable for the maximum power demanded by the current using equipment when it is functioning in its intended manner. 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 4 cm deep. Brass screws shall be used for attaching fittings and accessories to their base blocks. 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 out side), irrespective of being painted to match the surroundings. The size of such boards shall depend on the number of accessories that could 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.

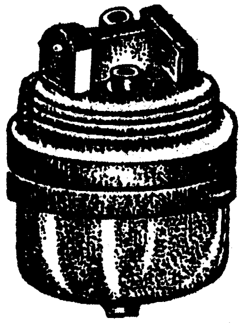
Similar part of all switches, lampholders, distribution fuse-boards, ceiling roses, brackets, pendants, fans and all other fittings shall be so chosen that they are of the same type and interchangeable in each installation. Electrical equipment which form integral part of wiring intended for switching or control or protection of wiring installations shall conform to the relevant Indian Standards wherever they exist.

7.1 Ceiling Roses

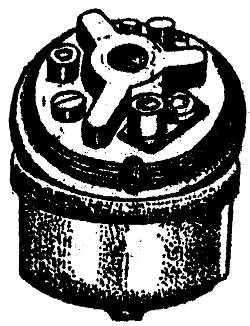
7.1.1 Ceiling rose shall not be used on a circuit the voltage of which normally exceeds 250 V. Ceiling roses may be of the 2-plate pattern and must have an earth terminal. The 3-plate type is used to enable the feed to be looped at the ceiling rose rather than to use an extra cable which would be needed to loop it at the switch. Figure 57 gives different types of ceiling roses.

7.1.2 For PVC sheathed wiring it is possible to eliminate the need for joint boxes if 3-plate ceiling roses are employed. No ceiling rose may be used on a circuit having a voltage normally exceeding 250 V. Not more than two flexible cords may be connected to any one ceiling rose unless the later is specially designed for multiple pendants.

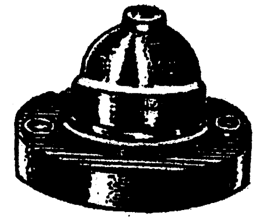
7.1.3 Special 3 and 4-pin fittings rated at 2 or 6 A may be obtained and these can be installed where lighting fittings need to be removed or rearranged. The ability to remove lighting easily can assist in



57A Porcelain Ceiling Rose with Two Plates



57B Porcelain Ceiling Rose with Three Plates



57C Ceiling Rose Made of Bakelite or Plastic

FIG. 57 CEILING ROSE

carrying our maintenance. Although the fitting is a socket outlet, it cannot be used for supplying hand held equipment.

7.1.4 For the conduit system of wiring it is usual to fit ceiling roses which screw direct on to a standard conduit box, the box being fitted with an earth terminal.

7.2 Luminaries

7.2.1 Every luminaire or group of luminaries must be controlled by a switch or a socket outlet and plug, placed in a readily accessible position. Luminaire should conform to relevant Indian Standard where existing.

7.2.2 In damp situations, every luminaire shall be of the water proof type, and in situations where there is likelihood of presence of flammable or explosive dust, vapour, or gas, the luminaries must be of the flameproof type in accordance with the recommendation of Part 7 of this Code and relevant Indian Standard (*see* IS 5571). Flammable shade shall not 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. General and safety requirements for electrical lighting fittings shall be in accordance with good practice. The lighting fittings shall conform to relevant Indian Standards where they exist.

The use of fittings-wire shall be restricted to the internal wiring of the lighting fittings. Where fittings 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

7.2.3 *Flexible Cords and Cables*

7.2.3.1 The conductor of flexible cords and cables shall be according to flexibility Class 5 of IS 8130. Flexible cords, if not properly installed and maintained, can become a cause of fire and shock. Flexible cords must not be used for fixed wiring. Flexible cords must not be used where exposed to dampness or immediately below water pipes. They should be open to view through out their entire length, except where passing through a ceiling when they must be protected with a properly bushed non-flammable tube. Flexible cords must never be held in position by means of insulated staples. Connections between flexible cords and cables shall be effected with an insulated connector, and this connector must be enclosed in a box or in part of a luminaire. If an extension of a flexible cord is made with a flexible cord connector consisting of pins and sockets, the sockets must be fed from the supply, so that the exposed pins are not alive when disconnected from the sockets. All flexible cords used for portable appliances shall be of the sheathed circular type and, therefore twisted cords must not be used for portable handlamps, floor and table lamps, etc. All flexible cords should be frequently inspected, especially at the point where they enter lampholders and other accessories, and renewed if found to be unsatisfactory. Flexible cords used in workshops and other places subjected to risk of mechanical damage shall be sheathed or armoured.

7.2.3.2 Where flexible cords support luminaries the maximum weight which may be supported is as follows:

Nominal Cross-sectional Area of Flexible Cord mm^2 (1)	*Maximum Permissible Weight* kg (2)
0.5	2
0.75	3
1.0	5

If necessary two or more flexible cords shall be used so that the weight supported by any cord does not exceed the above values.

7.2.3.3 In kitchens and sculleries, and in rooms with a fixed bath, flexible cords shall be of the PVC sheathed or an equally waterproof type.

7.2.3.4 In industrial premises luminaries 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:

Nominal Cross-sectional Area of Twin Cord mm^2 (1)	*Maximum Permissible Weight* kg (2)
0.5	2
0.75	3
1.0	5
1.5	5.3
2.5	8.8
4.0	14.0

7.2.3.5 Where the temperature of the luminaire is likely to exceed 60° C, special heat-resisting flexible cords should be used, including for pendant or enclosed type luminaries. The flexible cord should be insulated with heatproof insulation such as butyl or silicone rubber. Ordinary PVC insulated cords are not likely to withstand the heat given off by tungsten filament lamps. Flexible cords feeding electric heaters must also have heatproof insulation such as butyl or silicone rubber.

7.3 Lamp Holders

7.3.1 Insulated lampholders should be used wherever possible. Lampholders fitted with switches must be controlled by a fixed switch or socket outlet in the same room. Lamp holder should conform to relevant Indian Standards.

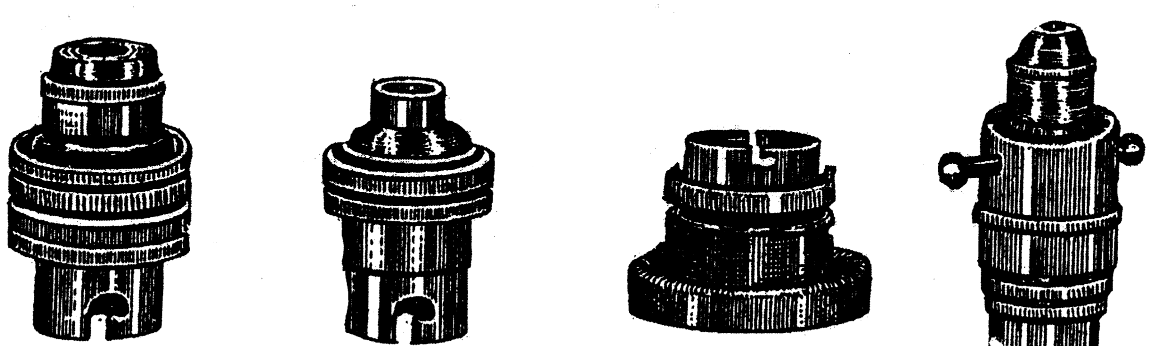
7.3.2 Lamp holders for use on brackets and the like shall be in accordance with Indian Standards and all those for use with flexible pendants shall be provided with cord grip. All lampholders shall be provided with shade carriers. The outer screwed contact of Edison screw-type lampholders must always be connected to the neutral of the supply. Small Edison screw lampholders must have a protective device not exceeding 6 A, but the larger sizes may have a protective device not exceeding 16 A. The small Bayonet Cap (BC) lampholder must have a protective device not exceeding 6 A, and for the larger BC lampholders the protective device must not exceed 16 A. Figure 58 shows different types of BC lamp holders.

7.3.3 No lampholder may be used on circuits exceeding 250 V and all metal lampholders must have an earth terminal. In bathrooms and other positions where there are stone floors or exposed extraneous conductive parts, lampholders should be fitted with insulated skirts to prevent inadvertent contact with live pins when a lamp is being removed or replaced.

7.4 Lamps

7.4.1 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 relevant Indian Standards. 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 lamp holder or handle. Metallic guards shall be earthed suitably.

7.4.2 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 jacketed type of cord is used. All wiring shall be free



58A Pendant Holder 58B Bracket Holder 58C Batten Holder 58D Push-pull Holder

FIG. 58 DIFFERENT TYPES OF BAYONET HOLDERS from short-circuits and shall be tested for these defects prior to being connected to the circuit. 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 atleast 125 mm between live parts and the mounting plane of the fixture.

7.4.3 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 lamp holders 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.

7.5 Socket Outlets and Plugs

7.5.1 Socket outlets are used for circuits not exceeding 250 V. Figure 59 shows various accessories and their use. Each 16A socket-outlet provided in buildings for the use of domestic appliances shall be provided with its own individual fuse or miniature circuit-breaker (MCB), 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 or MCB as an integral part of it. Each socket-outlet shall also be controlled by a switch which shall preferably be located immediately adjacent thereto or combined therewith. The switch controlling the socket-outlet shall be on the live side of the line. Ordinary socket-outlet may be fixed at any convenient place at a height above 20 cm from the floor level and shall be away from danger of mechanical injury. Socket outlets installed in old people's homes and in domestic premises likely to be occupied by old or disabled people, should be installed at not less than 1 m from floor level.

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 16 A and above shall preferably be provided with interlocked type switch. Socket outlets should conform to relevant Indian Standards.

7.5.2 In an earthed system of supply, a socket-outlet with plug shall be of three-pin type with the third 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

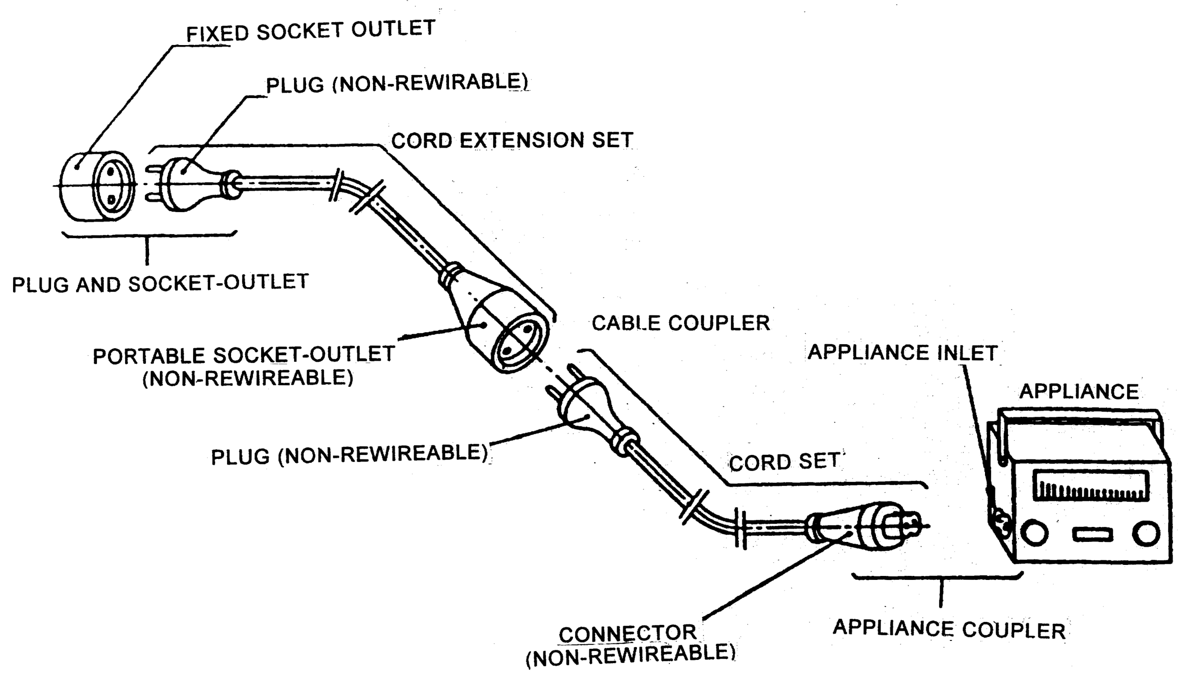


Fig. 59 Plug Socket Outlet and Associated Accessories

pins required for the purpose. In wiring installations, metal clad switch, socket-outlet and plugs shall be used for power wiring.

A recommended schedule of socket-outlets in a residential building is given at Table 2 of Part 3 of this Code.

Although 16 A socket-outlet is extensively used in industrial premises, other industrial type socket-outlets include single-phase and three-phase sockets with ratings up to 125 A.

The low voltage electrical equipment (safety) standards require equipment to be safe. Any part intended to be electrified should be adequately protested such that it is not accessible to a finger, including that of a child. This protection can be achieved by partly shrouding the live pins of plugs so that when the plug is in the process of being inserted even the smallest finger cannot make contact with live metal.

When installing socket outlets the cables must be connected to the correct terminals, which are;

a) red wire (phase or outer conductor) to terminal marked L.
b) black wire (neutral or middle conductor) to terminal marked N.
c) yellow/ green earth wire to terminal marked E.

7.5.3 If wrong connections are made to socket outlets it may be possible for a person to receive an electric shock from an appliance when it is switched off. Socket-outlet adaptors which enable two or more appliances to be connected to a single socket should contain fuses to prevent the socket-outlet from becoming overloaded.

7.6 Switches

7.6.1 There are various types of switches available, the most common being the 6 A switch which is used to control lights. There is also the 16 A switch for circuits carrying heavier currents. For ac circuits the micro-gap switch is also being used; it is much smaller than the older type and more satisfactory for breaking inductive loads.

Quick-make and slow-break switches are recommended for ac. A quick-break switch connected to an ac supply and loaded near to its capacity will tend to break down to earth when used to switch off an inductive load (such as fluorescent lamps).

7.6.2 In a room containing a fixed bath, switches must be fixed out of reach of the person in the bath, preferably out side the door, or be of the ceiling type operated by a cord. All single pole switches shall be fitted in the same conductor though out the installation, which shall be the phase conductor of the supply.

7.6.3 In damp situations, every switch shall be of the waterproof type with suitable screwed entries or glands to prevent moister entering the switch. To prevent condensed moisture from collecting inside a watertight switchbox, a very small hole should be drilled in the lowest part of the box to enable the moisture to drain away.

7.6.4 Flame proof switches must be fitted in all positions exposed to flammable or explosive dust, vapour, gas.

7.7 Fans

7.7.1 *Ceiling Fans*

Ceiling fans including their suspension shall conform to Indian Standards. The following should be adhered to during installation:

a) Control of a ceiling fan shall be through its own regulator as well as a switch in series.
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 1.0 mm^2 copper or 1.5 mm^2 aluminium 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.

NOTE — All fan clamps shall be so fabricated that fans revolve steadily.

7.7.2 *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 neatly 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.

7.7.3 *Fannage*

7.7.3.1 Where ceiling fans are provided, the bay sizes of a building, which control fan point locations, play an important part. Fans 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 could 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, such as air circulators or bracket fans would 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.

7.7.3.2 Proper air circulation could 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.

Exhaust fans are necessary for spaces, such as community toilets, kitchens, canteens and godowns to provide the required number of air changes (*see* Part 1/Sec 11 of this 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 site.

Positioning of fans and light fittings shall be chosen to make these effective without causing shadows and stroboscopic effect on the working planes.

ANNEX A
(*Clause* 2)

LIST OF INDIAN STANDARDS RELATED TO INSTALLATION

IS No.	*Title*
371 : 1999	Ceiling roses — Specification
732 : 1989	Code of practice for electrical wiring installations
1255 : 1983	Code of practice for installation and maintenance of power cables upto and including 33 kV rating
1293 : 2005	Plugs and socket-outlets of rated voltages up to and including 250 V and rated current up to and including 16 A — Specification
1646 : 1997	Code of practice for fire safety of buildings (general): Electrical installations
2412 : 1975	Link clips for electrical wiring
2667 : 1988	Fittings for rigid steel conduits for electrical wiring
3043 : 1987	Code of practice for earthing
3419 : 1988	Fittings for rigid non-metallic conduits
3480 : 1966	Flexible steel conduits for electrical wiring
3808 : 1979	Method of test for non-combustibility of building materials
3837 : 1976	Accessories for rigid steel conduits for electrical wiring

IS No.	*Title*
3854 : 1997	Switches for domestic and similar purposes
3961	Recommended current ratings for cables:
(Part 1) : 1967	Paper insulated lead sheathed cables
(Part 2) : 1967	PVC insulated and PVC sheathed heavy duty cables
(Part 3) : 1968	Rubber insulated cables
(Part 5) : 1968	PVC insulated light duty cables
4289	Specification for flexible cables for lifts and other flexible connections:
(Part 1) : 1984	Elastomer insulated cables
(Part 2) : 2000	PVC insulated circular cables
4649 : 1968	Adaptors for flexible steel conduits
5571 : 2000	Guide for selection of electrical equipment for hazardous areas
5572 : 1994	Classification of hazardous areas (other than mines) having flammable gases and vapours for electrical installation
6946 : 1990	PVC insulated cables for working voltages upto and including 1100 V
8130 : 1984	Conductors for insulated electric cables and flexible cords
8623	Specification for low-voltage switchgear and controlgear assemblies:
(Part 1) : 1993/ IEC 60439-1 : 1985	Requirements for type-tested and partially type-tested assemblies
(Part 2): 1993/ IEC 60439-2 : 1987	Particular requirements for busbar trunking systems (busway)
(Part 3) : 1993/ IEC 60439-3 : 1990	Particular requirements for equipment where unskilled persons have access for their use
9537	Conduits for electrical installations:
(Part 2) : 1981	Rigid steel conduits
(Part 3) : 1983	Rigid plain conduits of insulating materials
(Part 4) : 1983	Pliable self-recovering conduits of insulating materials
(Part 5) : 2000	Pliable conduits of insulating material
(Part 6) : 2000	Pliable conduits of metal or composite materials
(Part 8) : 2003	Rigid non-threadable conduits of aluminium alloy
11000 (Part2/ Sec1) : 1984 / IEC 695-2-1 : 1980	Fire hazard testing: Part 2 Test methods, Section 1 Glow-wire test and guidance
11353 : 1985	Guide for uniform system of marking and identification of conductors and apparatus terminals
13703 (Part 1) : 1993 /IEC 269-1 : 1986	LV Fuses for voltages not exceeding 1000 V ac or 1500 V dc: Part 1 General requirements
14255 : 1995	Aerial bunched cables for working voltages upto and including 1 100 V — Specification
14763 : 2000	Conduits for electrical purposes — Outside diameters of conduits for electrical installation and threads for conduits and fittings — Specification
14768 (Part 1) : 2000	Conduit fittings for electrical installations — Specification: Part 1 General requirements
14772 : 2000	General requirements for enclosures of accessories for household and similar fixed electrical installations — Specifications for an accessory or luminaries
14927	Cable trunking and ducting systems for electrical installations:
(Part 1) : 2001	General requirements
(Part 2) : 2001	Cable trunking and ducting systems intended for mounting on walls or ceilings
14930	Conduit systems for electrical installations:
(Part 1) : 2001	General requirements
(Part 2) : 2001	Particular requirements — Conduit systems buried underground
SP 69 : 2000	Banking and related financial services — Information security guidelines

ANNEX B

(*Clause* 6.7.1.0)

CLASSIFICATION CODING FOR CONDUIT SYSTEMS

The classification coding format for declared properties of the conduit system which may either be incorporated in the manufacturer's literature or marked on the product shall be as shown below. When the conduit is marked with the classification code, it includes at least the first four digits.

a) First digit — Resistance to compression

[*See* **6.1.1** of IS 14930 (Part 1)]

Very light compression strength	1
Light compression strength	2
Medium compression strength	3
Heavy compression strength	4
Very heavy compression strength	5

b) Second digit — Resistance to impact

[*See* **6.1.2** of IS 14930 (Part 1)]

Very light impact strength	1
Light impact strength	2
Medium impact strength	3
Heavy impact strength	4
Very heavy impact strength	5

c) Third digit — Lower temperature range

[*See* Table 1 of IS 14930 (Part 1)]

+ 5°C	1
– 5°C	2
–15°C	3
–25°C	4
–45°C	5

d) Fourth digit — Upper temperature range

[*See* Table 2 of IS 14930 (Part 1)]

+ 60°C	1
+ 90°C	2
+ 105°C	3
+ 120°C	4
+ 150°C	5
+ 250°C	6
+ 400°C	7

e) Fifth digit — Resistance to bending

[*See* **6.1.3** of IS 14930 (Part 1)]

Rigid	1
Pliable	2
Pliable/Self recovering	3
Flexible	4

f) Sixth digit — Electrical characteristics

[*See* **6.3** of IS 14930 (Part 1)]

None declared	0
With electrical continuity characteristics	1
With electrical insulating characteristic	2
With electrical continuity and insulating characteristics	3

g) Seventh digit — Resistance to ingress of solid objects

[*See* **6.4.1** of IS 14930 (Part 1)]

Protected against solid foreign objects 2.5 mm diameter and greater	3
Protected against solid foreign objects 1.0 diameter and greater	4
Dust protected	5
Dust tight	6

h) Eight digit — Resistance to ingress of water

[*See* **6.4.2** of IS 14930 (Part 1)]

None declared	0
Protected against vertically falling water drops	1
Protected against vertically falling water drops when conduit system tilted up to an angle of 15°	2
Protected against spraying/ water	3
Protected against splashing water	4
Protected against water jets	5
Protected against powerful water jets	6
protected against the effects of temporary immersion in water	7

j) Ninth digit — Resistance against corrosion

[*See* **6.4.3** of IS 14930 (Part 1)]

Low protection inside and outside	1
Medium protection inside and outside	2
Medium protection inside, high protection outside	3
High protection inside and outside	4

k) Tenth digit — Tensile strength

[*See* **6.1.4** of IS : 14930 (Part 1)]

None declared	0
Very light tensile strength	1
Light tensile strength	2
Medium tensile strength	3
Heavy tensile strength	4
Very heavy tensile strength	5

m) Eleventh digit — Resistance to flame propagation

[*See* **6.5** of IS 14930 (Part 1)]

Non-flame propagating	1
Flame propagating	2

n) Twelfth digit — Suspended load capacity

[*See* **6.1.5** of IS 14930 (Part 1)]

None declared	0
Very light suspended load capacity	1
Light suspended load capacity	2
Medium suspended load capacity	3
Heavy suspended load capacity	4
Very heavy suspended load capacity	5

p) Thirteenth digit — Fire effects

(Under consideration)

SECTION 10 SHORT-CIRCUIT CALCULATIONS

0 FOREWORD

Circuit calculations are performed for checking the adequacy of the electrical equipment for any electrical system that is characterized by the type of distribution system comprising of transformers, bus, cables etc.

The essential requirements and methods associated with following calculations are covered in this Section:

a) Short circuit calculations in 3 phase ac systems.
b) Current carrying capacity and Voltage drop calculations for cables and flexible cords.

Assistance for this Section has been derived from the following standards:

IS No.	*Title*
13234 : 1992	Guide for short circuit calculation in three phase ac systems
13235 : 1991/ IEC 865 (1986)	Calculation of the effects of short circuit currents

1 SCOPE

This Part 1/Section 10 covers guidelines and general requirements associated with circuit calculations, namely, short circuit calculations and voltage drop calculations for cables and flexible cords.

2 REFERENCES

The following Indian Standards have been referred in this Section:

IS No.	*Title*
2086 : 1993	Carriers and bases used in rewirable type electric fuses for voltages upto 650V
9926 : 1981	Fuse wires used in rewirable type electric fuses upto 650 V
13703 (Part 2/ Sec 1) : 1993/IEC 60269-2 : 1986	Specification for low-voltage fuses for voltages not exceeding 1 000 V ac or 1 500 V dc : Part 2 Fuses for use by authorized persons, Section 1 Supplementary requirements
13703 (Part 2/ Sec 2) : 1993/IEC 60269-2 : 1987	LV fuses for voltages not exceeding 1000 V ac or 1500 V dc: Part 2 Fuses for use by authorized persons, Section 2 Examples of standardized fuses
IS/IEC 60898-1 : 2002	Electrical accessories—Circuit breakers for over protection for household and similar installations: Part 1 Circuit breakers for ac operation

3 GENERAL CONSIDERATIONS

3.0 General

3.0.1 This subject of circuit calculations covers the guidelines relating to the short circuit withstand capability of the electrical equipment and to check permissible voltage drop in cables and flexible cords upto the equipment terminals.

3.0.2 The objective of the circuit calculation is to ensure that the selection of equipment under consideration is designed for safe and reliable long period of operation.

4 CIRCUIT CALCULATIONS

4.1 Short Circuit Calculations

4.1.1 *Design Considerations*

4.1.1.1 A complete calculation of the short-circuit currents should give the currents as a function of time at the short circuit location from the initiation of the short circuit up to its end, corresponding to the instantaneous value of the voltage at the beginning of the short-circuit.

4.1.1.2 In most of the practical cases it is sufficient to determine the r.m.s value of symmetrical AC component and the peak value i_p of the short-circuit current following the occurrence of a short circuit. The value of i_p depends on time constant of the decaying aperiodic component i_{DC} with frequency depending on the X/R ratio of the short-circuit impedance.

4.1.1.3 For determination of asymmetrical short-circuit breaking current, the decaying aperiodic component i_{DC} may be calculated with sufficient accuracy by:

$$i_{DC} = \sqrt{2}\, I''_k e^{-2\pi f t \tau}$$

where

I''_k = initial symmetrical short circuit current (A),
f = nominal system frequency (Hz),
t = time duration of fault(s), and
τ = time constant based on system X/R.

4.1.1.4 The calculation of maximum and minimum short circuit current are based on the following considerations:

a) For the duration of the short-circuit there is no change in the number of circuits involved, that is, a three phase short-circuit remains as three phase and similarly a line-to-earth short-circuit remains line-to-earth during the short circuit.

b) Tap changers of the transformer are at nominal position.

c) Arc resistances are not taken into account.

4.1.1.5 In situations where there will be no significant change in ac component decay due to far distance from generator (*see* Fig. 1), short-circuit current can be considered as the sum of the following two components:

a) The ac component with constant amplitude during the whole short-circuit.

b) The aperiodic component beginning with initial value *A* and decaying to zero.

4.1.1.6 For the systems where there will be significant change in ac component decay due to close location near Generator (*see* Fig. 2), short circuit-current can be considered as the sum of the following two components:

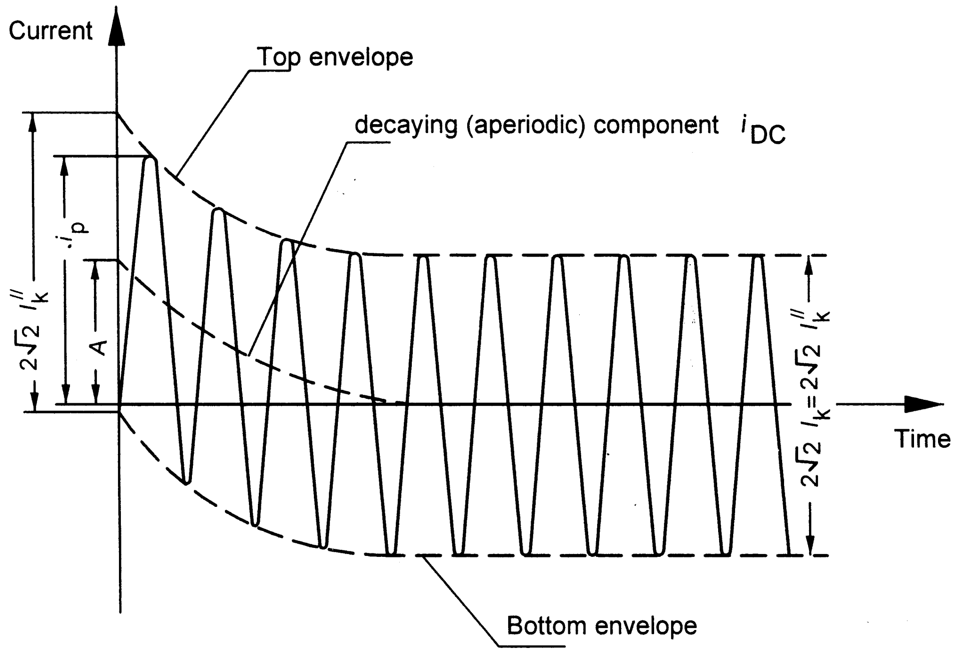
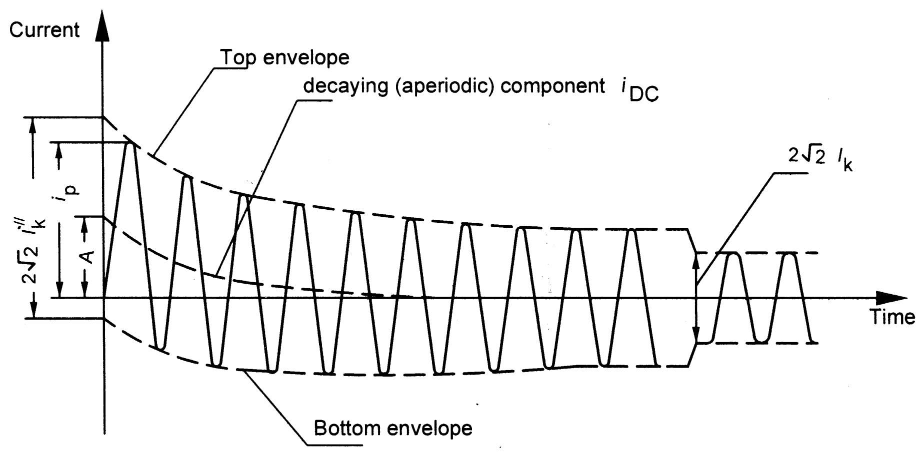


FIG. 1 SHORT-CIRCUIT CURRENT AT A SYSTEM FAR-FROM-GENERATOR



I''_k = initial symmetrical short-circuit current
i_p = peak short-circuit current
I_k = steady-state short-circuit current
i_{DC} = decaying (aperiodic) component of short-circuit current
A = initial value of the aperiodic component i_{DC}

FIG. 2 SHORT-CIRCUIT CURRENT AT A SYSTEM NEAR-TO-GENERATOR

a) The ac component with decaying amplitude during the whole short circuit.

b) The aperiodic component beginning with initial value *A* and decaying to zero.

4.1.2 *Calculation Methods*

4.1.2.1 *General*

Equivalent circuits are to be drawn for the system before calculation of short-circuit current with example as per Fig. 3.

4.1.2.1.1 *Balanced short-circuit*

The balanced three-phase short-circuit of a three-phase ac system often leads to the highest values of prospective (available) short-circuit current and the calculation becomes particularly simple on account of the balanced nature of the short circuit.

In calculating the short-circuit current, it is sufficient to take into account only the positive sequence short-circuit impedance, $Z_{(1)} = Z_k$ as seen from the fault location.

4.1.2.1.2 *Unbalanced short-circuit*

The following types of unbalanced (asymmetrical) short-circuits are to be considered:

a) line-to-line short-circuit without earth connection

b) line-to-line short-circuit with earth connection

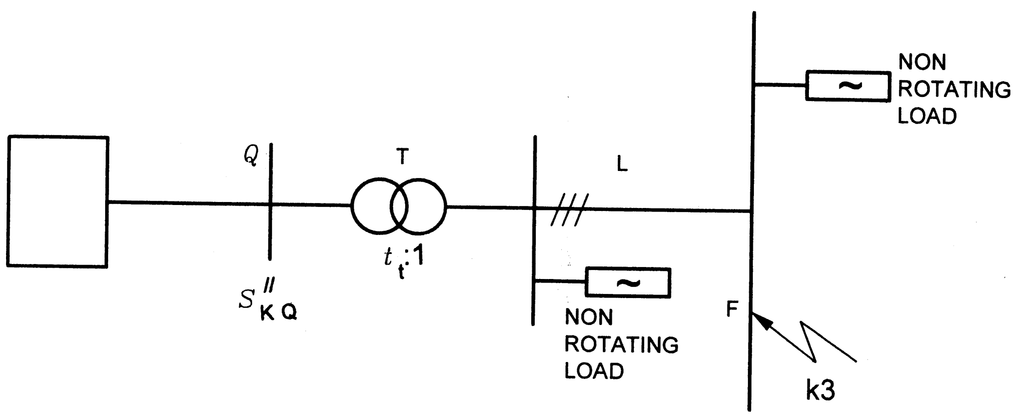
c) line-to-earth short-circuit

Normally, the three-phase short-circuit current is the largest among the above listed type of faults. In the event of a short-circuit near to a transformer with neutral earthing or a neutral earthing transformer, the line-to-earth short-circuit current may be greater than the three-phase short-circuit current. This applies in particular to transformers of vector group Yz, Dy and Dz when earthing the y- or z-winding on the low voltage side of the transformer.

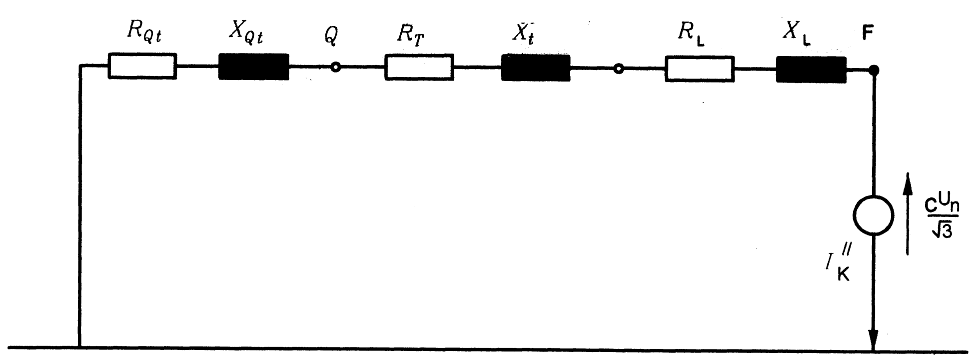
In three-phase systems the calculation of the current values resulting from unbalanced short-circuits is simplified by the use of the method of symmetrical components which requires the calculation of three independent system components, avoiding any coupling of mutual impedances.

Using this method, the currents in each line are found by superposing the currents of three symmetrical component systems:

a) positive-sequence current $\underline{I}_{(1)}$,



3A System Diagram



3B Equivalent Circuit Diagram (Positive Sequence System)

FIG. 3 ILLUSTATION FOR CALCULATING THE INITIAL SYMMETRICAL SHORT-CIRCUIT CURRENT $\underline{I}''_K$ IN COMPLIANCE WITH THE PROCEDURE FOR THE EQUIVALENT VOLTAGE SOURCE

b) negative-sequence current $\underline{I}_{(2)}$, and
c) zero-sequence current $\underline{I}_{(0)}$.

Taking the line L1 as reference the currents $\underline{I}_{L1}$, $\underline{I}_{L2}$ and $\underline{I}_{L3}$ are given by:

$$\underline{I}_{L1} = \underline{I}_{(1)} + \underline{I}_{(2)} + \underline{I}_{(0)} \quad (1a)$$
$$\underline{I}_{L2} = \underline{a}^2\,\underline{I}_{(1)} + \underline{a}\,\underline{I}_{(2)} + \underline{I}_{(0)} \quad (1b)$$
$$\underline{I}_{L3} = \underline{a}\,\underline{I}_{(1)} + \underline{a}^2\,\underline{I}_{(2)} + \underline{I}_{(0)} \quad (1c)$$

Each of the three symmetrical component systems has its own impedance.

The method of the symmetrical components postulates that the system impedances are balanced, for example in the case of transposed lines. The results of the short-circuit calculation have an acceptable accuracy also in the case of un-transposed lines.

4.1.2.1.3 *Short-circuit impedances*

While calculating the impedances, there shall be clear distinction between short-circuit impedances at the short-circuit location and short-circuit impedances of individual electrical equipment. Accordingly the calculations with symmetrical components namely, positive-sequence, negative-sequence and zero-sequence short-circuit impedances to be performed.

4.1.3 *Effects Due to Short Circuit*

4.1.3.1 *The electromagnetic effect on rigid and slack (line) conductors*

With the calculation methods, forces on insulators, stresses in rigid conductors and tensile forces in slack conductors are to be estimated.

4.1.3.1.1 *Mechanical forces due to short-circuit currents*

Currents in parallel conductors will induce electromagnetic forces between the conductors. When the parallel conductors are long compared to the distance between them, the forces will act evenly distributed along the conductors.

When the currents are in opposite directions the electromagnetic force is a repulsion which tends to induce deformations that would increase inductance of the circuit.

The value of the force in a given direction can be calculated by considering the work done in the case of a virtual displacement in the actual direction. As the work is done by the electromagnetic force, it must be equal to the change in the energy in the magnetic field caused by this virtual displacement.

The force between two conductors is proportional to the square of the current, or to the product of the two currents. As the current is a function of time, the force will also be a function of time. In the case of a short-circuit current without a dc component the force will vary with twice the frequency of the current. A dc component in the short-circuit current will give rise to an increase of the peak value of the force and to a component of force varying with the same frequency as the current. The peak value of the force is of particular interest in the case of mechanically rigid structures.

The force will result in bending stress on rigid conductors, tension stress and deflection in flexible conductors and bending, compression or tension loads on the supports.

4.1.3.1.2 *Stresses in rigid conductors and forces on supports*

The conductors may be supported in different manners, either fixed or simple or in a combination of both, and may have two, three, four or several supports. Depending on the kind of support and the number of supports, the stress in the conductors and the forces on the supports will be different for the same short-circuit current.

The stresses in the conductors and the forces on supports also depend on the ratio between the natural frequency of the mechanical system and the frequency of the electromagnetic force. Especially in the case of resonance, or near to resonance, the stresses and forces in the system may be amplified.

4.1.3.1.3 *Tensile forces in slack conductors (line conductors)*

A short-circuit current in a slack conductor will cause a tensile force in the conductor which will affect insulators, support structures and apparatus. It is necessary to distinguish between the tensile force during short-circuit and the tensile force after short-circuit, when the conductor falls back to its initial position.

4.1.3.2 *Thermal effect on bare conductors*

The heating of conductors due to short-circuit currents involves several phenomena of a non-linear character and other factors that have to be either neglected or approximated in order to make a mathematical approach possible.

For the purpose of this calculation, the following assumptions can been made:

a) Proximity-effect (magnetic influence of nearby parallel conductors) has been disregarded.
b) Resistance-temperature characteristic has been assumed linear.

c) The specific heat of the conductor is considered constant.
d) The heating is generally considered adiabatic.

4.1.3.2.1 *Calculation of temperature rise*

The loss of heat from a conductor during the short-circuit is very low, and the heating can generally be considered adiabatic. Hence the calculation for this can also be based on adiabatic conditions.

When repeated short-circuits occur with a short-time interval between them (that is rapid auto-reclosure) the cooling down in the short dead-time is of relatively low importance, and the heating can still be considered adiabatic. In cases where the dead-time interval is of longer duration (that is delayed auto-reclosure) the heat loss may be taken into account.

The calculation need not take into account the skin effect, that is the current is regarded as evenly distributed over the conductor cross-section area. This approximation is not valid for large cross-sections, and therefore for cross-sections above 600 mm^2 the skin effect shall be taken into account.

NOTE — If the main conductor is composed of sub-conductors, uneven current distribution between the sub-conductors will influence the temperature rise of sub-conductors.

4.1.3.2.2 *Calculation of thermal equivalent short-circuit current*

The thermal equivalent short-circuit current is to be calculated using the short-circuit current r.m.s. value and the factors *m* and *n* for the time-dependent heat effects of the dc and ac components of the short-circuit current

The thermal equivalent short-circuit current can be expressed by:

$$I_{\text{th}} = I''_{\text{k}} \sqrt{m+n}$$

where *m* and *n* are numerical factors, I''_{k} the r.m.s. value of the initial symmetrical short-circuit current; in a three-phase system, the balanced three-phase short-circuit is decisive. The values *m* and *n* are usually defined as functions of the duration of the short-circuit current. For a distribution network usually $n = 1$.

NOTE — The relation $I''_{\text{k}}/I_{\text{k}}$ is dependent on the impedance between the short-circuit and the source.

When a number of short-circuits occur with a short time interval in between, the resulting thermal equivalent short-circuit current is obtained from:

$$I_{\text{th}} = \sqrt{\frac{1}{T_{\text{k}}} \sum_{i=1}^{n} I_{\text{thi}}^2 \, T_{\text{ki}}}$$

and

$$T_{\text{k}} = \sum_{i=1}^{n} T_{\text{ki}}$$

4.1.3.2.3 *Calculation of temperature rise and rated short-time current density for conductors*

The temperature rise in a conductor caused by a short-circuit is a function of the duration of the short-circuit current, the thermal equivalent short-circuit current and the conductor material.

NOTE — The maximum permitted temperature of the support has to be taken into account.

4.1.3.2.4 *Calculation of the thermal short-circuit strength for different durations of the short-circuit current*

Electrical equipment has sufficient thermal short-circuit strength as long as the following relations hold for the thermal equivalent short-circuit current I_{th}:

$$I_{\text{th}} \leq I_{\text{thr}} \text{ for } T_{\text{k}} \leq T_{\text{kr}}$$

$$I_{\text{th}} < I_{\text{thr}} \sqrt{\frac{T_{\text{kr}}}{T_{\text{k}}}} \text{ for } T_{\text{k}} > T_{\text{k}}$$

where I_{thr} is the rated short-time current and T_{kr} the rated short-time.

The thermal short-circuit strength for a bare conductor is sufficient when the thermal equivalent short-circuit current density S_{th} satisfies the following relation:

$$S_{\text{th}} < S_{\text{thr}} \sqrt{\frac{T_{\text{kr}}}{T_{\text{k}}}}$$

With T_{kr} =1 s and for all T_{k}, the rated short time current density S_{thr} is shown in Fig 4.

4.2 Calculations for Current Carrying Capacity and Voltage Drop for Cables and Flexible Cords

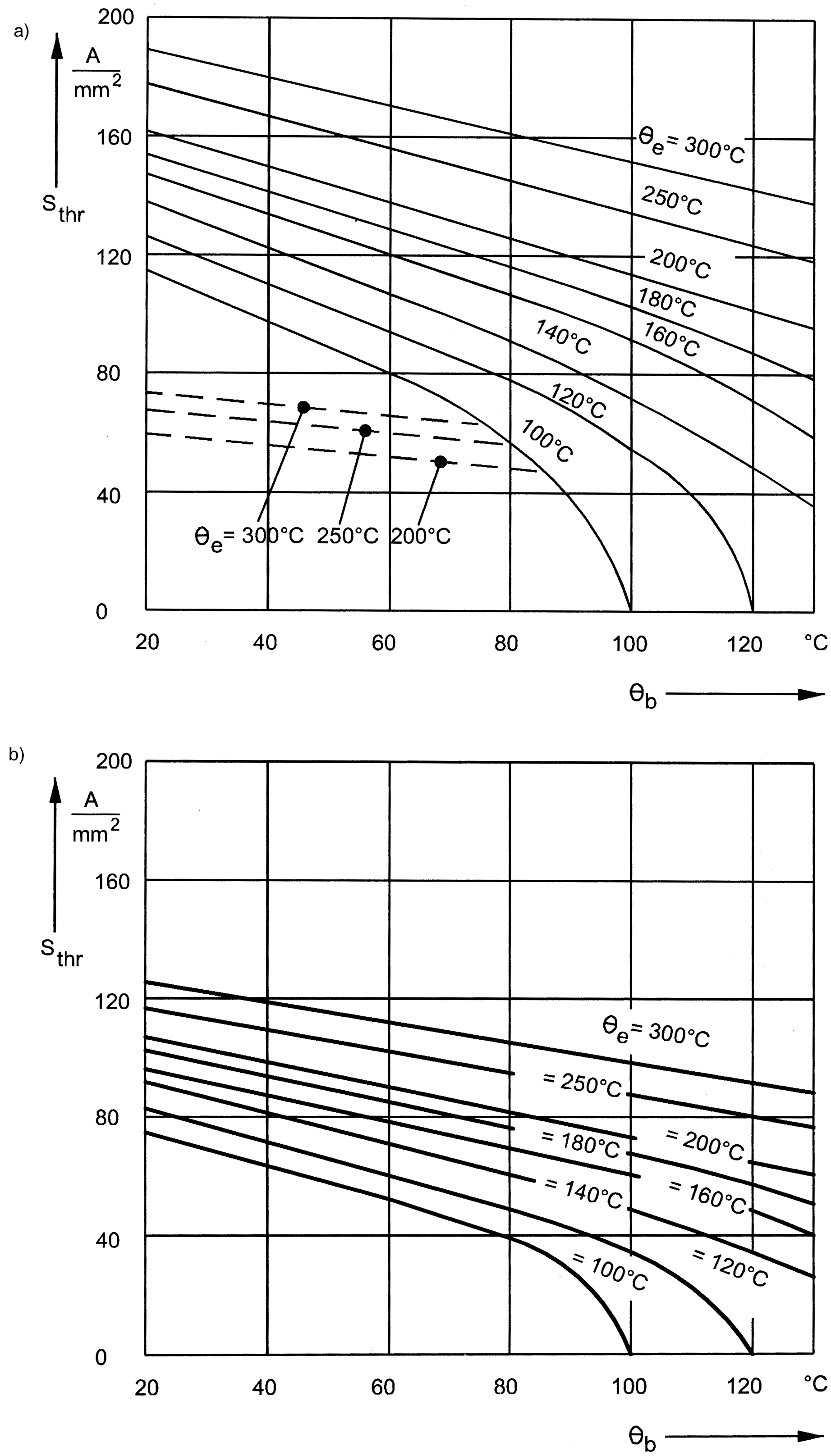
4.2.1 *Conductor Operating Temperature*

The current to be carried by any conductor for sustained periods during normal operation shall be such that the conductor operating temperature given in the appropriate table of current-carrying capacity in this section is not exceeded.

Where a conductor operates at a temperature exceeding 70 °C it shall be ascertained that the equipment connected to the conductor is suitable for the conductor operating temperature.

4.2.2 *Cables Connected in Parallel*

Except for a ring final circuit, cables connected in



a) *Full lines*: Copper

Dotted lines: Flat product of unalloyed steel and steel cables.

b) Aluminium, aluminium alloy, aluminium conductor steel reinforced (ACSR).

FIG. 4 RELATION BETWEEN RATED SHORT-TIME CURRENT DENSITY (T_{kr} =1 s) AND CONDUCTOR TEMPERATURE parallel shall be of the same construction, cross-sectional area, length and disposition, without branch circuits and arranged so as to carry substantially equal currents.

4.2.3 *Cables Connected to Bare Conductors or Bus Bars*

Where a cable is to be connected to a bare conductor or busbar its type of insulation and/or sheath shall be suitable for the maximum operating temperature of the bare conductor or busbar.

4.2.4 *Cables in Thermal Insulation*

Where a cable is to be run in a space to which thermal insulation is likely to be applied, the cable shall wherever practicable be fixed in a position such that it will not be covered by the thermal insulation. Where fixing in such a position is impracticable the cross-sectional area of the cable shall be appropriately increased.

For a single cable likely to be totally surrounded by thermally insulating material over a length of more than 0.5 m, the current-carrying capacity shall be taken, in the absence of more precise information, as 0.5 times the current-carrying capacity for that cable clipped direct to a surface and open.

Where a cable is to be totally surrounded by thermal insulation for less than 0.5 m the current-carrying capacity of the cable shall be reduced appropriately depending on the size of cable, length insulation and thermal properties of the insulation. The de-rating factors have to be appropriate to conductor sizes.

4.2.5 *Metallic Sheaths and/or Non-Magnetic Armour of Single-Core Cables*

The metallic sheaths and/or non-magnetic armour of single-core cables in the same circuit shall normally bonded together at both ends of their run (solid bonding). Alternatively the sheaths or armour of such cables having conductors of cross-sectional area exceeding 50 mm ^{2} and a non-conducting outer sheath may be bonded together at one point in their run (single point bonding) with suitable insulation at the un-bonded ends, in which case the length of the cables from the bonding point shall be limited so that, at full load, voltages from sheaths and/or armour to Earth,

a) do not exceed 25 V
b) do not cause corrosion when the cables are carrying their full load current, and
c) do not cause danger or damage to property when the cables are carrying short-circuit current.

4.2.6 *Correction Factors for Current-Carrying Capacity*

The current-carrying capacity of cable for continuous service is affected by ambient temperature and by frequency. This Clause provides correction factors in these respects as follows.

4.2.6.1 *Ambient temperature*

In practice the ambient air temperatures may be determined by thermometers placed in free air as close as practicable to the position at which the cables are installed or are to be installed, subject to the proviso that the measurements are not to be influenced by the heat arising from the cables; thus if the measurements are made while the cables are loaded, the thermometers should be placed about 0.5 m or ten times the overall diameter of the cable whichever is the lesser, from the cables, in the horizontal plane, or 150 mm below the lowest of the cables.

Where cables are subject to such radiation due to solar or other infra-red, the current-carrying capacity may need to be specially calculated.

4.2.6.2 *Grouping*

Appropriate correction factors to be applied to the manufacture declared current-carrying capacity where cables or circuits are grouped.

4.2.7 *Effective Current-Carrying Capacity*

The current-carrying capacity of cable corresponds to the maximum current that can be carried in specified conditions without the conductors exceeding the permissible limit of steady state temperature for the type of insulation concerned.

The values of current calculated represent the effective current-carrying capacity only where no correction factor is applicable. Otherwise the current-carrying corresponds to the value multiplied by the appropriate factors for ambient temperature, grouping and thermal insulation, as applicable.

Irrespective of the type of over current protective device associated with the conductors concerned, the ambient temperature correction factors to be used when calculating current-carrying capacity (as opposed to those used when selecting cable size).

4.2.8 *Overload Protection*

Where overload protection is required, the type of protection provided does not affect the current-carrying capacity of a cable for continuous service (I_z) but it may affect the choice of conductor size. The operating conditions of a cable are influenced not only by the limiting conductor temperature for continuous service, but also by the conductor temperature which might be attained during the conventional operating time of the overload protection device, in the event of an overload.

This means that the operating current of the protective device must not exceed $1.45I_z$. Where the protective device is a fuse as per IS 13703 (Part 2/Section 1) and IS 13703 (Part 2/Section 2) or IS 2086 or a miniature circuit breaker as per IS/IEC 60898, this requirement is satisfied by selecting a value of I_z not less than $I_{n.}$

In practice, because of the standard steps in nominal rating of fuse and circuit breakers, it is often necessary to select a value of I_n exceeding I_b. In that case, because it is also necessary for I_z in turn to be not less than the selected value of In, the choice of conductor cross-sectional area maybe dictated by the over load conditions and the current-carrying capacity (I_z) of the conductors will not always by fully used.

The size needed for a conductor protected against overload by a IS 9926 fuse fix in rewirable type fuse can be obtained by the use of a correction factor, 1.45/2 = 0.725 which results in the same degree of protection as that afforded by other overload protective devices. This factor is to be applied to the nominal rating of the fuse as a divisor, thus indicating the minimum value of I_t required of the conductor to be protected. In this case also, the choice of conductor size is dictated by the overload conditions and the current carrying capacity (I_z) of the conductors can not be fully used.

4.2.9 *Determination of the Size of Cable to be Used*

Having established the design current (I_b) of the circuit under consideration, the conductor size has to be sized necessarily from consideration of the conditions of normal load and overload is then determined. All correction factors affecting I_z (that is, the factor for ambient temperature, grouping and thermal insulation) can, if desired, be applied to the values of I_t as multipliers. This involves a process of trial and error until a cross-sectional area is reached which ensures that I_z is not less than I_b and not less than I_n of any protective device it is intended to select. In any event, if a correction factor for protection by a semi-enclosed fuse is necessary, this has to be applied to I_n as a divisor. It is therefore more convenient to apply all the correction factors to I_n as divisors.

4.2.10 *Voltage Drop in Consumers' Installations*

4.2.10.1 *Acceptable values of voltage drop*

Under normal service conditions the voltage at the terminals of any fixed current-using equipment shall be greater than the lower limit corresponding to the Indian Standard relevant to the equipment.

Where the fixed current-using equipment concerned is not the subject of Indian Standard the voltage at the terminals shall be such as not to impair the safe functioning of the equipment.

The requirements are deemed to be satisfied for a supply given if the voltage drop between the origin of the installation (usually the supply terminal) and the fixed current-using equipment does not exceed 5 percent of the normal voltage of the supply.

A greater voltage drop may be accepted for a motor during starting periods and for other equipment with high in-rush currents provided it is verified that the voltage variations are within the limits specified in the relevant Indian Standards for the equipment or, in the absence of an Indian Standard, in accordance with the manufacturer's recommendations.

4.2.10.2 *Calculation of voltage drop*

For a given run, to calculate the voltage drop (mV/A/m) the value for the cable concerned has to be multiplied by the length of the run in metres and by the current the cable is intended to carry, namely the design current of the circuit (I_b) in amperes.

For three-phase circuits the calculated mV/A/m values relate to the line voltage and balanced conditions have to be assumed.

The direct use of the calculated $(m/V/A/m)_r$ or $(mV/A/m)_z$ values, as appropriate may lead to pessimistically high calculated values of voltage drop or, in other words, to unnecessarily low values of permitted circuit lengths.

Where the design current of a circuit is significantly less than the effective current-carrying capacity of the cable chosen, the actual voltage drop would be less than the calculated value because the conductor temperature (and hence its resistance) will be less than that on which the calculated mV/A/m had been based.

In some cases it may be advantageous to take account of the load power factor when calculating voltage drop.

4.2.10.3 *Correction Factor for operating temperature*

For cables having conductors of cross-sectional area 16 mm^2 or less the design value of mV/A/m is obtained by multiplying the calculated value by a factor C_t, given by

$$C_t = \frac{230 + t_p - \left(C_a{}^2 C_g{}^2 - \dfrac{I_b{}^2}{I_t{}^2} \right)\left(t_p - 30\right)}{230 + t_p}$$

where t_p = maximum permitted normal operating temperature, in ° C.

NOTE — For convenience, the above formula is based on the resistance-temperature coefficient of 0.004 per °C at 20°C for both copper and aluminum conductors.

For very large conductor sizes where the resistive component of voltage drop is much less than the corresponding reactive part (that is when $x/r \geq 3$) this correction factor need not be considered.

4.2.10.4 *Correction for load power factor*

For cables having conductors of cross-sectional area of 16 mm² or less the design value of mV/A/m is obtained approximately by multiplying the calculated value by the power factor of the load, cos φ.

For cables having conductors of cross-sectional area greater than 16 mm² the design value of m/V/A/m is approximately:

Cos φ [Calculated $(m/V/A/m)_r$] + sin φ [Calculated $(m/V/A/m)_x$]

For single-core cables in flat formation the calculated values apply to the outer cables and may under-estimate for the voltage drop between an outer cable and the centre cable for cross-sectional areas above 240 mm² and power factors greater than 0.8.

4.2.10.5 Combined correction for both operating temperature and load power factor

Where it is considered appropriate to correct the calculated mV/A/m value so for both operating temperature and load power factor, the design values of mV/A/m are given by:

a) for cable having conductors of 16 mm² or less cross-sectional area

   C_t cos φ (Calculated mV/A/m)

b) for cables having conductors of cross-sectional area greater than 16 mm²

   C_t cos φ (Calculated $mV/A/m)_r$) + sin φ

SECTION 11 ELECTRICAL ASPECTS OF BUILDING SERVICES

0 FOREWORD

Most of the modern day services in buildings depend on electrical energy. These services, broadly; are:

a) Lighting and ventilation,
b) Air-conditioning and heating, and
c) Lifts and escalators.

From the point of view of conservation of energy and safety in its use, it is found essential to draw attention to essential design principles for building services.

Apart from the three major power consuming services in a building there are other functional/safety services that are basically light current installations, whose proper functioning is important. These are:

a) Electrical audio systems,
b) Fire-alarm and fighting systems,
c) Electric call-bell systems,
c) Electric clock systems,
d) Computer system,
e) Telephone systems, and
f) Building management systems.

Attention should be paid to the requirements to be complied within the design and construction of building services. This Section provides basic information on the electrical aspects of building services. Further details can be had from the relevant Indian Standards.

1 SCOPE

This Part 1/Section 11 of the Code covers requirements for installation work relating to building services that use electric power.

NOTE — SP 7 'National Building Code of India' should be referred for non-electrical aspects of building services.

2 REFERENCES

A list of Indian Standards related to building services is given at Annex A.

3 GENERAL GUIDELINES

3.1 Extensive guidelines on building design aspects have been covered in SP 7 from the point of view of ensuring economic services in an occupancy. These shall be referred to from the point of view of ensuring good design of building services and early coordination amongst all concerned.

3.2 Orientation of Building

3.2.1 The chief aim of orientation of buildings is to provide physically and psychologically comfortable living inside the buildings by creating conditions which suitably and successfully ward off the undesirable effects of severe weather to a considerable extent by judicious use of the recommendations and knowledge of climatic factors.

3.2.2 From the point of view of lighting and ventilation, the following climatic factors influence the optimum orientation of the buildings:

a) Solar radiation and temperature,
b) Clouds,
c) Relative humidity, and
d) Prevailing winds.

IS 7662 (Part 1) gives recommendations on orientation of buildings.

4 ASPECTS OF LIGHTING SERVICES

4.1 Principles of Good Lighting

4.1.1 Good lighting is necessary for all buildings and has three primary aims. The first is to promote the work and other activities carried on within the buildings; the second is to promote the safety of people using the building; and the third is to create, in conjunction with the structure and decoration, a pleasing environment conducive to interest and a sense of well-being.

Realization of these aims involves:

a) Careful planning of the brightness and colour patterns within the working area and the surroundings so that attention is drawn naturally to the important areas, detail is seen quickly and accurately and the room is free from any sense of gloom or monotony.
b) Using directional lighting, where appropriate, to assist preception of task detail and to give good modelling.
c) Controlling direct and reflected glare from light sources to eliminate visual discomfort,
d) In artificial lighting installations, minimizing flicker from certain types of lamp and paying attention to the colour rendering properties of the light.
e) Correlating lighting throughout the building to prevent excessive differences between adjacent areas and so as to reduce the risk of accidents, and

f) Installing emergency lighting systems where necessary.

4.1.2 Good lighting design shall take into account the following:

a) Planning the brightness pattern from the point of view of visual performance, safety and amenity and surroundings;
b) Form of texture in the task area and surroundings;
c) Controlling glare, stroboscopic effect and flicker;
d) Colour rendering;
e) Lighting for movement;
f) Provision for emergency;
g) Maintenance factors in lighting installation; and
h) Maximum energy effectiveness of the lighting system used consistent with the specific needs of visual tasks performed.

4.1.3 Guidelines on principles of good lighting design can be had from IS 3646 (Part 1). Reference should be made to National Lighting Code, which covers all aspects of lighting.

4.2 Design Aspect

4.2.1 *Illumination Levels*

The level of illumination for a particular occupation depends on the following criteria:

a) Adequacy for preventing both strain in seeing and liability to accidents caused by poor visibility,
b) Adequacy for realizing maximum visual capacity,
c) Adequacy for the performance of visual tasks at satisfactory high levels of efficiency, and
d) Adequacy for pleasantness or amenity.

4.2.2 *Designing for Daylight*

Reference shall be made to IS 2440 and National Lighting Code.

4.2.3 *Lighting Problems and Economics*

Reference is drawn to Annexes C and D of IS 3646 (Part 1) and National Lighting Code.

5 ASPECTS OF VENTILATION

5.0 General

5.0.1 Ventilation of buildings is required to supply fresh air for respiration of occupants, to dilute inside air to prevent vitiation by body odours and to remove any products of combustion or other contaminants in air and to provide such thermal environments as will assist the maintenance of heat balance of the body in order to prevent discomfort and injury to health of the occupants.

5.0.2 The following govern design considerations:

a) Supply of fresh air for respiration,
b) Removal of combustion products or other contaminants and to prevent vitiation by body odours,
c) Recommended schedule of values of air changes for various occupancies, and
d) The limits of comfort and heat tolerance of the occupants.

5.1 Methods of Ventilation

General ventilation involves providing a building with relatively large quantities of outside air in order to improve general environment of building. This may be achieved in one of the following ways:

a) Natural supply and natural exhaust of air,
b) Natural supply and mechanical exhaust of air,
c) Mechanical supply and natural exhaust of air, and
d) Mechanical supply and mechanical exhaust of air.

5.2 Mechanical Ventilation

Reference should be made to IS 3103 and IS 3362 which cover methods of mechanical ventilation.

6 ASPECTS OF AIR-CONDITIONING AND HEATING SERVICES

6.1 General

The object of air-conditioning facilities in buildings shall be to provide conditions under which people can live in comfort, work safely and efficiently. It shall aim at controlling and optimizing factors in the building like air purity, air movement, dry bulb temperature, relative humidity, noise and vibration, energy efficiency and fire safety.

6.1.1 The design of the system and its associated controls should take into account the following:

a) The nature of the application,
b) The type of construction of building,
c) External and internal load patterns,
d) Desired space conditions,
e) Permissible control limits,
f) Control methods for minimizing use of primary energy,
g) Opportunities for heat recovery,

h) Economic factors (including probable future cost and availability of power),
j) Outdoor air quality,
k) Energy efficiency,
m) Filteration standard,
n) Hours of use,
p) Outdoor air quality, and
q) Diversity factor.

6.1.2 The operation of the system in the following circumstances should be considered when assessing the complete design:

a) In summer;
b) In monsoon;
c) In winter;
d) In intermediate seasons;
e) At night;
f) At weekends and holidays;
g) Under frost conditions, where applicable;
h) If electricity supply failure occurs and when the supply is restored; and
j) If extended low voltage conditions persist.

6.1.3 Consideration should be given to changes in building load and the system design so that maximum operational efficiency is maintained under part load conditions. Similarly, the total system should be separated into smaller increments having similar load requirements so that each area can be separately controlled to maintain optimum operating conditions.

6.2 Electrical Requirements

6.2.1 *Conduits*

Where conduits are used for carrying insulated electrical conductors and when such conduits pass from a non-air-conditioned area into an air-conditioned area or into a fan chamber of duct, a junction box shall be installed or other means shall be adopted to break the continuity of such conduit at the point of entry or just outside, and the conduit should be sealed round the conductors to prevent air being carried from one area into the other through the conduit and thereby giving rise not only to leakage and inefficiency but also to the risk of condensation of moisture inside the conduits. The same method applies equally to other types of wiring, like wood sheathing or ducts which allow air to pass through around the conductors.

6.2.2 In case of air-conditioning plants where re-heating is used, a safety device shall be incorporated in the installation to cut off automatically the source of heating, such as steam or electricity by means of a thermostat or some other device, as soon as the temperature of the room reaches a predetermined high level not exceeding 44ºC, unless a higher temperature is required for an industrial process carried on in the air-conditioned enclosure.

6.2.3 In case of air-conditioning plants where heating by means of an electric heater designed to operate in an air current is used, a safety device shall be incorporated in the installation to cut off the supply of electricity to the heating device whenever there is failure of the air current in which the heater is required to operate. Serious harm to the plant and sometimes fires may be caused by negligence in this respect.

The surface temperature of all electric heaters used in an air-conditioned plant should be limited, preferably to 400°C, and in any case it shall not exceed 538°C, when measured in still air.

6.2.4 Air-conditioning and ventilating systems circulating air to more than one floor or fire area shall be provided with dampers designed to close automatically in case of fire and thereby prevent spread of fire or smoke. Such system shall also be provided with automatic controls to stop fans in case of fire, unless arranged to remove smoke from a fire, in which case these shall be designed to remain in operation.

6.2.5 Air-conditioning system serving large places of assembly (over 1 000 persons), large departmental stores or hotels with over 100 rooms in a single block shall be provided with effective means for preventing circulation of smoke through the system in the case of a fire in air filters or from other sources drawn into the system even though there is insufficient heat to actuate heat sensitive devices controlling fans or dampers. Such means shall consist of suitable photo-electric or other effective smoke sensitive controls, or may be manually operated controls.

7 ELECTRICAL ASPECTS OF LIFTS AND ESCALATOR SERVICES

7.0 General

7.0.1 For the information of the electrical engineer, the lift/escalator manufacturer should advise the architect/engineer of the building of his structural and electrical requirements. This should be available early in the planning stage to ensure proper electrical provisions to be made for the service and suitable cables and switchgears. During preliminary planning of the building, the aspect of lifts and escalators installation shall be discussed with all concerned parties namely, client, architect, consulting engineer and/or lift manufacturer.

7.0.2 The following aspects shall be taken into account to decide the electrical requirements for lifts:

a) Number of lifts, size, capacity and position;
b) Number of floors served by the lift;
c) Height between floor levels;
d) Provisions for machine room and proper access to it;
e) Provisions for ventilation and lighting;
f) Electric supply required;
g) Details of wiring and apparatus required;
h) Quantity/quality of service;
j) Occupant load factors;
k) Car speed;
m) Control system;
n) Operation and maintenance;
p) Provision for lift and depth;
q) Number of entrances;
r) Provision of telephone or alarm bell inside the lift car;
s) Provision of battery backup emergency light inside the lift car; and
t) Providing battery backup automatic rescue device or uninterrupted power supply (UPS).

7.1 Design and Operation

Reference is drawn to IS 14665 (Part 2/Sec 1), IS 14665 (Part 2/Sec 2), IS 14665 (Part 3/Sec 1) and IS 14665 (Part 3/Sec 2).

7.2 Electrical Installation Requirements

7.2.1 *General*

The requirements for main switches and wiring with reference to relevant regulations may be adhered to. The lift maker should specify, on a schedule, particulars of full load current, starting current, maximum permissible voltage drop, size of switches and other details to suit requirements. For multiple lifts a diversity factor may be used to determine the cable size and should be stated by the lift manufacturer.

It is important that the switches at the intake and in the machine room which are provided by the electrical contractor are of correct size, so that correctly rated fuses can be fitted. No form of 'No Volt' trip relay should be included anywhere in the power supply of the lift.

The lift maker should provide overcurrent protection for power and control circuits, either on the controller or by a circuit-breaker, but the following are not included in the contract.

a) *Power supply mains* — The lift sub-circuit from the intake room should be separate from other building service.

   Each lift should be capable of being isolated from the mains supply. This means of isolation should be lockable.

b) For banks of interconnected lifts, a separate sub-circuit is required for the common supervisory system, in order that any car may be shut down without isolating the supervisory control of the remainder.

c) *Lighting* — Machine rooms and all other rooms containing lift equipment should be provided with adequate illumination and with a switch fixed adjacent to the entrance. At least one socket outlet, suitable for lamps or tools, should be provided in each room.

The car lighting supply should be independent of the power supply mains and should be connected to the inverter system with battery backup.

Pits should be provided with a light, the switch for which should be in the lift well, and accessible from the lower terminal floor entrance.

When the alarm system is connected to a transformer or trickle-charger, the supply should be taken from the machine room lighting.

7.2.2 *Electrical Wiring and Apparatus*

7.2.2.1 All electrical supply lines and apparatus in connection with the lift installation shall be so constructed and shall be so installed, protected, worked and maintained that there may be no danger to persons therefrom.

7.2.2.2 All metal casings or metallic coverings containing or protecting any electric supply lines of apparatus shall be efficiently earthed.

7.2.2.3 No bare conductor shall be used in any life car as may cause danger to persons.

7.2.2.4 All cables and other wiring in connection with the lift installation shall be of suitable grade for the voltage at which these are intended to be worked and if metallic covering is used it shall be efficiently earthed.

7.2.2.5 Suitable caution notice shall be affixed near every motor or other apparatus operating at a voltage exceeding 250 V.

7.2.2.6 Circuits which supply current to the motor shall not be included in any twin or multicore trailing cable used in connection with the control and safety devices.

7.2.2.7 A single trailing cable for lighting control and signal circuit shall be permitted, if all the conductors of this trailing cable are insulated for maximum voltage running through any one conductor of this cable.

7.2.2.8 *Emergency signal or telephone*

It is recommended that lift car should be provided either with an emergency signal that is operative from the lift car and audible outside the lift well or with a telephone.

When an alarm bell is to be provided, each car is fitted with an alarm push which is wired to a terminal box in the lift well at the ground floor by the lift maker. This alarm bell, to be supplied by the lift maker (with indicator for more than one lift), should be fixed in an agreed position and wired to the lift well. The supply may be from a battery (or transformer) fixed in the machine room or, when available, from the building fire alarm supply.

When a telephone is to be provided in the lift car, the lift maker should fit the cabinet in the car and provide wiring from the car to a terminal box adjacent to the lift well.

7.2.2.9 *Building Management System — Interface for Lifts*

Where more than three lifts are provided in a building and especially when these are provided at different locations in the building, a form of central monitoring may be provided. Such central monitoring may be through a Building Management System, if provided in the building or through a display panel.

7.2.2.10 *Earthing*

The terminal for the earthing of the frame of the motor, the winding machine, the frame of the control panel, the cases and covers of the tappet switch and similar electric appliances which normally carry the main current shall be at least equivalent to a 10 mm diameter bolt, stud or screw. The cross-sectional area of copper earthing conductor shall be not smaller than those specified in Part 1/Sec 14 of the Code.

The terminal for the earthing of the metallic cases and covers of doors interlocks, door contacts, call and control buttons, stop buttons, car switches, limit switches, junction boxes and similar electrical fittings which normally carry only the control current shall be, at least equivalent to a 5 mm brass screw, such terminal being specially provided for this purpose.

The earthing conductor shall be secured to earthing terminal in accordance with the recommendations made in IS 3043 and also in conformity with the provisions of *Indian Electricity Rules* 1956.

Where screwed conduit screws into electric fittings carrying control current and making the case and cover electrically continuous with the conduit, the earthing of the conduit may be considered to earth the fitting. Where flexible conduit is used for leading into a fitting, the fitting and such length of flexible conduit shall be effectively earthed.

One side of the secondary winding of bell transformers and their cases shall be earthed.

7.3 Additional Requirements for Escalators

7.3.1 *Connection Between Driving Machine and Main Drive Shaft*

The driving machine shall be connected to the main drive shaft by toothed gearing, a coupling, or a chain.

7.3.2 *Driving Motor*

An electric motor shall not drive more than one escalator.

7.3.3 *Brake*

Each escalator shall be provided with an electrically released, mechanically applied brake capable of stopping the up or down travelling escalator with any load up to rated load. This brake shall be located either on the driving machine or on the main drive shaft.

Where a chain is used to connect the driving machine to the main drive shaft, a brake shall be provided on this shaft. It is not required that this brake be of the electrically released type, if an electrically released brake is provided on the driving machine.

7.3.4 No bare conductor shall be used in any escalator as may cause danger to persons.

7.3.5 Electrical conductors shall be encashed in rigid conduits, electrical tubings or wireways which shall be security fastened to the supporting structure.

7.3.6 All electrical supply lines and apparatus in the escalator shall be of suitable construction and shall be so installed, protected, worked and maintained that there is no danger to persons from them.

All metal casings or metallic coverings, containing or protecting any electric supply line or apparatus shall be efficiently connected with earth.

7.3.7 *Disconnect Switch*

An enclosed, fused switch or a circuit-breaker shall be installed and shall be connected into the power supply line to the driving machine motor. Disconnecting switches or circuit-breakers shall be of the manually closed multi-pole type. The switch shall be so placed that it is closed to and visible from the escalator machine to which the supply is controlled.

With dc power supplies the main disconnecting switch and any circuit-breaker shall be so arranged and connected that the circuit of brake magnet coil is opened at the same time that the main circuit is opened.

7.3.8 *Enclosure of Electrical Parts*

All electric safety switches and controllers shall be enclosed to protect against accidental contact.

7.3.9 *Caution Notice*

Suitable 'CAUTION' notice shall be affixed near every motor or other apparatus operating at a voltage exceeding 250 V.

7.3.10 *Insulation*

The electrical parts of starting and stopping devices, other operating and similar devices, controllers and similar other parts shall be efficiently insulated and the insulation shall be capable of withstanding for a period of one minute the continuous application of a ac test voltage equal to ten times the voltage at which these electrical parts are energized, subject to a maximum voltage of 2 000 V when the test voltage is applied between contacts or similar parts in the open position, and between such contacts and earthed parts.

8 ELECTRICAL ASPECTS OF AUDIO SYSTEM SERVICES

8.0 General

8.0.1 This clause covers essential installation design aspects of electrical audio systems for indoor and outdoor use both for temporary and permanent installations.

8.0.2 This applies to sound distribution systems and public address systems but does not cover installations in conference halls where both microphones and loudspeaker are distributed amongst the audience.

8.0.3 Specific requirements if any, for individual occupancies are covered in individual Sections of the Code.

8.0.4 For guidance on selection of equipment and their installation and maintenance, reference shall be made to IS 1881 and IS 1882.

8.1 Exchange of Information

8.1.1 The initial and ultimate requirements of the installations should be ascertained as accurately as possible by prior consultations. Plans shall show,

a) details of the installation proposed,
b) accommodation and location of the central amplifier equipment, and
c) ducts and overhead lines required for wiring.

8.2 Design Requirements

8.2.0 The output from the microphone, gramophone, tape-recorder or radio receiver or CD player from a sound film is amplified and presented through a system of loudspeakers installed at chosen locations. The design of this installation shall be such that, depending on the nature of occupancy, the quality of reproduction is as desired. Reference is drawn to **5.2** of IS 1881 and IS 1882 on the quality of reproduction suitable for different purposes, and the acoustic power requirements therein. The choice of equipment such as these for input signals, amplifying equipment/system and loudspeaker shall be governed by the considerations enumerated in IS 1881 and IS 1882.

8.2.1 *Wiring for Audio System*

8.2.1.0 All equipments shall be securely installed in rooms guarded against unauthorized access. Precautions shall be taken to keep dust away.

8.2.1.1 All present controls should be mounted behind cover plates and designed for adjustment only with the help of tools. All controls shall be mechanically and electrically noiseless.

8.2.1.2 The positioning of equipment shall be such that the lengths of the interconnecting cables is kept to the minimum.

8.2.1.3 In case the number of the equipment is large, they shall be mounted on racks of suitable dimensions of metal or wood, in such a manner that the controls are within easy reach. The patch cords shall be neatly arranged.

8.2.1.4 In determining the positioning of the microphones and loudspeakers in the installation, advice of an acoustical expert shall be sought for best accuracy and reproducibility.

8.2.1.5 For outdoor installations, the line-matching transformers shall be mounted in weather-proof junction boxes.

8.2.1.6 In large open grounds such as an outdoor stadium, care shall be taken to ensure that the sound heard from different loudspeakers do not have any noticeable time lag.

8.2.1.7 The plugs and sockets used in electrical audio systems shall not be interchangeable with those meant for power currents.

8.2.1.8 Microphone and gramophone cables shall preferably use twisted pairs of conductors with sufficient insulation screened continuously with a close mesh of tinned-copper braid. The copper braiding should be sheathed with an insulating covering. These shall be isolated from power, loudspeaker and telephone cables. Joints in the cables shall be avoided. Microphone cables shall be laid without sharp bends. Indoor cables can be laid on the floor along the walls or under the carpet. When laid in the open, they shall be either buried in the ground at a depth not less than 20 cm, or inside an iron-pipe at that depth if heavy mechanical movement is expected above. This may also be laid overhead at a height not less than 3.5 m, clipped securely to a bearer wire. Any wiring required to be run along corridors or outside walls below 1.8 m shall be protected by a conduit.

8.2.1.9 The loudspeaker cables shall be so chosen that the line losses do not exceed the values given in Table 1 of IS 1882.

8.2.2 *Power Supplies*

8.2.2.1 The equipment should normally operate from 230 V, single phase 50 Hz ac mains supply. A voltage regulating device shall be provided if the regulation is poorer than ±5 percent. In the absence of ac mains supply the system shall be suitable for operating from a storage battery.

8.2.2.2 The supply mains shall be controlled by a MCB of adequate capacity.

8.2.3 *Earthing*

Proper earthing of the equipment shall be made in accordance with good practice.

8.3 Inspection and Testing

The completed installation shall be inspected and tested by the engineer to ensure that the work has been carried out in the manner specified.

8.4 Miscellaneous Provisions

Where necessary, that is in installations where the breakdown of the sound distribution systems should be restored instantaneously or within a limited time, the stand-by equipment shall be readily available.

9 ELECTRICAL ASPECTS OF FIRE ALARM AND FIGHTING SYSTEMS

9.0 General

9.0.1 This clause covers the electrical aspects of the installation of fire alarm/protection system in buildings.

9.0.2 This clause is applicable in general to all types of occupancies, while specific requirements if any or individual situations are covered in the respective sections of the Code.

9.0.3 For total requirements for fire protection of buildings, including non-electrical aspects such as choice and disposition of fire-fighting equipment, depending on the nature of occupancy installation and maintenance aspects, etc., reference shall be made to SP 7 and the relevant Indian Standards.

9.1 Fire Detectors

9.1.1 The following types of fire detectors are available for installation in buildings:

a) Heat detectors (*see* IS 2175):
   1) 'Point' or 'spot' type detector
   2) Line type detector.

   NOTE — These may be of fixed temperature detector or rate of rise detector.

b) Smoke detectors:
   1) Optical detectors.
   2) Ionization chamber detector,
   3) Chemically sensitive detector.

c) Flame detectors.

9.1.2 For guidance on their choice and siting in the installation, *see* SP 7.

9.2 Wiring for Fire Alarm Systems

9.2.1 The equipment and wiring of the fire alarm system shall be independent of any other equipment or wiring, and shall be spaced at least 5 cm away from each other and other wiring. The wiring of the fire alarm systems, shall be in metallic conduits. The wiring shall be kept away from lift shafts, stair cases and other flue-like opening.

9.2.2 Alarm sounders shall be of the same kind in a particular installation.

9.2.3 For large or intricate premises, it is necessary that the origin of a call be indicated. For this, the premises shall be divided into sections zones. All call points in a section shall be connected to the same indicator. The various drops or lamp indicators shall be grouped together on the main indicator board or control panel. When the premises are extensive, a number of main indicator boards may be used covering different sectors. These shall be supplemented by sector indicators for the various sectors at a central control point.

9.2.4 At the control point the indicator board or the zone and section indicating boards and all common control apparatus and supervisory equipment shall be located. For every installation a control point shall be provided, where it can be under constant observation. The main control centre shall be located on the ground floor and should be segregated from the rest of the building by fire-break wall.

9.2.5 No section shall have more than 200 fire detectors connected together.

9.2.6 The origin of the calls may be indicated by the use of lamp indicators. Each indicator shall include:

a) two lamps connected in parallel associated with each indication, so arranged that failure of either of the lamps is readily apparent, or
b) one lamp glowing during normal operation of the system for each section and the alarm

indicated by the extinguishing of the lamp for the section where the call originates. Alarms should not sound on the failure of the indicator.

9.2.7 The arrangement of the circuits and the electrical connections shall be such that a call or fault in any circuit does not prevent the receipt of calls on any other circuit.

9.2.8 The indicating device associated with the various call points and sections shall be grouped together on the main indicator board. If necessary remote indicating panel, with audible alarms in the night quarters of the caretaker of the building should be provided.

9.2.9 The silencing switches/push buttons in their off position shall give an indication of this fact on the main control panel operation of silencing switches shall not prevent sounding of alarm from any other zone simultaneously, or cancel the other indications of the alarm or fault.

9.2.10 For fire alarm systems, cables of the following types shall be used:

a) Mineral insulated aluminium sheathed cables;
b) PVC insulated cables,
c) Rubber insulated braided cables,
d) PVC or rubber insulated armoured cables, and
e) Hand metal sheathed cables.

The laying of the cables shall be done in accordance with Part 1/Section 1 of the Code.

9.2.11 The source of supply for the alarm system shall be a secondary battery continuously trickle/float charged from ac mains, with facilities for automatic recharging in 8 h sufficiently to supply the maximum alarm load at an adequate voltage for at least 2 h. The capacity of battery shall be such that it is capable of maintaining the maximum alarm load on the system at an adequate voltage for at least 1 h plus the standing load or losses for at least 48 h. Suitable overload protective devices shall be provided to prevent discharging of the batteries through the charging equipment.

9.3 Fire Fighting Equipment

9.3.0 The choice of fire fighting equipment and their installation details shall be governed by the requirements specified in SP 7.

9.3.1 *Requirements for Electrical Drives for Pumps in Hydrant and Sprinkler Systems*

9.3.1.1 Full details of the electric supply shall be furnished together with details of generator plant to the appropriate authorities.

9.3.1.2 Sufficient power shall be made available for the purpose and the power source shall be entirely independent of all other equipment in the premises and shall not be interrupted at any time by the main switch controlling supply to the premises. An indicator lamp shall continuously glow in a prominent position to indicate status of power in the substation and in the fire-pump room.

9.3.1.3 Pumping sets shall be direct coupled type, and shall work satisfactorily at varying load.

9.3.1.4 All motors and electrical equipment shall be continuously rated, drip-proof with air inlets and outlets protected with meshed wire panels where required motors shall have a suitable fixed warming resistance to maintain them in dry condition.

9.3.1.5 The starting equipment of the set shall incorporate an ammeter and clearly marked to show full load current. They shall not incorporate no-volt trips.

9.3.1.6 The electric circuit for fire fighting system shall be provided at its origin with a suitable switch for isolation, but overload and no-volt protection shall not be provided in the switch.

10 ELECTRICAL CALL BELL SERVICES

10.0 General

10.0.1 Guidance on installation of electric bells and call systems are covered in IS 8884.

10.0.2 On the basis of information collected on the extent of installation of electric bells and buzzers, or indicator call system in the building, the following aspects shall be ascertained in collaboration with the parties concerned:

a) Accommodation required for control apparatus, location and distribution points; and
b) Details of chases, ducts and conduits required for wiring.

10.1 Equipment and Materials

10.1.1 If wooden bases are used for bells and buzzers, the component parts shall be rigidly held together independently of the base, so that they are unaffected by any warping.

10.1.2 Bells and buzzers which have a make or break contact shall be provided with means of adjusting the contact gap and pressure and means for locking the arrangement.

10.1.3 Equipment for outdoor use shall be suitably protected against the environmental conditions.

10.1.4 Bell push switches shall be of robust construction. Terminals shall be of adequate size and should be so arranged that the loosening of a terminal screw does not disturb the contact assembly. Any flexible chords attached to them should be covered with hard wearing braid.

10.1.4.1 Relays may be required for the following situations:

a) Where mains operated device is to be controlled by a circuit operating at a voltage not exceeding 24 V,
b) For repeating a call indication until at a distant point or points, and
c) For maintaining a call indication until an indication is reset.

10.1.5 The indications shall be one of the following types:

a) *Lamp type* — where sound of bell is undesirable; for example in hospitals or in noisy locations such as forges, mills, etc.
b) *Flag type* — where positive indication is required which remain in position until restored.
c) *Pendulum type* — for small installations having up to 20 call points.

10.2 Choice of Call Bell System

The following guidelines are recommended:

a) *Simple call bell system* — For dwellings and small offices (*see* Fig. 1).
b) *Multiple call bell system* — Hotels, hospitals or similar large buildings where call points are numerous (*see* Fig. 2).
c) *Time bell system* — Factories, schools.

10.3 Power Supply

The system may be operated at the normal mains voltage, though it is preferable for the control circuit to be operated at a voltage not exceeding 24 V.

10.4 Wiring

The wiring shall be done in accordance with Part 1/Section 9 of the Code.

11 CLOCK SYSTEMS

11.1 Design Considerations

11.1.1 Reference is drawn to **5.1** of IS 8969. A schematic diagram is shown in Fig. 3.

11.1.2 The enclosure of the clocks shall have no openings giving access to live parts or functional

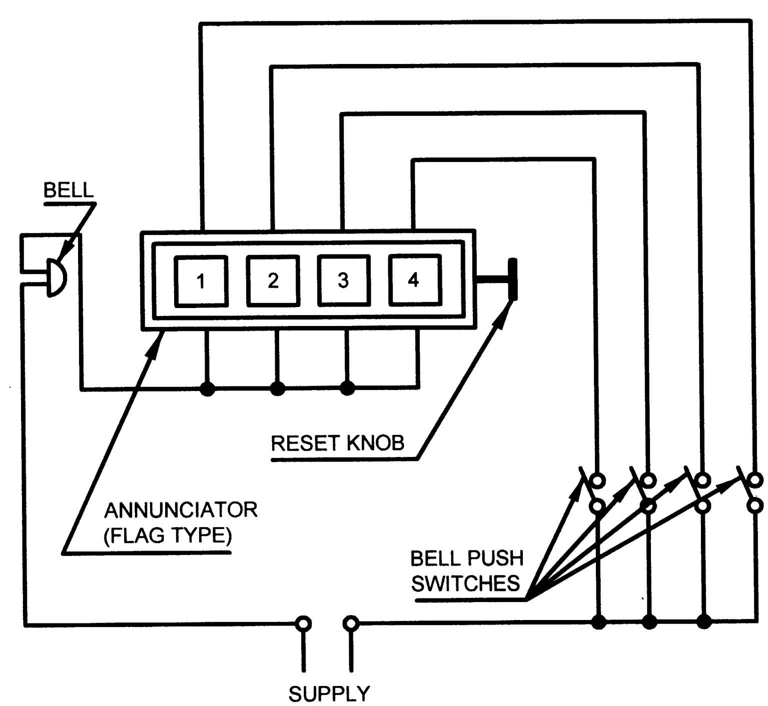


FIG. 1 SIMPLE ELECTRIC CALL BELL SYSTEM

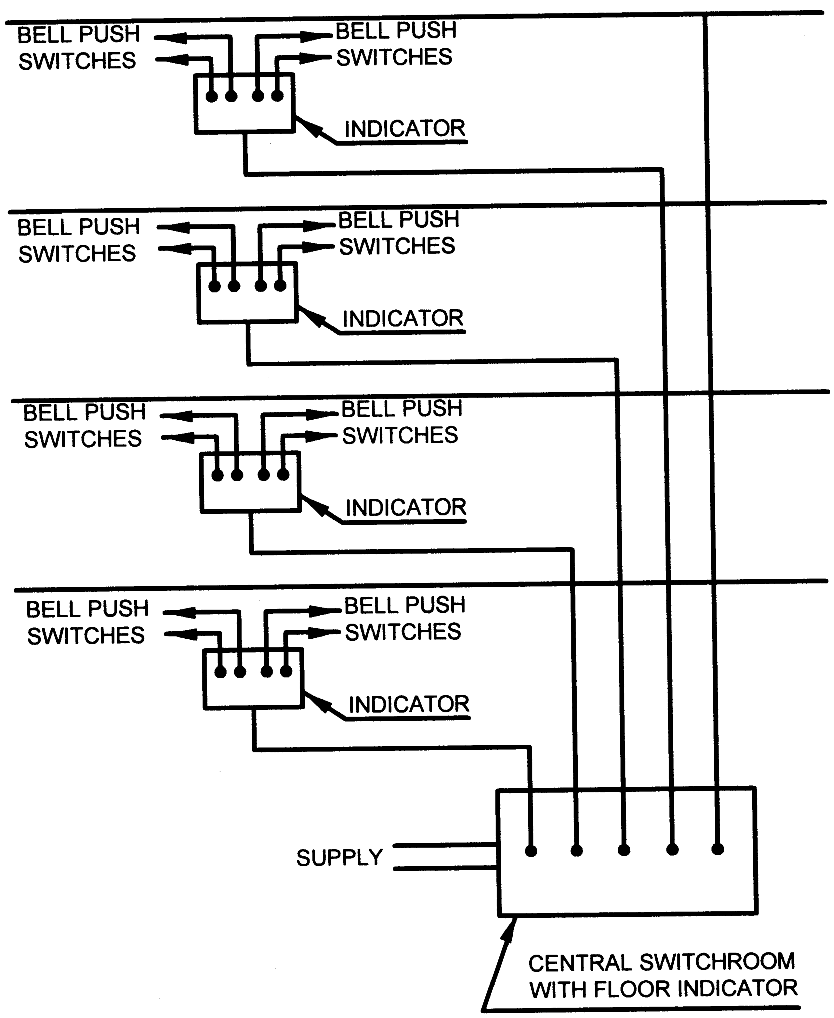


FIG. 2 MULTIPLE CALL BELL SYSTEM

insulated parts or functional insulation other than the openings necessary for the use and working of the clocks. Where such openings are necessary, sufficient protection against accidental contact with live parts shall be provided.

11.1.3 To ensure necessary continuity of supply, direct connection of the system to the supply mains is not recommended. Batteries should always be provided. The capacity of the battery shall be at least sufficient to supply the installation for 48 h, not less than 10 Ah.

11.1.3.1 Where the supply is ac, single battery on constant trickle charge is recommended, means being provided for charging at a higher rate when necessary.

11.1.3.2 Where the supply is dc, two batteries should be provided with changeover switch.

11.2 Location of Clocks

11.2.1 The master clock shall be placed in a room not smaller than 2.4 m × 3.6 m.

11.2.2 The location and size of slave clocks may frequently depend upon aesthetic requirements, but from the point of view of readability, a ratio of 0.30 m diameter of dial to every 2.7 m of height is acceptable. The following is adequate:

Dia of Clock	*Height from Floor*
0.30 m	2.70 m
0.45 m	3.30 m
0.60 m	4.50 m

11.3 Wiring

The wiring shall be done in accordance with Part 1/ Section 9 of the Code. Special conductor shall be provided, or the conduit may be colour coded for distinction from other circuits.

12 ELECTRICAL ASPECTS OF COMPUTER CONTROL OF ENVIRONMENTAL SYSTEMS

12.0 General

12.0.1 Building users require services to meet the environmental and functional needs associated with a particular type of building, and these services vary considerably according to the type of building involved. However, the basic requirements are for comfort, safety security, efficiency, reliability and operational utilities. The increased application requirement calls for coordinated and efficient control of the various systems and their sub-systems. Configuration of these systems in a computer programme is a necessicity now.

12.0.2 General building classifications are residential, commercial, industrial, public, medical establishments and industrial premises. The requirements differ according to the particular purpose of the building. The complexities of the services also relate to the requirements and additionally to the size and class-type of the building.

12.1 Exchange of Information

12.1.0 The architect should exchange information with the engineer concerned when the building plans are being prepared. The chief purpose of such an exchange is to obtain information regarding the architectural and electrical features of the building so that due provision may be made to retain the aesthetic features and the essential services while planning the locations of the various devices and equipment of the environmental services. Information may also be obtained at an early stage regarding other services, such as electrical installation, gas and water pipes etc.

12.1.1 Scale drawings showing plans and elevations of the structure, electrical wirings shall be obtained

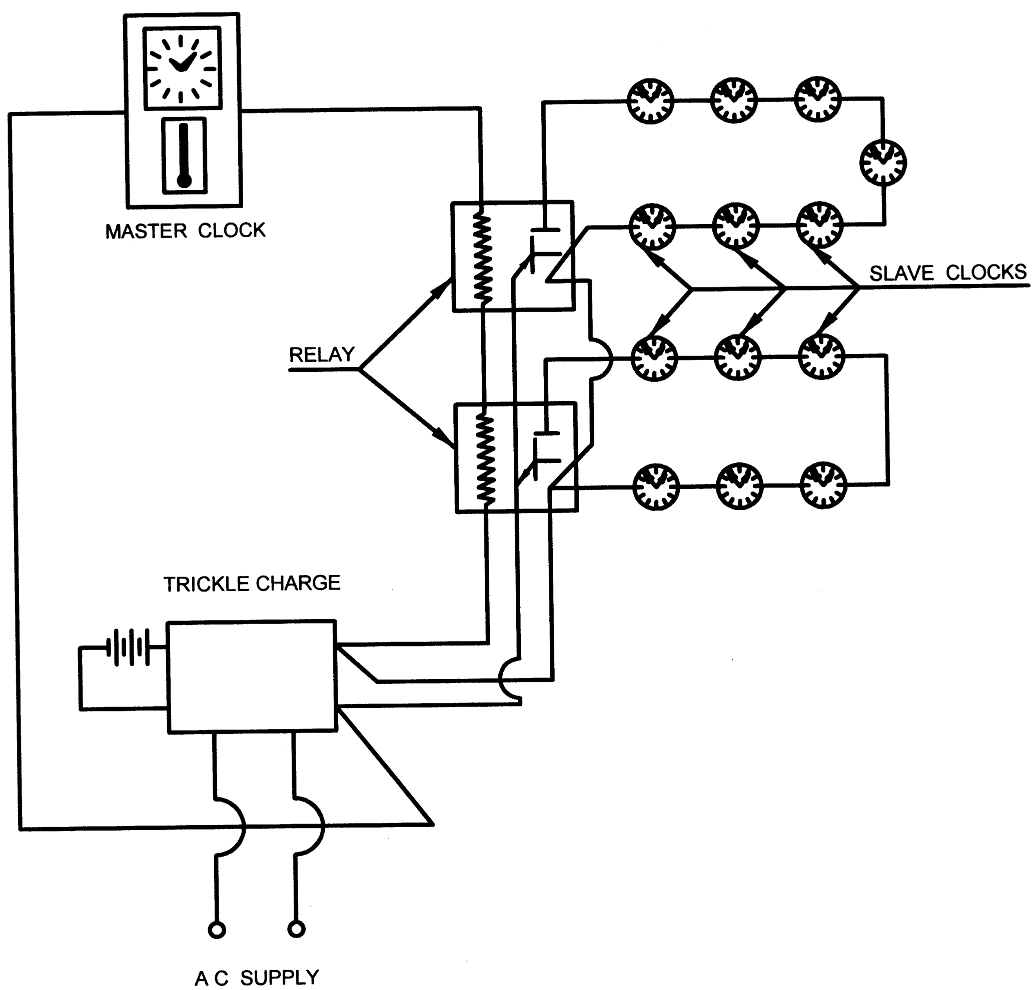


FIG. 3 IMPULSE MASTER CLOCK SYSTEM

and the nature and location of the devices, sensors and controllers of the environmental services shall be indicated on them.

12.1.2 The initial and final requirements of the installations should be ascertained as accurately as possible by prior consultations. Plans shall show,

a) details of the installations proposed;
b) accommodation and locations of the central control units, server, monitor, etc; and
c) ducts and cable routing required for wiring.

12.2 Building Management System (BMS)

12.2.0 Thermal comfort, lighting, ventilation, air-conditioning, security, safety, fire detection and control system and electrical power are always required, and residential building represents this basic level of need.

12.2.1 The management of building services systems for a larger establishment is more difficult due to the variety, increased complexity, lack of individual responsibility and high capital and operating costs for the systems involved. The more complex control systems are termed building management systems (BMS). They are employed in commercial, public and industrial buildings and control the services of heating, ventilation, air-conditioning, steam, refrigeration, gas, water, general and emergency lighting, emergency electrical systems, power distribution, mechanical transportation, fire detection alarm and fighting systems, general and noxious fume ventilation, security and waste disposal.

12.2.2 The building management systems (BMS) means that all services can be monitored and reset from a central location without delay or movement by the engineer. BMS can also advise on preventative maintenance schedules, thereby improving overall plant reliability and operating efficiency. Consequently, plant operation is greatly simplified by allowing an engineer to reset any control level, monitor energy consumption, organize maintenance and make fault diagnosis from a central location. Remedial action is quicker and can often be carried out by a smaller engineering staff than would be required otherwise.

12.3 BMS Architecture

12.3.1 BMS architecture and performance requirements shall be based on a distributed system of intelligent, stand alone controllers, operating BMS incorporates control and monitoring of all systems such as environmental, fire and security but, in some cases, separate dedicated fire protection systems are favoured by the authorities and reference to local fire codes and regulations is essential. The integration of fire protection and security systems into BMS shall be subject to the approval of the local fire prevention authority. It is possible to keep the fire protection system panel separate while still providing communication links with the BMS for alarm and reporting purposes.

12.3.2 Back-up power supplies such as the UPS systems, although required for any BMS, need more consideration for centralized intelligence systems. A parallel systems structure and duplication of equipment to provide redundancy facilities may also be necessary, depending on the level of reliability required or the importance of the functions.

12.4 Design Requirements

12.4.1 The BMS shall include all workstation software and hardware, Process Control Units (PCU), Terminal Controllers, Local Controller, Local Area Network (LAN), sensors, control devices, actuators, system software, Interconnecting cable, installation and calibration, supervision, Distributed intelligence systems also have a central computer, with the addition of remote intelligent outstations capable of carrying out all control functions independent of the main computer. Outstations are located near to the building zone which they serve, as in the earlier systems, and are programmed to perform the required control functions. The outstation can, however, be interrogated and reset from the main computer and also communicate routine information and alarms as required by the plant operator.

12.4.2 System administration shall be available from the Workstation in Control Room on Ethernet LAN (Local Area Network) WAN (Wide Area Network) in the system. The system specifically must have the capability to support multiple workstations, depending on complexity and magnitude of the services, connected on the LAN or WAN network at the same time. The building management system shall allow all connected workstations to function in a true multi-user, multi-tasking environment employing user-friendly Windows platform using TCP/IP Protocol or any other open protocol.

12.4.3 The system architecture shall be capable of supporting single site and/or campuses as well as multiple sites located in different geographical locations.

12.4.4 The system shall be capable of modular expansion without software upgrades or wiring revisions.

12.5 General Characteristic of Software

12.5.1 Software shall be modular in design for flexibility in expansion or revision of the system.

12.5.2 The software shall include a General Purpose Operating System, which will be based on a user-friendly open platform. The architecture of the system, and the application software/firmware shall generally be compiled for faster execution speeds.

12.6 Hardware Requirements

12.6.0 The BMS consists of many subsystems and equipment, sensors and peripheral devices. However, the servers provide a single interface point for operations, maintenance and management analysis. Various subsystems and systems are connected to provide information on different parameters at different locations.

12.6.1 The on-site operator workstation shall be user friendly, operator interface with the complete system. As an example, the requirements of a workstation equipment are given below:

a) Workstation equivalent to Pentium-IV 1GHz or higher processor,
b) 256 MB Random Access Memory,
c) 40 GB Hard Disk or better,
d) 3.5 IN, 1.44 MB Diskette Drive,
e) Read/Write CD ROM 52X or Faster;
f) Serial Port,
g) Parallel Printer Port,
h) USB Port,
j) 19″ SVG Colour Monitor,
k) Colour Graphics Card with at least 6 MB RAM,
m) 101 Keyboard,
n) 3 button track ball with scroll wheel/optical mouse,
p) 3COM Etherlink III with modem, and
q) Printer.

12.6.2 *System Controllers*

It is desirable to monitor and/or control all points in the system through 'Intelligent' Distributed Control Units. Each Distributed Control Unit in the system shall contain its own microprocessor and memory with a minimum 300 h battery backup. Each distributed control unit shall be a completely independent stand-alone 'master' with its own hardware clock calendar and all firmware and software to maintain complete on an independent basis.

12.6.2.1 *Communication backbone*

12.6.2.2 The central computer communicates with the outstations through a standard interface and either a dedicated line, a leased line or a telephone switched line. Smaller systems on one site are usually connected using a twisted pair in either a ring, star or tree network.

12.6.2.3 Optic fibre transmission is currently being installed and allows very fast and high bandwidth transmission. As BMS becomes more widely accepted, it is likely that system capacities will increase to a level that will make optic fibre technology an attractive proposition.

12.6.2.4 For transmission distances within the building or site up to about 1.6 km, telephone lines are usually employed. The computer and outstations are connected to the telephone line via a modem, which converts the input signals to pulses which are transmittable on the telephone line, thus enabling information to be transmitted and received.

12.6.2.5 In many cases, particularly for remote sites an autodial modem restricts the use and cost of telephone lines by automatically communicating only when required. Autodial modems are therefore used for large or multiple sites and the telephone lines are accessed through the existing telecom system. Modems generally operate over a range of speeds (baud rate) with generally increased cost for the higher speed, for example, 9 600 baud is now common. (1 baud = 1 bit/second.) The baud rate is software set to suit the particular system, and some manufacturers use higher transmission rates for directly wired systems.

12.6.2.6 Autodial communication with the computer can be either direct dialling by the operator, programmed down-loading of data at predetermined times, or priority alarm reports.

12.6.2.7 It is advisable to have more than one line per station, one of which is dedicated to priority reporting and the other to routine reporting and monitoring. This allows each function to be effective without conflict with the other.

12.6.3 *Control Monitoring Stations*

12.6.3.1 A typical control monitoring station consists of a microcomputer, visual display unit (VDU), backing store and printer. One station is usually installed in a central location, but systems with several stations working on a master/slave principle can be obtained for large sites.

12.6.3.2 Buildings under phased development can be provided with a distributed intelligence system without a central computer. Under these circumstances, the outstation can be programmed and interrogated directly by portable hand-held microcomputers, which are taken around the site by personnel and plugged into the outstation as required. A central computer can be added to the system at a later date, when the development is complete or finances allow.

12.6.3.3 The location of the central computer requires careful consideration and should be provided with a clean power supply with back-up, as referred to previously. If connected to fire safety systems, it should be located where it can be easily accessed and interrogated by the fire brigade. The fire alarm protection system may be connected directly to the fire brigade, but the information supplied at the control station is likely to be more comprehensive and useful for directing fire-fighting operations and controlling services that may affect safety or the spread of fire. Smoke removal and staircase pressurization systems for high rise buildings are often an integral part of the mechanical ventilation or air conditioning system. When this is the case, ready access by the fire brigade for system status and control is essential.

12.6.4 *VDUs and Key Boards*

12.6.4.1 High resolution VDUs enable text and graphics to be displayed. Communication with the system software can be through keyboard, mouse or touch screen. The touch screen is the simplest but least flexible method and has not been widely adopted by BMS manufacturers.

12.6.5 *Printers*

12.6.5.1 The output of data and information from the system is transferred to paper copy by a printer. This is essential so that a readable log of the system performance is available for distribution to other interested members of the engineering and management team.

12.6.6 *LANs*

12.6.6.1 The Controller LAN utilizes a peer-to-peer, token passing protocol to communicate between nodes on the network. The Process Control Unit shall provide direct control and monitoring of process functions from a 'Peer-to-Peer' LAN based controller. These process functions include environmental control, trending, energy management, and process control, which may be executed locally in a stand-alone mode or 'globalized' across the Token Passing LAN, reports.

12.6.7 *Data Communications*

12.6.7.1 The standard specifications of generally acceptable ratings are indicated hereunder:

a) *PC port*

1) Protocol: Asynchronous, Polling, RS-232
2) Baud Rate: 300, 1 200, 2 400 or 9 600 Bps

b) *Host LAN*

1) Protocol: Token Passing, RS-485
2) Baud Rate: 9 600 or 19 200 Bps

c) *Cables*

1) *LAN*

22 AWG (0.324 mm) shielded, twisted pair (Belden 9184), 5 000' (1 500 mm) maximum or 24 AWG (0.206 mm) shielded, twisted pair (Belden 9841) 4 000' (1 200 mm) maximum per segment.

2) *Communication ports*

i) Controller LAN: RS-485; 19,200 or 9 600 baud, SDLC, token-passing.
ii) Hand Held Console Port: RJ11 Modular, 1 200 baud, TTL.
iii) RS-232 Port: PC @ 9 600 baud (7801 TAP function), or Hayes direct dial asynchronous modem @ 1 200, 2 400 baud or 9 600 baud.
iv) RS-232 Expansion Board Port: Supports synchronous modem, direct or two-way dial SDLC (78061 or 78035 TAP functions) @ baud rates of 1 200 to 9 600 baud. Requires optional plug on module.

3) *Network wiring requirements*

Cable Supported: Twisted pair, shielded. 22 AWG (0.324 mm^2) or larger, 30 pF/ft. or less between conductors, 55 pF/ft. or less conductor to shield, 85 to 150 Ohm impedance Belden 9841 or equivalent.

4) *Controller LAN length*

i) 1 500 m per segment.
ii) 7 600 m with repeaters

5) *Controller LAN*

RS-485; 19 200 or 9 600 baud, SDLC, token-passing.

6) *Door controller LAN*

RS-485; 9 600 baud, asynchronous, polling.

7) *Hand held console port*

RJII Modular; 1 200 baud, TTL.

8) *RS-232 port*

PC @ 9 600 baud (7801 TAP function) or Hayes direct-dial a synchronous modem @ 1.200, 2 400 or 9 600 baud.

9) *RS-232 expansion board port*

Supports synchronous modem, direct or two-way dial SDLC (78061 or 78035 TAP functions) @ baud rate of 1 200 to 9 600 baud, Requires optional plug on module.

10) *Network wiring requirements*

   i) *Controller LAN length*

      1 500 m per segment; 7 600 m with repeaters

   ii) *Micro controller sub-LAN length*

      1 500 m

      1) *Cable supported*

         Twisted pair, shielded, 22 AWG (0.324 mm^2) or larger, 30 pF/ft. or less between conductors, 55 pF/ft. or less conductor to shield, 85 to 150 ohm impedance.

      2) *Auto dial support telephone numbers*

         8; stored in NOVRAM, Number of Digits — 31 per phone number; Supported — Phone, Beeper, Pager.

12.6.8 *Input/Output Sensors*

The input devices, depending on application and usage are:

a) Space air temperature sensor,
b) Relative humidity sensor,
c) Air flow switch,
d) Water flow switch,
e) Water flow measuring transducer,
f) Tank float switch,
g) Current sensor,
h) kWh transducer,
j) Current, voltage and watt transducers,
k) Occupancy sensor,
m) Personal attendance sensor,
n) Motion detector,
p) Electronic door lock,
q) Card reader,
r) Access controller,
s) Damper and valve and their actuators, and
t) Electronic to pneumatic transducers.

12.7 Installation

All devices shall be installed in pre-engineering locations to be shown on the drawings in accordance with standard industry practice.

12.7.1 *Cables*

12.7.1.1 *Cables in conduits*

It shall be secured from building structure, not from other services.

12.7.1.2 *Cables on trays and ladders*

Cables shall be fixed neatly to trays and ladders in single layers and parallel to the tray edge to avoid unnecessary crossovers. Cables shall be fixed at intervals not exceeding 48" by means of non-corrosive fastening materials.

12.7.1.3 *Segregation*

Data cabling shall be physically segregated from power and SMS input/output cabling and mains cabling.

12.7.2 *Panels*

12.7.2.1 *General*

Panels and Controllers shall be installed within a dedicated metal enclosure.

12.7.2.2 *Documentation*

Terminal numbers, points list, point addresses and short and long descriptions shall be described inside a plastic fade-free in a pocket.

12.7.3 *Small Point Controllers*

Small point controllers shall be installed adjacent to the controlled device, accessible for maintenance and contained in a suitable enclosure.

12.7.4 *Transmission Systems*

12.7.4.1 The BMS shall utilize the above LAN architecture to allow all of the Control Units to share data as well as to globalize alarms. The Controller LAN shall be based on a peer-to-peer, token passing technique with a data speed of not less than 19.2 kB. The turnaround time for a global point to be received by any node, including operator stations, shall be less than 3 s.

12.7.4.2 Fiber Optic Pathways, Fiber Optic Media shall be used, as required, between buildings for the Controller LANs. Wherever the Optical Fiber enters or leaves the building, provide a fiber to hard copper interface device. The FOI shall regenerate data prior to transmitting this data to either the fiber or hard copper channels, so as not to result in the degradation of signal and to minimize the accumulation of errors between multiple FOIs. The FOI shall include “jabber” protection, such that continuous data from a defective component will not destroy communications on the LAN. Provide visual indication of receiving and transmitting data activity on the hardwired drop. Provide visual indication of data transmission on the fiber media, jabber presence of fiber and hard copper channels, and bad signal quality on the hard copper channel.

12.8 Testing and Commissioning

12.8.1 *General*

The contractor shall perform all tests submitted in the Test Procedure and remain on site until the BMS is fully operational.

12.8.2 *Factory Testing*

Demonstrate such control loop shall be demonstrated including all calculations and global functions. Analog values shall be simulated, if required. Attendance by three (3) persons nominated by the Owner shall be allowed. After Test, summary of results and necessary modifications shall be submitted.

12.8.3 *Final Acceptance Test*

Acceptance of the system shall require a demonstration of the standby of the system. This test shall not start until the customer has obtained 30 days beneficial use of the system.

13 TELEPHONE SYSTEMS

13.0 General

13.0.1 Telephone systems are classified as communications systems. Telephone communication through the public network is in most countries the responsibility of the Telecom administrations. These are systems, which must meet more stringent requirements for reliability of transmission.

13.0.2 *Electronic Private Automatic Branch Exchanges (EPABX)*

Electronic private branch exchanges are connected to the public exchanges through exchange lines. Operationally they form part of the subscriber equipment of the public telephone system. EPABX permit internal communication between the extensions of a system and external communication, for approved branch systems, over the exchange lines. Communication within the private branch system, normally, does not attract charges.

13.0.3 *Backbone Cabling*

Generally the inter-floor/inter-building backbone cabling is included in the scope of main building design. The backbone cabling should accommodate analog voice signal alone or analog and data signals simultaneously, as the case may be. It is the speed of data transmission and bandwidth, which matter most in the design of the communication backbone.

13.1 Exchange of Information

13.1.1 The exact requirement of the subscribers shall be assessed before drawing out the specification of the EPABX system. This means that information on number of subscribers in the building, distribution of the phones in the floors and other areas, nature of traffic etc are to be collected.

13.1.2 The initial and final requirements of the installations should be ascertained as accurately as possible by prior consultations. Plans shall show:

a) details of the installations proposed;
b) the accommodation and location of the EPABX console, monitor, etc; and
c) the ducts and cable routing required for wiring.

13.2 Design Requirements

13.2.1 The basic architecture and performance requirements of the modern day communication system is microprocessor-based pulse code modulated (PCM)/ Time Division Multiplexing (TDM) technology.

13.2.2 The environmental conditions for the EPABX should preferably be controlled so that the room air temperature is maintained between 10 °C and 40 °C and relative humidity between 50 percent and 95 percent.

13.2.3 Integrated Services Digital Network (ISDN) is a common requirement now-a-days for commercial buildings since it is possible to handle simultaneous calls of different types namely voice, data and images transfer (Tele & Video conferencing) without any loss of data, at a minimum speed of 64 kBps, which can be increased further depending on requirement. EPABX system shall be capable of interfacing with other EPABX system through appropriate protocol.

13.2.4 *Hardware Requirement*

13.2.4.1 *Electronic private automatic branch exchange*

In EPABX system the individual call stations are connected each by a twisted pair of wires to the automatic exchange (*see* Fig.4). This is also the termination for the exchange lines and, where necessary.

13.2.4.2 *Power supply*

Depending on the size and type of installation, the telephone system requires for its operation a dc power supply of 24 V or 48 V, which is obtained from the power mains through a rectifier. The rectifiers, provided with closed-loop control and for small and medium sized systems, are accommodated in the exchange housing. For large systems rectifiers (controlled) are supplied in separate cabinets.

13.2.5 *Standby Batteries*

Standby batteries can be provided as an adjunct to the rectifier. These are necessary for important installations such as police stations, fire stations, etc, to cover possible main supply failures.

13.2.6 *Space Requirements*

13.2.6.1 The switching equipment for the telephone systems and small EPABX's takes up little room. Apart from the telephones, only relatively small wall-mounted junction boxes or exchange units are required. The exchanges, furthermore, produce little or no noise, so that they can be accommodated in an office if desired. For large systems a separate room should be provided for the exchange equipment, and similarly for the answering panel. Space should be allowed in planning for additional cabinets or racks, exchange equipment platforms etc that may be necessitated by future enlargement of the systems. The size of the battery room depends upon the type of power supply equipment used.

13.2.7 *Features*

There are various features available with the present day EPABX with introduction of concerned cards and features to be incorporated have to be decided depending on functional requirement. Some of the most common features included are Abbreviated Dialing, Recorded Announcement System, Last number redial, Executive override, multi-party conference, call forwarding, Direct Inward Dialing (DID), Automatic alarm make-up call, STD barring, group hunting, networking facility.

13.3 Installation

13.3.1 *Wiring Installation*

For wiring within buildings, wire is mainly installed in embedded PVC conduit, or wiring cables with conductors of 0.6 mm or 0.8 mm diameter for surface wiring.

13.3.1.1 In running the wires it is important to maintain a separation of at least 10 mm between the communications wiring and power cables.

13.3.1.2 If conductors belonging to different communications systems are run together — for example, telephone wires and loudspeaker wires, or heavily loaded slave clock circuits — there is a risk of mutual interference between them. In such cases it is advisable to use screened cables.

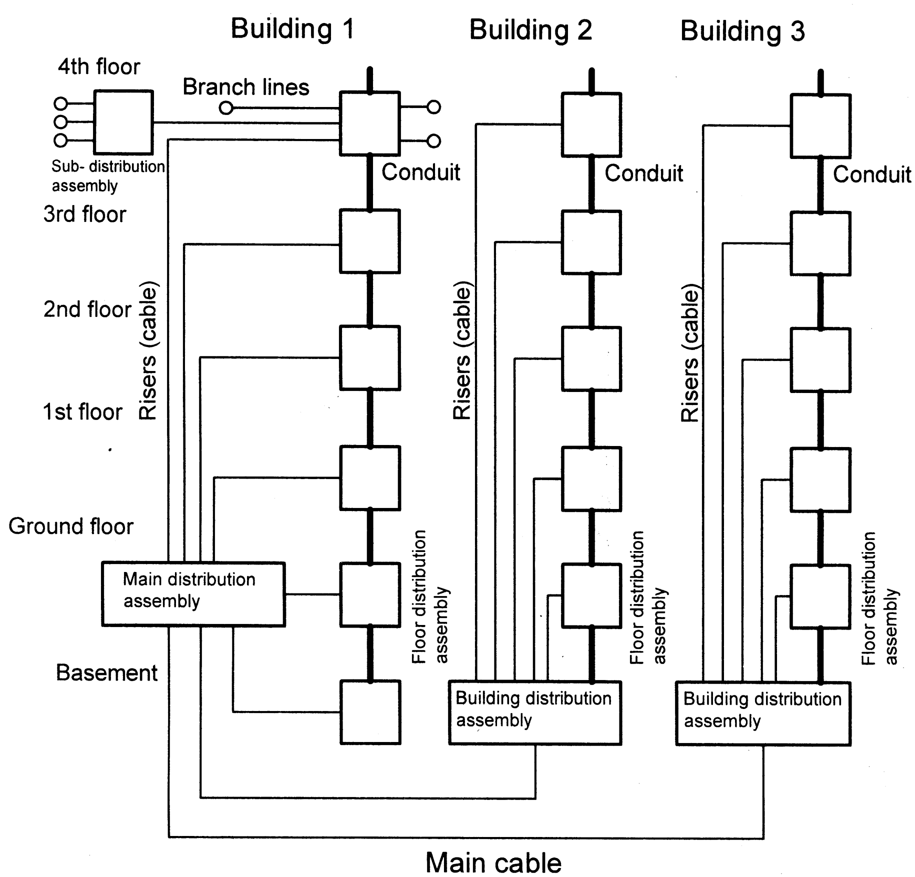


FIG. 4 EXAMPLE OF THE ARRANGEMENT OF A BASIC EPABX SYSTEM IN LARGE BUILDING

13.3.1.3 In communication cables the cores are twisted together either in pairs or in star quad formation. For speech transmission — to avoid crosstalk — either a twisted pair or, in the case of the star quad a pair of opposite cores — should be used.

13.3.2 *Ducts, Apertures and Channels*

In the course of constructing the shell of the building the appropriate channels and ducts should be formed in the masonry and lead-through apertures provided in walls, ceilings, joists and pillars. Suitable accommodation should be provided for the distribution boards in large communications system (for example recesses, shafts etc).

13.3.2.1 *Conduits*

PVC conduit can be used for the individual sections of conduit networks in residential buildings for the riser conduit from floor to floor, horizontal branches in the floors up to the distribution boxes in the apartments, and between the distribution boxes in the apartments and the flush-type junction boxes.

13.3.3 *Connection of Telephones*

13.3.3.1 At the positions allocated for the telephones the conduit should be terminated in flush-type boxes. For junction boxes and socket outlets for the connection of telephones, flush-type boxes (switch boxes) to standards are adequate. A maximum of two telephones can be connected to a junction box.

13.3.3.2 In most cases the telephone is connected permanently to the subscriber's line through a junction box. If it is required to be able to use it in a number of rooms, socket outlets and plugs should be provided. Units for flush and surface mounting are available for both methods of connection.

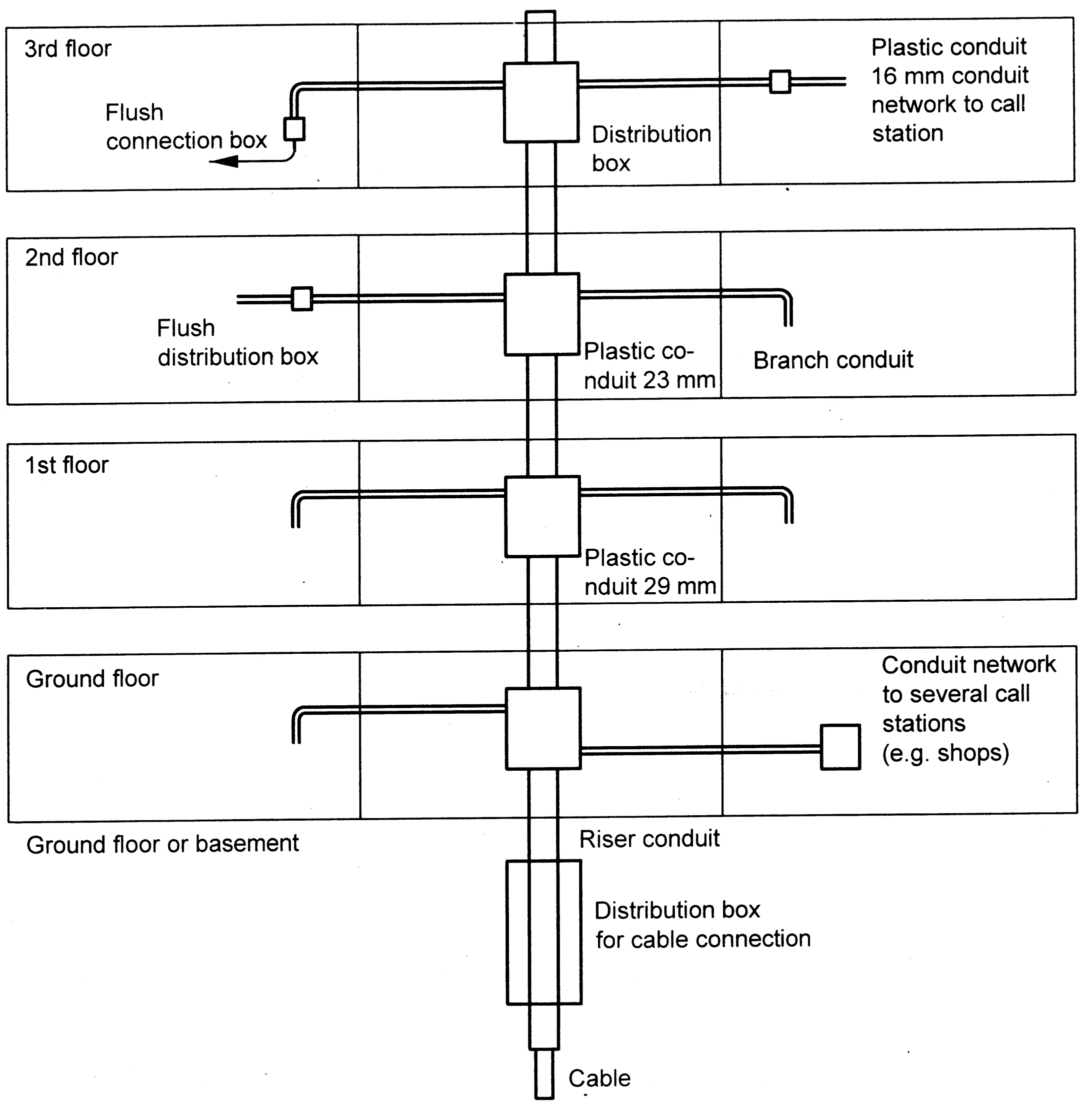


FIG. 5 TYPICAL CONDUIT WIRING SYSTEM

13.3.4 *Installation of Telephone Wiring*

13.3.4.1 *Wiring in residential building*

In residential buildings a concealed wiring arrangement is most conveniently and economically installed in an adequately dimensioned conduit network. It has been found satisfactory to provide riser conduits or cable ducts and horizontal branch conduits to the apartments, with distribution boxes at the junctions (Fig. 5). With a concealed installation of this kind it is possible at any time to alter the wiring or add to it without inconvenience to the occupier.

13.3.4.2 *Wiring in non-residential buildings*

In office buildings, manufacturing plants, department stores etc. particular importance is attached to flexible arrangement and utilisation of the accommodation. To this end the, communication wiring can be run in underfloor trunking systems or window-sealed trunking rather than on the walls.

13.3.5 *Accessory Installation*

13.3.5.1 *Main distribution board*

All the lines are collected in the main distribution board. The main distribution board should be located in the same part of the building in the immediate vicinity of the telephone equipment. If the telephone equipment extends over several buildings, each building is connected to the main distribution board by a main cable.

13.3.5.2 *Floor distribution board*

The floor distribution boards should be accommodated close to the stair well. The rising mains are run vertically to the floors.

13.3.5.3 Preventive fire precautions (for example fireproof barriers) should be considered at an early stage of planning

13.3.5.4 *Riser cables*

The ducts and ceiling apertures for the riser cables should be sufficiently large to permit the later addition of cables or PVC conduits without great expense.

13.3.5.5 *Spare conduits*

In addition at least one extra conduit should be provided from one floor distribution board to the next.

13.4 Inspection and Testing

13.4.1 The completed installation shall be inspected and simulation testing to be done to ensure that all the designed functions are available as per the standards and norms of specified by the manufacturer.

14 SUPPLIES FOR SAFETY SERVICES

14.0 General

14.0.1 For a safety service, a source of supply shall be selected which will maintain a supply of adequate duration.

14.0.2 For a safety service required to operate in fire conditions, all equipment shall be provided, either by construction or by erection, with protection providing fire resistance of adequate duration.

14.0.3 A protective measure against indirect contact without automatic disconnection at the first fault is preferred. In an IT system, continuous insulation monitoring shall be provided to give audible and visible indications of a first fault.

14.0.4 Equipment shall be arranged to facilitate periodic inspection, testing and maintenance.

14.1 Sources

14.1.1 A source for safety services shall be one of the following:

a) A primary cell or cells.
b) A storage battery.
c) A generator set capable of independent operation.
d) A separate feeder effectively independent of the normal feeder (provided that an assessment is made that the two supplies are unlikely to fail concurrently).

14.1.2 A source for a safety service shall be installed as fixed equipment and in such a manner that it cannot be adversely affected by failure of the normal source.

14.1.3 A source for a safety service shall be placed in a suitable location and be accessible only to skilled or instructed persons.

14.1.4 A single source for a safety service shall not be used for another purpose. However, where more than one source is available, such sources may supply stand-by systems provided that, in the event of failure of one source, the energy remaining available will be sufficient for the starting and operation of all safety services; this generally necessitates the automatic off-loading of equipment not providing safety services.

14.1.5 Clauses **14.1.3** and **14.1.4** do not apply to equipment individually supplied by a self-contained battery.

14.1.6 The location of the source shall be properly and adequately ventilated so that any exhaust gases, smoke or fumes from the source cannot penetrate, to a hazardous extent, areas occupied by persons.

14.2 Circuits

14.2.1 The circuit of a safety service shall be independent of any other circuit and an electrical fault or any intervention or modification in one system shall not affect the correct functioning of the other.

14.2.2 The circuit of a safety service shall not pass through any location exposed to abnormal fire risk unless the wiring system used is adequately fire resistant.

14.2.3 The protection against overload in the circuit may be omitted.

14.2.4 Every over-current protective device shall be selected and erected so as to avoid an over-current in one circuit impairing the correct operation of any other safety services circuit.

14.2.5 Switchgear and control gear shall be clearly identified and grouped in locations accessible only to skilled or instructed persons.

14.2.6 Every alarm, indication and control device shall be clearly identified.

14.3 Utilization Equipment

14.3.1 In equipment supplied by two different circuits, a fault occurring in one circuit shall not impair the protection against electric shock nor the correct operation of the other circuit.

14.4 Special Requirements for Safety Services Having Sources not Capable of Operation in Parallel

14.4.1 Precautions shall be taken to prevent the paralleling of the sources, for example by both mechanical and electrical interlocking.

14.4.2 The requirements of the regulations for protection against fault current and against indirect contact shall be met for each source.

14.5 Special Requirements for Safety Services Having Sources Capable of Operation in Parallel

14.5.1 The requirements of the regulations for protection against short-circuit and indirect contact shall be met whether the installation is supplied by either of the two sources or by both in parallel.

14.5.2 Precautions shall be taken, where necessary, to limit current circulation, particularly thereof third harmonics or multiples thereof, in the connection between the neutral points of sources.

ANNEX A

(*Clause* 2)

LIST OF INDIAN STANDARDS RELATED TO BUILDING SERVICES

IS No.	*Title*
1881 : 1998	Code of practice for indoor installation of public address systems
1882 : 1993	Code of practice for outdoor installation of public address system
2175 : 1988	Specification for heat sensitive fire detectors for use in automatic fire alarm system
2440 : 1975	Guide for daylighting of buildings
3103 : 1975	Code of practice for industrial ventilation
3043 : 1987	Code of practice for earthing
3362 : 1977	Code of practice for natural ventilation of residential buildings
3646 (Part 1): 1992	Code of practice for interior illumination: Part 1 General requirements and recommendations for welding interiors
7662 (Part 1): 1974	Recommendations for orientation of buildings: Part 1 Non-industrial buildings
8884 : 1978	Code of practice for the installation of electric bells and call system
8969 : 1978	Code of practice for installation and maintenance of impulse and electronic master and slave electric clock systems
14665 (Part 2/ Sec 1) : 2000	Electric traction lifts: Part 2 Code of practice for installation, operation and maintenance, Section 1 Passenger and goods lifts
14665 (Part 2/ Sec 2) : 2000	Electric traction lifts: Part 2 Code of practice for installation, operation and maintenance, Section 2 Service lifts
14665 (Part 3/ Sec 1) : 2000	Electric traction lifts: Part 3 Safety rules, Section 1 Passenger and goods lifts
14665 (Part 3/ Sec 2) : 2000	Electric traction lifts: Part 3 Safety rules, Section 2 Service lifts
SP 7 : 2005	National Building Code of India
SP 72 : 2010	National Lighting Code

SECTION 12 SELECTION OF EQUIPMENT

FOREWORD

Several Indian Standards exist, which cover details of selection, installation, and maintenance of electric power equipment. This Part 1/Section 12 of the Code is formulated in such a manner as to bring out only the essential criteria for selection of equipment, and users of the Code are recommended to make reference to individual product codes for detailed guidelines.

1 SCOPE

This Part 1/Section 12 of the Code covers general criteria for selection of equipment.

NOTE — This Part 1/Section 12 shall be read in conjunction with the Indian Standard/Codes on individual equipment.

2 SELECTION OF EQUIPMENT

2.1 Conformity to Indian Standards

Every item of electrical equipment used in the installation shall conform to the relevant Indian Standards, wherever available.

2.2 Characteristics

Every item of electrical equipment selected shall have suitable characteristics appropriate to the values and conditions on which the design of the electrical installation (*see* **3.2** of Part 1/Section 7) is based and shall, in particular, fulfill the requirements given to **2.2.1** to **2.2.4**.

2.2.1 *Voltage*

Electrical equipment shall be suitable with respect to the maximum steady voltage (rms value for ac) likely to be applied, as well as overvoltages likely to occur.

NOTE — For certain equipment, it may be necessary to take account of the lowest voltage likely to occur.

2.2.2 *Current*

All electrical equipment shall be selected with respect to the maximum steady current (rms value for ac) which it has to carry in normal service, and with respect to the current likely to be carried in abnormal conditions and the period (for example, operating time of protective devices, if any) during which it may be expected to flow.

2.2.3 *Frequency*

If frequency has an influence on the characteristics of electrical equipment, the rated frequency of the equipment shall correspond to the frequency likely to occur in the circuit.

2.2.4 *Power*

All electrical equipment to be selected on the basis of its power characteristics, shall be suitable for the duty demanded of the equipment, taking into account the load factor and the normal service conditions.

2.3 Conditions of Installation

All electrical equipment shall be selected so as to withstand safely the stresses and the environmental conditions (*see* **3.2** of Part 1/Section 7 of this Code) characteristic of its location to which it may be exposed. The general characteristics of building installations are assessed according to the guidelines given in Part 1/ Section 8 of this Code. If, however, an item of equipment does not have by design the properties corresponding to its location it may be used on condition that adequate additional protection provided as part of the completed electrical installation.

2.4 Prevention of Harmful Effects

All electrical equipment shall be selected so that it will not cause harmful effects on, other equipment or impair the supply during normal service including switching operations. In this context, the factors which may have an influence include;

a) Power factor,
b) Inrush current,
c) Asymmetrical load, and
d) Harmonics.

2.5 Guidelines on the selection of specific equipment are covered in the relevant Indian Standards. Guidelines on selection of protective devices are given at Part 1/ Section 14 of this Code.

SECTION 13 ERECTION AND PRE-COMISSIONING TESTING OF INSTALLATION

0 FOREWORD

Testing and ensuring that the installation conforms to the predetermined conditions before the installation could be energized, is a necessary prerequisite under the statutory provisions. Several aspects/parameters are required to be verified before an installation could be certified as ready for energizing and use.

While a general check list of items to be checked and necessary tests to be done are included in this Section, individual product standards and individual Codes of practice cover more detailed guidelines on pre-commissioning checks for individual equipment.

In addition to initial testing, periodic testing and preventive maintenance checks are necessary, the nature and frequency of such measures depending on the nature of the electrical installation in question. Guidelines on such aspects are outside the purview of the Code. However, a reference could be made to individual equipment codes which cover maintenance schedules.

1 SCOPE

This Part 1/Section 13 of the Code covers general principles of erection of installation and guidelines on initial testing before commissioning.

2 REFERENCES

A list of relevant Indian Standards is given at Annex A.

3 ERECTION

3.1 For the erection of the electrical installation, good workmanship by suitably qualified personnel and the use of proper materials shall be ensured.

3.2 The characteristics of the electrical equipment, as determined in accordance with Part 1/Section 12 shall not be impaired in the process of erection.

3.3 Protective conductors and neutral conductors shall be identifiable at least at their terminations by colouring or other means. These conductors in flexible cords or flexible cables shall be identifiable by colouring or other means throughout their length (*see* **3.6** of Part 1/Section 4).

3.4 Connections between conductors and between conductors and other electrical equipment shall be made in such a way that safe and reliable contacts are ensured. For electrical wiring installation, IS 732 should be followed. Also *see* Part 1/Section 14 of the Code.

3.5 All electrical equipment shall be installed in such a manner that the designed cooling conditions are not impaired.

3.6 All electrical equipment likely to cause high temperatures or electric arcs shall be placed or guarded so as to eliminate the risk of ignition of flammable materials. Where the temperature of any exposed parts of electrical equipment is likely to cause injury to persons, these parts shall be so located as to prevent accidental contact therewith.

3.7 Several Indian Standards exist on installation of specific electrical equipment. These shall be adhered to during erection of the installation.

4 INSPECTION AND TESTING

4.1 General Requirements

4.1.1 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 *Indian Electricity Rules*, 1956. In the event of defects being found, these shall be rectified, as soon as practicable, and the installation retested.

4.1.2 After putting the installation into service periodic inspection and testing shall be carried out in order to maintain the installation in a sound condition.

4.1.3 Where an addition is to be made to the fixed wiring of an existing installation the latter shall be examined for compliance with recommendations of this Code.

4.2 Inspection of the Installation

4.2.0 *General*

At the completion of wiring, a general inspection shall be carried out by competent personnel to verify that the provisions of this Code and that of *Indian Electricity Rules*, 1956 have been complied with. This, among other things, shall include checking whether all equipment, fittings, accessories, wires and cables, used in the installation are of adequate rating and quality to meet the requirements 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 of termination with respect to tightness, contact pressure and contact area. A complete check shall also be made of all the protective devices, with respect to the rating, range of settings and for co-ordination between the various protective devices.

4.2.1 *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 equipments are efficiently earthed and properly connected to the required number of earth electrodes;
4) the required ground clearance to live terminals is provided;
5) suitable fencing is provided with gate with lockable arrangements;
6) the required number of caution boards, fire-fighting equipments, operating rods, rubber mats, etc, are kept in the substation;
7) in case of indoor substation, sufficient ventilation and draining arrangements are made;
8) all cable trenches are provided with non-flammable covers;
9) free accessibility is provided for all equipment for normal operation;
10) all name-plates are fixed and the equipment are fully painted;
11) all construction materials and temporary connections are removed;
12) oil levels, bus bar tightness, transformer tap position, etc, are in order;
13) earth pipe troughs and cover slabs are provided for earth electrodes/earth pits. Neutral and lightning arrester earth pits are marked for easy identification;
14) earth electrodes are of GI pipes or CI pipes or MS rods or copper plates. For earth connections, brass bolts and nuts with lead washers are provided in the pipes/plates;
15) earth pipe troughs, oil sumps/pits are free from rubbish and dirt and stone jelly and the earth connections are visible and easily accessible;
16) Panels and switchgears are all vermin and damp proof and all unused openings or holes are blocked properly;
17) the earth bus bars for tightness and for corrosion free joint surface;
18) control switchfuses are provided at an accessible height from ground;
19) adequate head room is available in the transformer room for easy topping up of oil, maintenance, etc;
20) safety devices, horizontal and vertical barriers, bus bar covers/shrouds, automatic safety shutters/doors interlock, handle interlock for safe and reliable operation in all panels and cubicles;
21) clearances in the front, rear and sides of the switchboards, are adequate;
22) the gap in the horngap fuse and the size of fuse adequate;
23) the switch operates freely, all the blades make contact at the same time. The arcing horns contact in advance, and the handles are provided with locking arrangements;
24) Insulators are free from cracks, and are clean;
25) in the case of transformers, there is any oil leak;
26) connections to bushings in transformers are tightened and have good contact;
27) bushings are free from cracks and are clean;
28) accessories of transformers like breathers, vent pipe, buchholz relay, etc, are in order;
29) connections to gas relay in transformers are in order;
30) oil and winding temperature are set for specific requirements in transformers;
31) in case of cable cellars, adequate arrangements to pump out water that has entered due to seepage or other reason is provided; and
32) all incoming and outgoing circuits of panels are clearly and indelibly labelled for identifications both at the front and at the rear.

4.2.2 *Installation at Voltage not exceeding 650 V*

It shall be checked whether:

a) all blocking materials that are used for safe transportation in switchgears, contractors, 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 linked switch or circuit-breaker or lockable push button is provided near the motors/apparatus for controlling supply to the motor apparatus in any easily accessible location;
e) two separate and distinct earth connections are provided for the motor apparatus;
f) control switchfuse 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 equipments, the fourth core being used for earthing, and separate supply for lighting circuit is taken;

j) if flexible metallic house is used for wiring to motors and equipments, the wiring is enclosed to the full lengths, and the hose secured properly;

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 equipments 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 and calibrated;

r) the relays are inspected visually by moving covers for deposits or dusts or other foreign matter;

s) flat washers backed up by spiring washers are used for making end connections; and

t) number of wires in a conduit conform to provisions of this Code.

4.3 Testing of Installation

4.3.0 *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.

4.3.1 *Switchboards*

Switchboards shall be tested in the manner indicated below:

a) all switchboards shall be tested for di-electric test in the manner recommended in IS 8623 (Part 1),

b) all earth connections shall be checked for continuity,

c) the operation of all protective devices shall be tested by means of secondary or primary injection tests,

d) the operation of the circuit-breakers shall be tested from all control stations,

e) indication/signalling lamps shall be checked for working,

f) the operation of the circuit-breakers shall be tested for all interlock,

g) the closing and opening timings of the circuit-breakers shall be tested wherever required for autotransfer schemes,

h) contact resistance of main and isolator contacts shall be measured, and

j) the specific gravity of the electrolyte and the voltage of the control battery shall be measured.

4.3.2 *Transformers*

All commissioning tests as listed in IS 10028 (Part 2) shall be carried out.

4.3.3 *Cables*

Cable installations shall be checked as laid down in IS 1255.

4.3.4 *Motors and Other Equipment*

The following tests are made on motor and other equipment:

a) The insulation resistance of each phase winding against the frame and between the windings shall be measured. Megohm-meter 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:

$$R_i = \frac{20 \times E_n}{1\,000 + 2P}$$

where

R_i = insulation resistance in MΩ at 25ºC,

E_n = rated phase-to-phase voltage, and

P = rated power kW.

If the resistance is measured at a temperature different from 25°C, the value shall be corrected to 25ºC.

b) The insulation resistance as measured at ambient temperature does not always give a reliable value, since moisture might 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.

4.3.5 *Energymeters*

IS 15707 should be followed in case of energymeters.

4.3.6 *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 dc 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 (ac or dc) or a polyphase 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 megohms of an installation measured as in (a) shall be not less than 50 divided by the number of points on the circuits, provided that the whole installation need not be required to have an insulation resistance greater than 1MΩ.

c) Control rheostats, heating and power appliances and electric signs, may, if desired, he disconnected from the circuit during the test, but in that event the insulation resistance between the case or framework, and all live parts of each rheostat, appliance and sign shall be not less than that specified in the relevant Indian Standard or where there is no such specification shall be not less than 0.5 MΩ.

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 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).

e) On completion of an electrical installation (or an extension to an installation) a certificate shall be furnished by the contractor, countersigned by the certified supervisor under whose direct supervision the installation was carried out. this certificate shall be in a prescribed form as required by the local electric supply authority.

4.3.7 *Earthing*

For checking the efficiency of earthing the following tests are recommended (*see* IS 3043):

a) The earth resistance of each electrode is measured.

b) The earth resistance of earthing grid is measured.

c) All electrodes are connected to the grid and the earth resistance of the entire earthing system is measured.

These tests shall preferably be done during the summer months.

ANNEX A

(*Clause* 2)

LIST OF INDIAN STANDARDS ON INSTALLATION

IS No.	*Title*
732 : 1989	Code of practice for electrical wiring installations
1255 : 1983	Code of practice for installation and maintenance of power cables upto and including 33 kV rating
1646 : 1997	Code of practice for fire safety of buildings (general): Electrical installations
3043 : 1987	Code of practice for earthing
4051 : 1967	Code of practice for installation and maintenance of electrical equipment in mines
5571 : 2000	Guide for selection of electrical equipment for hazardous areas
8623 (Part 1) : 1993/ IEC 60439-1 : 1985	Specification for low-voltage switchgear and controlgear assemblies: Part 1 Requirements for type-tested and partially type-tested assemblies
10028 (Part 2) : 1981	Code of practice for selection, installation and maintenance of transformers: Part 2 Installation
14927	Cable trunking and ducting systems for electrical installations :
(Part 1) : 2001	General requirements
(Part 2) : 2001	Cable trunking and ducting systems intended for mounting on walls or ceilings
14930	Conduit systems for electrical installations:
(Part 1) : 2001	General requirements
(Part 2) : 2001	Particular requirements — Conduit systems buried underground
15707 : 2006	Testing, evaluation, installation and maintenance of ac electricity meters — Code of practice

SECTION 14 EARTHING

FOREWORD

Earthing provides safety of persons and apparatus against earth faults. Any system is characterised by the type of distribution system, which include types of systems of live conductors and types of system earthing. The different types of earthing systems are also covered under this Part 1/Section 14 of the Code. The choice of one system or the other would depend on several considerations as each offer different degree of performance/safety.

This Part 1/Section 14 of the Code summarises the essential requirements associated with earthing in electrical installations. These relate to general conditions of soil resistivity, design parameters of earth electrode, earth bus and earth wires and methods of measurements. Particular requirements for earthing depending on the type of installation are covered in respective Sections of the Code.

1 SCOPE

This Part 1/Section 14 of the Code covers general requirements associated with earthing in electrical installations. Specific requirements for earthing in individual installations are covered in respective Parts of the Code.

NOTES

1 This Section shall be read in conjunction with the provisions of IS 3043.

2 Additional rules applying to earth leakage circuit-breaker systems are covered in Annex A.

2 REFERENCES

For further details, the following standards may be referred:

IS No.	*Title*
732 : 1989	Code of practice for electrical wiring installations (*third revision*)
3043 : 1987	Code of practice for earthing (*first revision*)
IS 8437(Part 1) : 1993	Guide on effects of current passing through human body: Part 1 General aspects
IS 8437(Part 2) : 1993	Guide on effects of current passing through human body: Part 2 Special aspects
IS/IEC 60947-2 : 2006	Low voltage switchgear and controlgear: Part 2 Circuit breakers
IS/IEC 60947-4-1: 2002	Low-voltage switchgear and controlgear: Part 4 Contactors and motor-starters, Section 1 Electro-mechanical contactors and motor-starters

3 GENERAL REMARKS

3.0 General

3.0.1 The subject of earthing covers the problems relating to the conduction of electricity through earth. The terms earth and earthing have been used in this Code, irrespective of reliance being placed on the earth itself, to denote a low impedance return path of the fault current. As a matter of fact, the earth now rarely serves as a part of the return circuit but is being used mainly for fixing the voltage of system neutrals. The earth connection improves service continuity and avoids damage to equipment and danger to human lives.

3.0.2 The object of an earthing system is to provide as nearly as possible a surface under and around a station which shall be at a uniform potential and as nearly zero or absolute earth potential as possible. The purpose of this is to ensure that in general all parts of apparatus, other than live parts, shall be at earth potential, as well as to ensure that operators and attendants shall be at earth potential at all times. Also by providing such an earth surface of uniform potential under and surrounding the station, as nearly as possible, there can exist no difference of potential in a short distance big enough to shock or injure an attendant when short-circuits or other abnormal occurrence take place.

3.0.3 Earthing associated with current-carrying conductor is normally essential to the security of the system and is generally known as system earthing, while earthing of non-current carrying metal work and conductor is essential to the safety of human life, of animals and of property and is generally known as equipment earthing.

3.0.4 Earthing shall generally be carried out in accordance with the requirements of *Indian Electricity Rules*, 1956 as amended from time to time, and the relevant regulations of the electricity supply authority concerned. The following clauses of *The Indian Electricity Rules,* 1956 are particularly applicable:

32, 51, 61, 62, 67, 69, 88 (2) and 90.

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

3.0.5.1 In cases where direct earthing may prove harmful rather than provide safety (for example, high frequency and mains frequency coreless induction furnaces), relaxation may be obtained from the competent authority.

3.0.6 Earth electrodes shall be provided at generating stations, substations and consumer premises in accordance with the requirements.

3.0.7 All far as possible all earth terminals shall be visible.

3.0.8 All connections shall be carefully made; if they are poorly made or inadequate for the purpose for which they are intended, loss of life or serious personal injury may result.

3.0.9 Each earth system shall be so devised that the testing of individual earth electrode is possible. It is recommended that the value of any earth system resistance shall not be more than 5.0, unless otherwise specified.

3.0.10 It is recommended that a drawing showing the main earth connection and earth electrodes be prepared for each installation.

3.0.11 No addition to the current-carrying system either temporary or permanent, shall be made, which will increase the maximum available earth fault current or its duration until it has been ascertained that the existing arrangement of earth electrodes, earth busbar, etc, are capable of carrying the new value of earth fault current which may be obtained by this addition.

3.0.12 No cut-out, link or switch other than a linked switch arranged to operate simultaneously on the earthed or earthed neutral conductor and the live conductors shall be inserted on any supply system. This however, does not include the case of a switch for use in controlling a generator or a transformer or a link for test purposes.

3.0.13 All materials, fittings, etc, used in earthing shall conform to Indian Standards wherever these exist. In the case of materials for which Indian Standard specifications do not exist, the materials shall be approved by the competent authority.

3.1 Design Considerations

3.1.1 *System Earthing*

3.1.1.1 The regulations that every medium, high and extra high voltage equipment shall be earthed by not less than two separate and distinct connections with earth is designed primarily to preserve the security of the system by ensuring that the voltage on each live conductor is restricted to such a value with respect to the potential of the general mass of the earth as is consistent with the levels of insulation applied. Distinct connection with the earth shall be provided for lightning protection system for buildings or other installations. Distinct earthing system shall be provided for centralized electronic system of any building.

3.1.1.2 The earth system resistance should be such that when any fault occurs against which earthing is designed to give protection, the protective gear will operate to make the faulty portions of plant harmless. In most cases such operation involves isolation of the faulty main or plant by circuit-breaker or fuses. In the cases of underground system there may be no difficulty, but in the case of overhead line system protected only by fuses there may be difficulty in so arranging the value of the earth resistance that a conductor falling and making good contact with earth shall cause the fuses in the supply to operate.

NOTE — Earthing may not give protection against faults which are not essentially earth faults. For example, if a phase conductor of an overhead spur line breaks, and the part remote from the supply falls to the ground, it is unlikely that any protective gear relying on earthing will operate since the major fault is the open-circuit against which earthing gives no protection.

3.1.2 *Equipment Earthing*

The object of equipment earthing is to ensure effective operation of the protective gear in the event of leakage through such metal work, the potential of which with respect to neighbouring objects may attain a value which would cause danger to life or risk or fire.

3.1.3 *Soil Resistivity*

3.1.3.1 The resistance to earth of an electrode of given dimensions is dependent on the electrical resistivity of the soil in which it is installed. It follows, therefore, that an overriding consideration in deciding which of the alternative method of protection is to be adopted for a particular system or location is the soil resistivity in the area concerned.

3.1.3.2 The type of soil largely determines its resistivity and representative values for soils generally found in India are given at Annex B. Earth conductivity is, however, essentially electrolytic in nature and is affected therefore by moisture content of the soil and its chemical composition and concentration of salts dissolved in the contained water. Grain size and distribution and closeness of packing are also contributory factors since they control the manner in which the moisture is held in soil. Many of these factors vary locally and some seasonally and, therefore, the values given in Annex B should be taken only as a general guide. Local values should be verified by actual measurement and this is especially important where the soil is stratified, as owing to the disposition of earth current, the effective resistivity depends not only on the surface layers but also on the underlying geological formation.

3.1.3.3 The soil temperature also has some effect on soil resistivity but is important only near and below freezing point, necessitating the installation of earth electrode at depths to which frost will not penetrate.

3.1.3.4 While the fundamental nature and properties of a soil in a given area cannot be changed, use can be made of purely local conditions in choosing suitable electrode sites and of methods of preparing the site selected, to secure optimum resistivity. Reference is drawn to IS 3043.

3.1.4 *Potential Gradients*

It is necessary to ensure, especially in case of large electrical installations, that a person walking on the ground or touching an earthed objects, in or around the premises shall not have large dangerous potential differences impressed across his body in case of a fault within or outside the premises. Such danger may arise if steep potential gradients exist within the premises or between boundary of the premises and an accessible point outside. For this the step potential and touch potential should be investigated and kept within safe limits. Within an earthing grid, the step and touch potentials may be lowered to any value by reducing the mesh interval of the grid. The situation is more difficult in the zone immediately outside the periphery where the problems may exist even for the theoretical case of a single plate covering the sub-station area. This problem may be serious in small stations where the grid may cover only a limited area. Attempts should be made to design a substation so as to eliminate the possibility of touch contact beyond the earth-system periphery, when the limitations on step potential become less exacting. While assessing the touch potential, the method of earthing of the object touched, for example, whether it is earthed directly below or remotely should be kept in view in order to consider the possibility of occurrence of large potential differences.

Special attention should be paid to the points near the operating handles of apparatus and, if necessary, potential equalizer grillages of closer mesh securely bonded to the structure and the operating handle should be buried below the surface where the operator may stand when operating the switch.

3.1.5 At consumer's premises where the apparatus is protected by fuses, the total earth circuit impedance shall not be more than that obtained by graphs given in Fig. 1.

4 EARTH ELECTRODES

4.1 Material

4.1.1 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 will be used.

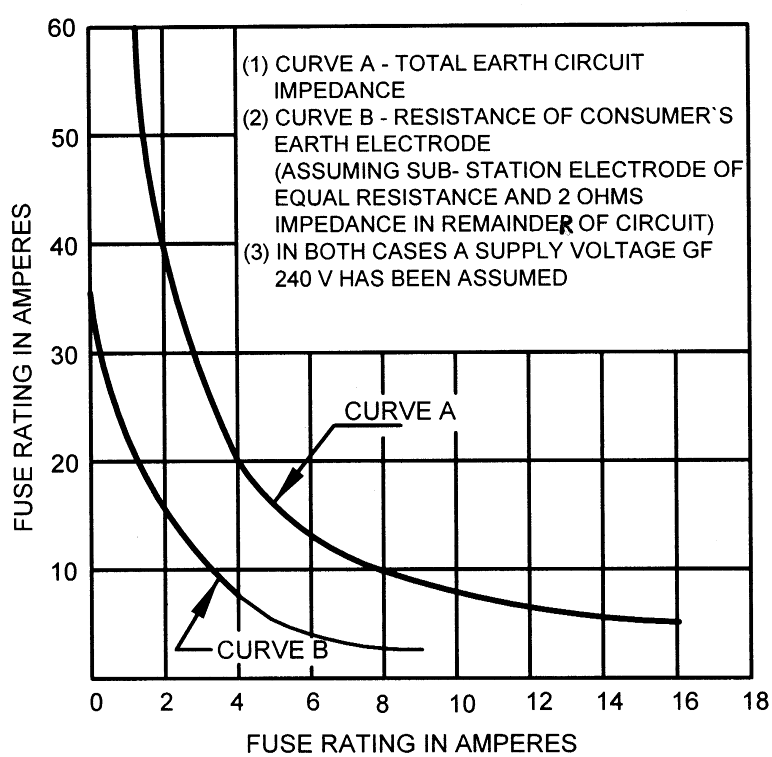


FIG. 1 RECOMMENDED EARTH CIRCUIT IMPEDANCE OF RESISTANCE FOR DIFFERENT VALUES OF FUSE RATING

4.1.2 Under ordinary conditions of soil, use of copper, iron or mild steel electrodes is recommended.

4.1.3 In cases where soil conditions point to excessive corrosion of the electrode and the connections, it is recommended to use either copper electrode or copper clad electrode or zinc coated (galvanized) iron electrodes.

4.1.4 In direct current system, however, due to electrolytic action which causes serious corrosion, it is recommended to use only copper electrodes.

4.1.5 The electrode shall be kept free from paint, enamel and grease.

4.1.6 It is recommended to use similar material for earth electrodes and earth conductors or otherwise precautions should be taken to avoid corrosion.

4.2 Current Loading

4.2.1 An earth electrode should be designed to have a loading capacity adequate for the system in which it forms a part, that is, it should be capable of dissipating without failure, energy in the earth path at the point at which it is installed under any condition of operation of the system. Failure is fundamentally due to excessive rise of temperature at the surface of the electrode and is thus a function of current density and duration as well as electrical and thermal properties of soil.

4.2.2 Two conditions of operation occur in system operation, namely;

a) Long duration overloading as with normal system operation, and
b) Short time overloading as under fault conditions in directly earthed system.

4.3 Voltage Gradient

4.3.1 Under fault conditions the earth electrode is raised to a potential with respect to the general mass of the earth. This results in the existence of voltages in the soil around the electrode which may be injurious to telephone and pilot cables whose cores are substantially at earth potential owing to the voltage to which the sheaths of such cables are raised. The voltage gradient at the surface of the earth may also constitute danger to life.

4.3.2 Earth electrodes should not be installed in proximity to a metal fence to avoid the possibility of the fence becoming live, and thus dangerous at points remote from the substation, or alternatively giving rise to danger within the resistance area of the electrode which can be reduced only by introducing a good connection with the general mass of the earth. If the metal fence is unavoidable, it should be earthed.

4.4 Types of Earth Electrodes

The following types of earth electrodes are considered standard:

a) Rod and pipe electrodes,
b) Strip or conductor electrodes,
c) Plates electrodes, and
d) Cable sheaths.

For details regarding their design, reference shall be made to IS 3043.

4.5 Design Data on Earth Electrodes

4.5.1 The design data on the various types of earth electrodes is given in Table 1.

4.5.2 *Effect of Shape on Electrode Resistance*

The resistance of any electrode buried in the earth is in fact related to the capacitance of that electrode and its image in free space. The relationship is given by:

$$R = \frac{100\,\rho}{4\,\pi\,C}$$

where

R = resistance in an infinite medium;

ρ = resistivity of the medium (soil); in ohm-metre; and

C = capacitance of the electrode and its image in free space.

In practical case, the capacitance is divided into two by the plane of earth's surface so that,

$$R = \frac{100\,\rho}{4\,\pi\,C}$$

a) For rod or pipe electrodes, the formula is

$$R = \frac{100\,\rho}{4\,\pi\,C} \log_e \frac{2l}{d} \text{ ohms}$$

where

l = length of rod or pipe, in cm; and

d = diameter of rod or pipe, in cm.

b) For strip or round conductor electrodes,

$$R = \frac{100\,\rho}{4\,\pi\,C} \log_e \frac{4l}{d} \text{ ohms}$$

where

l = length of the strip, in cm; and

t = width (strip) or twice the diameter (conductors), in cm.

c) For plate electrodes,

$$R = \frac{\rho}{4}\sqrt{\frac{\pi}{A}}\ \text{ohms}$$

where

A = area of both sides of plate, in m^2.

4.5.3 *Effect of Depth of Burial*

To reduce the depth of burial without increasing the resistance, a number of rods or pipes shall be connected together in parallel (*see* Fig. 4). The resistance in this case is practically proportional to the reciprocal of the number of electrodes used so long as each is situated outside the resistance area of the other. The distance between two electrodes in such a case shall preferably be not less than twice the length of the electrode.

5 EARTH BUS AND EARTH WIRES

5.0 General

5.0.1 The minimum allowable size of earth wire is determined principally by mechanical consideration for they are more liable to mechanical injury and should therefore be strong enough to resist any strain that is likely to be put upon them.

5.0.2 All earth wires and earth continuity conductors shall be of copper, galvanized iron, or steel or aluminium.

NOTE — Bare aluminium shall not be used underground.

5.0.3 They shall be either stranded or solid bars or flat rectangular strips and may be bare provided due care is taken to avoid corrosion and mechanical damage to it. Where required, they shall be run inside metallic conduits.

5.0.4 Interconnections of earth-continuity conductors and main and branch earth wires shall be made in such a way that reliable and good electrical connections are permanently ensured.

NOTE — Welded, bolted and clamped joints are permissible. For stranded conductors, sleeve connectors (for example, indented, riveted or bolted connectors) are permissible. Bolted connectors and their screws shall be protected against any possible corrosion.

5.0.5 The path of the earth wire shall, as far as possible, be out of reach of any person.

5.0.6 If the metal sheath and armour have been used as an earth continuity conductor the armour shall be bonded to the metal sheath and the connection between the earth wire and earthing electrode shall be made to the metal sheath.

5.0.7 If a clamp has been used to provide connection

Table 1 Design Data on Earth Electrodes
(*Clause* 4.5.1)

All dimensions in millimetres.

Sl No.	Measurement	Type of Electrodes				
		Rod	Pipe (*see* Note 1)	Strip	Round Conductor	Plate (*see* Note 2)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
i)	Diameter (not less than)	16 mm[1)] 12.5 mm[2)]	38 mm[1)] 100 mm[2)]			
ii)	Length of conductor/rod	3 500 mm	3 500 mm	500 mm	15 000 mm	1 500 mm
iii)	Depth upto which buried	3 750 mm	3 550 mm			3 200 mm
iv)	Size			25 mm × 1.60 mm[2)] 25 mm × 4 mm[1)]	3.0 mm^2 [2)] 6 mm^2 [1)]	1 200 mm × 1200 mm[3)] 600 mm × 600 mm[1)]
v)	Thickness		3.15 mm[1)]			6.30 mm[2)] 3.5 mm[1)]

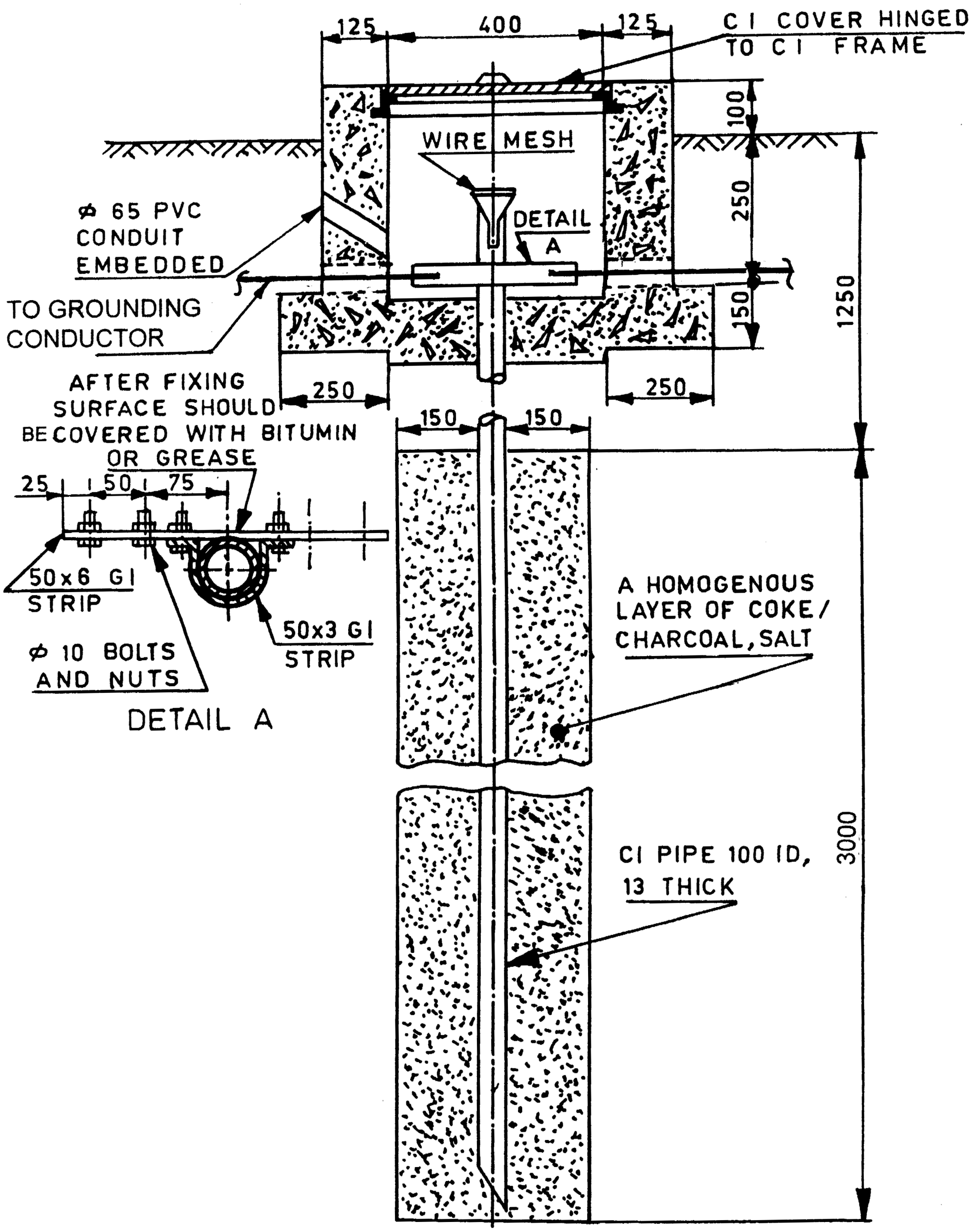
1) Steel or galvanized iron.
2) Copper.
3) Cast iron.

NOTES

1 A typical illustration of pipe earth electrode is given in Fig. 2.

2 A typical illustration of plate electrode is given in Fig. 3. If two or more plates are used in parallel, they shall be separated by not less than 3.0 m.

3 Adequate quantity of water to be poured into sump every few days to keep the soil surrounding the earth pipe permanently moist.

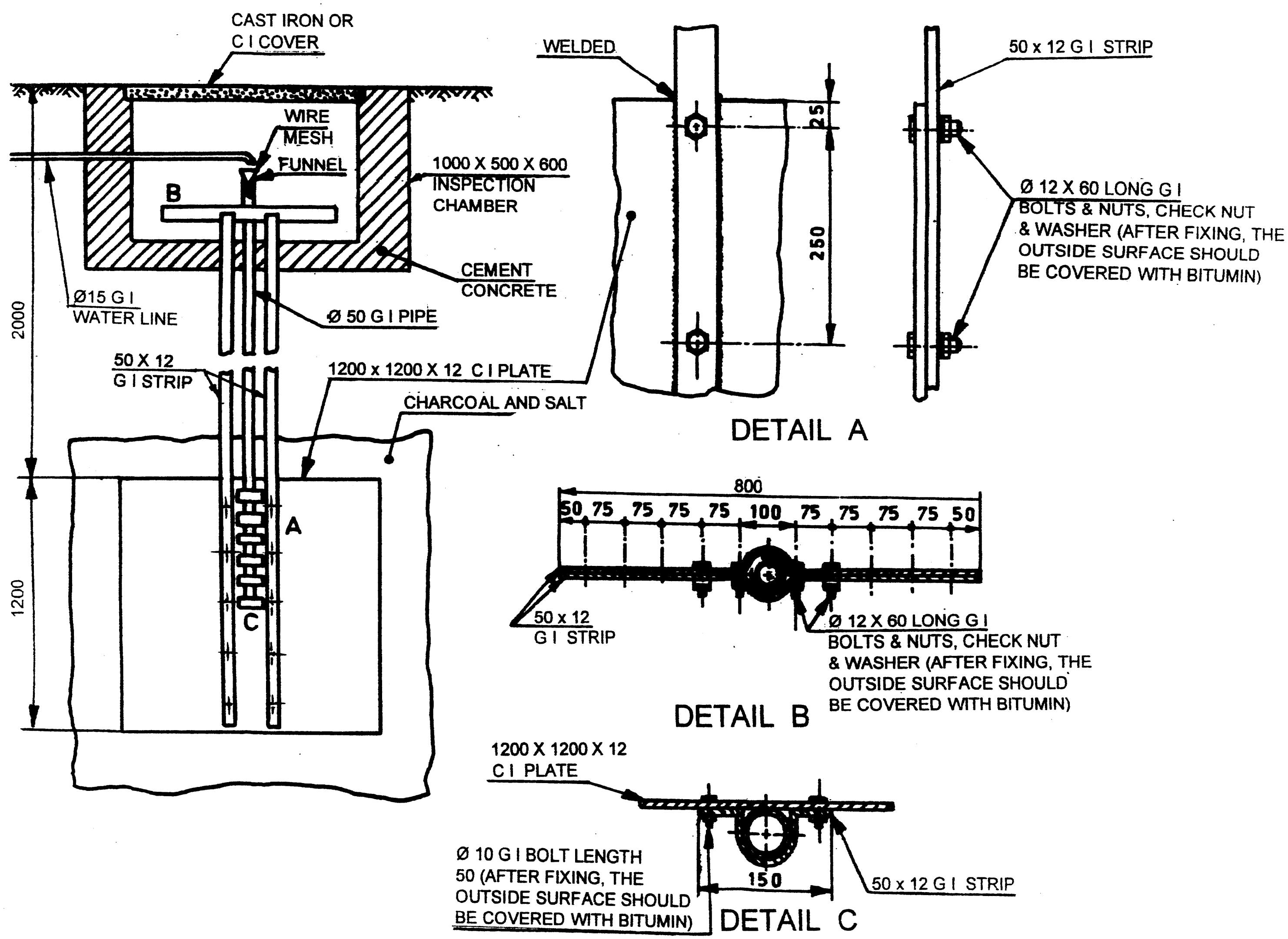


NOTES

1 All dimensions in millimetres.

2 After laying the earth from the earth bus to the electrode through the PVC conduits at the pit entry conduits should be sealed with bitumin compound.

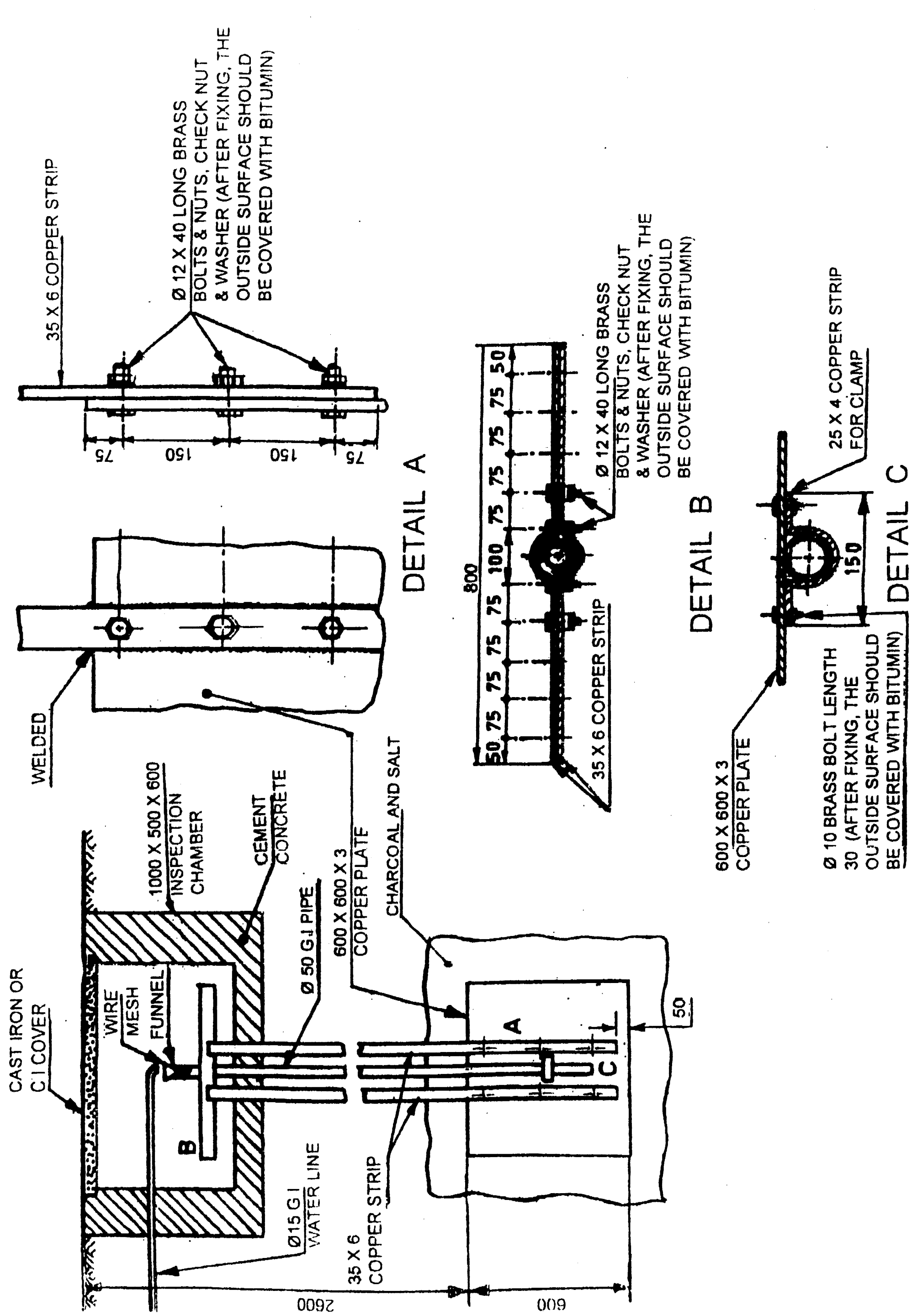
FIG. 2 A TYPICAL ILLUSTRATION OF PIPE EARTH ELECTRODE



All dimensions in millimetres.

3A Earthing with GI Plate

FIG. 3 A TYPICAL ILLUSTRATION OF PLATE EARTH ELECTRODE — *Continued*



All dimensions in millimetres.

3B Earthing with Copper Plate

FIG. 3 A TYPICAL ILLUSTRATION OF PLATE EARTH ELECTRODE

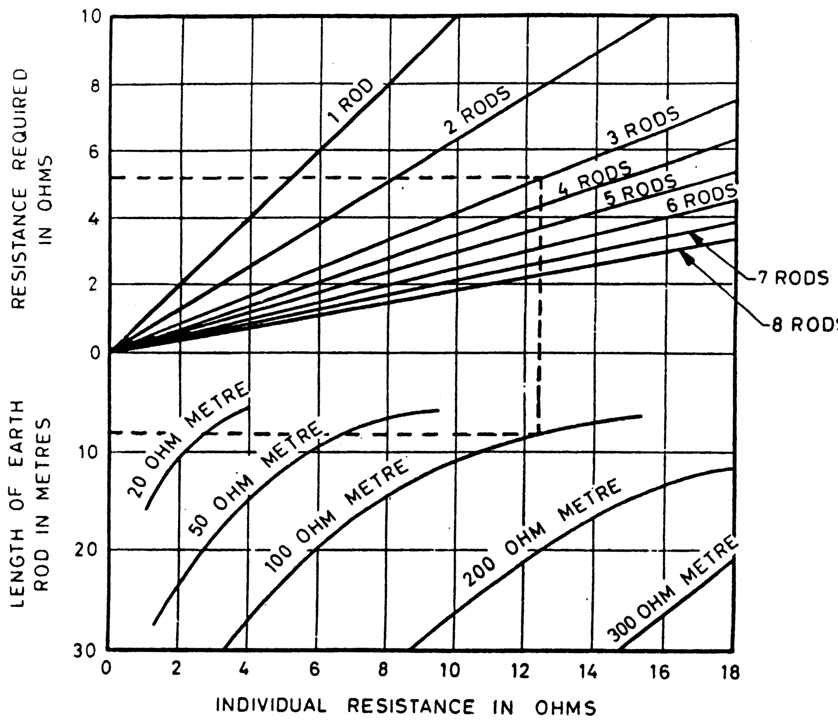


FIG. 4 RESISTANCE OF ELECTRODE AT VARIOUS DEPTHS AND SOIL RESISTANCES

between the earth wire and the metal sheath and armour, it shall be so designed and installed as to provide reliable connection without damage to the cable.

5.0.8 The neutral conductor shall not be used as earth wire.

5.0.9 The minimum sizes of earth-continuity conductors and earth wires shall be as given in the relevant part of the Code.

6 MEASUREMENT OF EARTH ELECTRODE RESISTANCE

6.1 Fall of Potential Method

In this method two auxiliary earth electrodes, besides the test electrode, are placed at suitable distances from the test electrode (*see* Fig. 5). A measured current is passed between the electrode '*A*' to be tested and an auxiliary current electrode '*C*' and the potential difference between the electrode '*A*' and the auxiliary potential electrode '*B*' is measured. The resistance of the test electrode '*A*' is then given by:

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

where

R = resistance of the test electrode, in ohms;

V = reading of the voltmeter, in V; and

I = reading of the ammeter, in amperes.

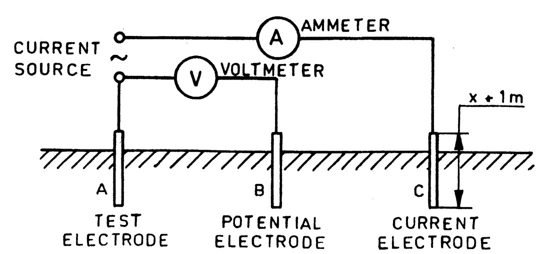


FIG. 5 METHOD OF MEASUREMENT OF EARTH ELECTRODE RESISTANCE

6.1.1 If the test is made at power frequency, that is, 50 Hz, the resistance of the voltmeter should be high compared to that of the auxiliary potential electrode 'B' and in no case should be less than 20 000 Ω.

NOTE — In most cases there will be stray currents flowing in the soil and unless some steps are taken to eliminate their effect, they may produce serious errors in the measured value. If the testing current is of the same frequency as the stray current, this elimination becomes very difficult and it is better to use an earth tester incorporating a hand-driven generator. These earth testers usually generate direct current and have rotary current-reverser and synchronous rectifier mounted on the generator shaft so that alternating current is supplied to the test circuit and the resulting potentials are rectified for measurement by a direct-reading moving-coil ohm-meter. The presence of stray currents in the soil is indicated by a wandering of the instrument pointer, but an increase or decrease of generator handle speed will cause this to disappear.

6.1.2 The source of current shall be isolated from the supply by a double by a double wound transformer.

6.1.3 At the time of test, where possible, the test electrode shall be separated from the earthing system.

6.1.4 The auxiliary electrodes usually consist of 12.5 mm diameter mild steel rod driven up to 1 m into the ground.

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

6.1.6 Unless three consecutive readings of test electrode resistance with different spacings of electrodes agree, the test shall be repeated by increasing the distance between electrodes '*A*' and '*C*' up to 50 m and each time placing the electrode '*B*' midway between them.

6.2 Alternative Method

6.2.1 The method described in **6.1** may not give satisfactory results if the test electrode is of very low impedance (1 ohm or less). This applies particularly while measuring the combined resistance of large installations. In these cases, the following method may be adopted.

6.2.1.1 Two suitable directions, at least 90° apart, are first selected. The potential lead is laid in one direction and an electrode is placed 250 to 300 m from the fence. The current lead is taken in the other direction and the current electrode located at the same distance as the potential electrode. A reading is taken under this condition. The current electrode is then moved out in 30 m steps until the same reading is obtained for three consecutive locations. The current electrode is then left in the last foregoing position and the potential electrode is moved out in 30 m steps until three consecutive readings are obtained without a change in value. The last readings then correspond to the true value of earth resistance.

7 EARTHING OF INSTALLATIONS IN BUILDINGS

7.1 The earthing arrangements of the consumer's installation shall be such that on occurrence of a fault of negligible impedance from a phase or non-earthed conductor to adjacent exposed metal, a current corresponding to not less than three-and-a-half times the rating of the fuse or one-and-a-half times the setting of the overload earth leakage circuit-breaker will flow except where residual current operated devices or voltage operated earth leakage circuit-breakers are used and make the faulty circuit dead. Where fuses are used to disconnect the faulty section of an installation in the event of an earth fault, the total permissible impedance of the earth fault path may be computed from the following formula (for a normal three-phase system with earthed neutral).

$$Z = \frac{\text{Phase-to-earth voltage of system}}{\text{Minimum fusing current off ues} \times \text{Factor of safety}}$$

where

Z = permissible impedance, in ohm.

NOTE — The factor of safety in calculating the permissible impedance should be left to the discretion of the designer.

7.1.1 The factor of safety in the above formula ensures that in most cases the fuse will blow in a time which is sufficiently short to avoid danger and allowing for a number of circumstances, such as the grading of fuse rating, increase of resistance due to drying out of the earth electrodes in dry weather, inevitable extensions to installations involving increase in length of the circuit conductors and the earth-continuity conductors, etc.

7.1.2 It will be observed that this requirement determines the overall impedance and does not contain a specific reference to any part of the circuit such as the conduit or other earth-continuity conductor together with the earthing lead. In fact, in large installations the overall impedance permissible may be less than 1 ohm, so that considerably less than this might be allowable for the earth-continuity system.

7.2 It is desirable when planning an installation to consult the supply authority or an electrical contractor having knowledge of local conditions, in order to ascertain which of the two, namely, the use of fuses of overload circuit-breakers, for protection against earth-leakage currents is likely to prove satisfactory.

7.3 It is recommended that the maximum sustained voltage developed under fault conditions between exposed metal required to be earthed and the consumer's earth terminal shall not exceed 32 V rms.

7.4 Only pipe, rod or plate earth electrodes are recommended and they shall satisfy the requirements of **4.5**.

7.5 Earth-Continuity Conductors

7.5.1 Connection to earth of those parts of an installation which require to be earthed shall be made by means of an earth-continuity conductor which may be a separate earth conductor, the metal sheath of the cables or the earth continuity conductor contained in a cable, flexible cable or flexible cord.

7.5.2 *Earth-Continuity Conductors and Earth Wires not Contained in the Cables*

The size of the earth-continuity conductors should be correlated with the size of the current carrying conductors, that is, the sizes of earth-continuity conductors should not be less than half of the largest current carrying conductors, provided the minimum size of earth-continuity conductors is not less than 1.5 mm^2 for copper and 2.5 mm^2 for aluminium and need not be greater than 70 mm^2 for copper and 120 mm^2 for aluminium. As regards the sizes of galvanized iron and steel earth-continuity conductors, they may be equal to size of current-carrying conductors with which they are used. The size of earth-continuity conductors to be used along with aluminium current-carrying conductors should be calculated on the basis of equivalent size of the copper current-carrying conductors.

7.5.3 *Earth-Continuity Conductors and Earth Wires Contained in the Cables*

For flexible cables, the size of the earth-continuity conductors should be equal to the size of the current-carrying conductors and for metal sheathed, PVC and tough rubber sheathed cables the sizes of the earth-continuity conductors shall be in accordance with relevant Indian Standards.

7.5.4 *Cable Sheaths Used as Earth-Continuity Conductors*

Where the metal sheaths of cables are used as earth-continuity conductors, every joint in such sheaths shall be so made that its current-carrying capacity is not less than that of the sheath itself. Where necessary, they shall be protected against corrosion.

Where non-metallic joint boxes are used, means shall be provided to maintain the continuity, such as a metal strip having a resistance not greater than that of the sheath of the largest cable entering the box.

7.5.5 *Metal Conduit Pipe Used as on Earth-Continuity Conductor*

Metal conduit pipe should generally not be used as an earth-continuity conductor but where used as very high standard of workmanship in installation is essential. Joints shall be so made that their current-carrying capacity is not less than that of the conduit itself. Slackness in joints may result in deterioration and even complete loss of continuity. Plain slip or pin-grip sockets are insufficient to ensure satisfactory electrical continuity of joints. In the case of screwed conduit, lock nuts should also be used.

7.5.6 *Pipes and Structural Steel Work*

Pipes, such as water pipe, gas pipe, or members of structural steel work shall not be used as earth-continuity conductor.

8 MEASUREMENT OF EARTH LOOP IMPEDANCE

8.1 The current which will flow under earth fault conditions and will thus be available to operate the overload protection depends upon the impedance of the earth return loop. This includes the line conductor, fault, earth-continuity conductor and earthing-lead, earth electrodes at consumer's premises and substations and any parallel metallic return to the transformer neutral as well as the transformer winding. To test the overall earthing for any installation depending for protection on the operation of overcurrent devices, for example, fuses, it is necessary to measure the impedance of this loop under practical fault conditions. After the supply has been connected this shall be done by the use of an earth loop impedance tester as shown in Fig. 6. The neutral is used in place of the phase conductor for the purpose of the test. The open-circuit voltage of the loop tester should not exceed 32 V.

9 TYPES OF SYSTEM EARTHING

9.1 Internationally, it has been agreed to classify the earthing systems as TN System, TT System and IT System.

9.1.1 *TN System*

This type of system has one or more points of the source of energy directly earthed, and the exposed and extraneous conductive parts of the installation are connected by means of protective conductors to the earthed point(s) of the source, that is, there is a metallic path for earth fault currents to flow from the installation to the earthed point(s) of the source. TN systems are further sub-divided into TN-C, TN-S and TN-C-S systems.

9.1.2 *TT System*

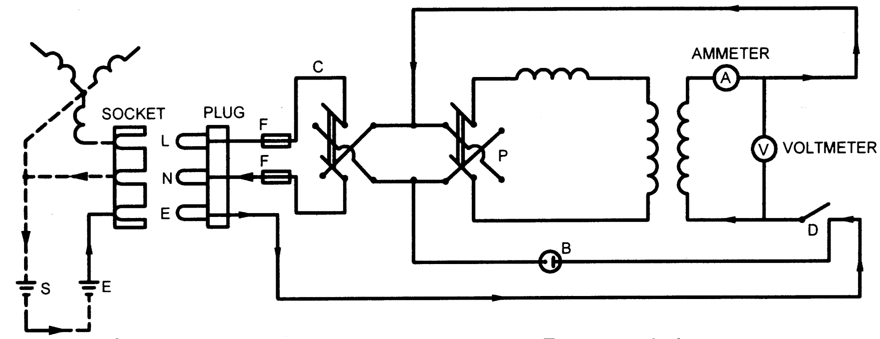
This type of system has one or more points of the source of energy directly earthed and the exposed and extraneous conductive parts of the installation are connected to a local earth electrode or electrodes and are electrically independent of the source earth(s).

9.1.3 *IT System*

This type of system has the source either unearthed or earthed through a high impedance and the exposed conductive parts of the installation are connected to electrically independent earth electrodes.

9.1.4 It is also recognized that, in practice, a system may be an admixture of types. For the purpose of this Code, earthing systems are designated as follows:

a) *TN-S system (for 240 V single-phase domestic/ commercial supply)* — Systems where there are separate neutral and protective conductors



A = ammeter
B = neon indicator
C = main switch
D = test switch
E = consumer's earth electrode
F = supply fuse
P = polarity switch
S = substation earth electrode
V = voltmeter

At *FF*, jacks are provided for insertion of plugs for connection to external neutral and/or earth conductors, if desired.

NOTES

1 Arrows shows current flow in neutral or earth loop.

2 Supply system is shown in dotted.

FIG. 6 CIRCUIT DIAGRAM OF EARTH LOOP IMPEDANCE TESTER

throughout the system. A system where the metallic path between the installation and the source of energy is the sheath and armouring of the supply cable (*see* Fig. 7A).

b) *Indian TN-S System (for 415 V three-phase domestic commercial supply)* — An independent earth electrode within the consumer's premises is provided (*see* Fig. 7B).

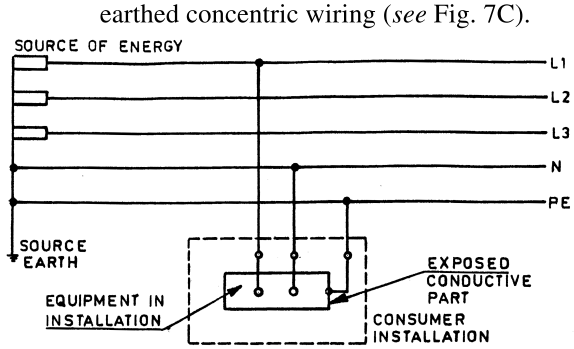
c) *Indian TN-C System* — The neutral and protective functions are combined in a single conductor throughout the system (for example earthed concentric wiring (*see* Fig. 7C).

d) *TN-C-S System* — The neutral and protective functions are combined in a single conductor but only in part of the system (*see* Fig. 7D).

e) *T-TN-S System (for 6.6/11 kV three-phase bulk supply)* — The consumers installation, a TN-S system receiving power at a captive substation through a delta connected transformer primary (*see* Fig. 7E).

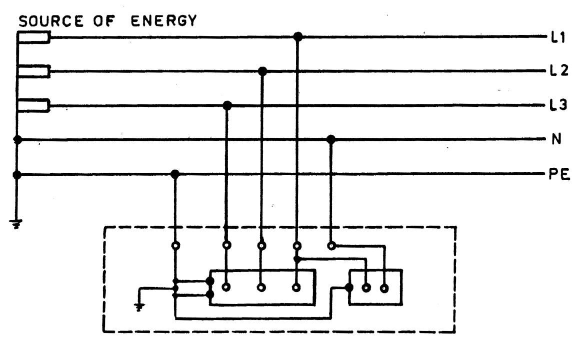
f) *TT System (for 415V three-phase industrial supply)* — Same as **9.1.2** (*see* Fig. 7F)

g) *IT System* — Same **9.1.3** (*see* Fig. 7G).



NOTE — The protective conductor (PE) is the metallic covering (armour or load sheath of the cable supplying the installation or a separate conductor). All exposed conductive parts of an installation are connected to this protective conductor via main earthing terminal of the installation.

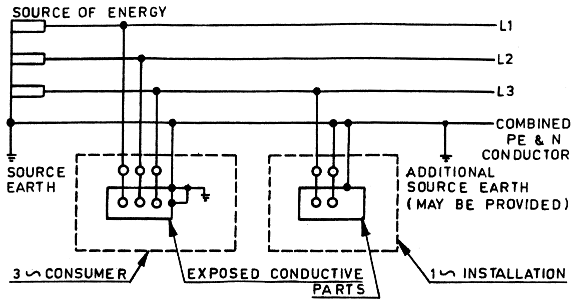
7A TN-S System Separate Neutral and Protective Conductors Throughout the System, 230V Simple Phase. Domestic/Commercial Supply for 3 ~ TN-S



NOTE — For 415 V Three Phase Domestic/Commercial Supply Having 3-Phase and 1-Phase Loads. All exposed conductive parts of the installation are connected to protective conductor via the main earthing terminal of the installation. An independent earth electrode within the consumer's premises is also provided.

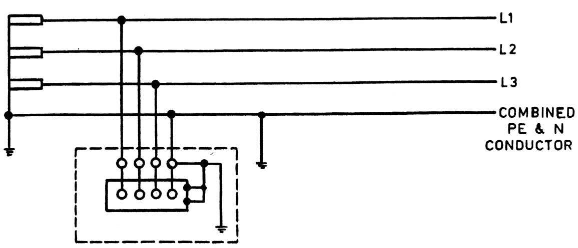
7B Indian TN-S System

FIG. 7 TYPES OF SYSTEM EARTHING — (*Continued*)



NOTE — All exposed conductive parts are connected to the PEN conductor. For 3~ consumer, local earth electrode has to be provided in addition.

7C Indian TN-C System (Neutral and Protective Functions Combined in a Single Conductor Throughout System)

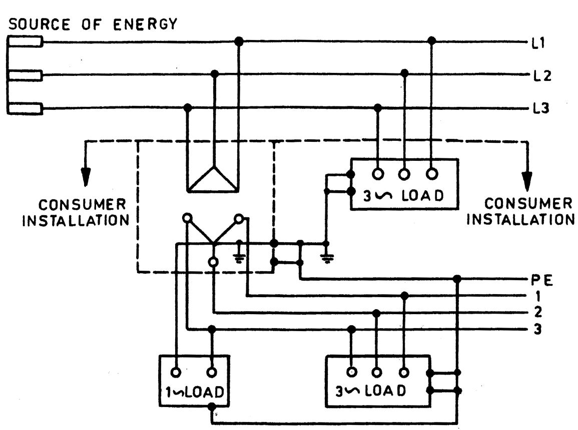


NOTE — The usual form of a TN-C-S system is as shown, where the supply is TN-C and the arrangement in the installations in TN-S. This type of distribution is known also as Protective Multiple Earthing and the PEN conductor is referred to as the combined neutral and earth (CNE) conductor.

The supply system PEN conductor is earthed at several points and an earth electrode may be necessary at or near a consumer's installation. All exposed conductive parts of an installation are connected to the PEN conductor via the main earthing terminal and the neutral terminal, these terminals being linked together.

The protective neutral bonding (PNB) is a variant of TN-C-S with single point earthing.

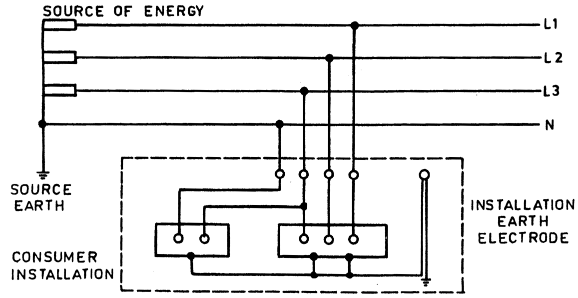
7D TN-C-S System, Neutral and Protective Functions Combined in a Single Conductor in a Part of the System



6.6/11 kV Three phase bulk supply.

7E T-TN-S System

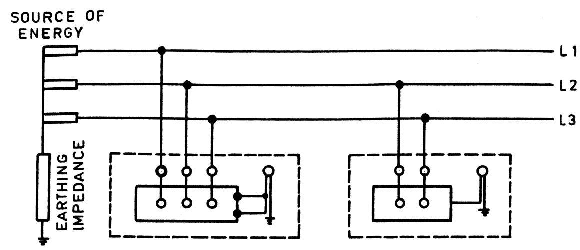
FIG. 7 TYPES OF SYSTEM EARTHING — (*Continued*)



415 V Three phase industrial supply having 3-phase and 1-phase loads.

NOTE — All exposed conductive parts of the installation are connected to an earth electrode which is electrically independent of the source earth. Single phase TT system are not present in India.

7F TT System



NOTE — All exposed conductive parts of an installation are connected to an earth electrode.

The source is either connected to earth through a deliberately introduced earthing impedance or is isolated from earth.

7G IT System

FIG. 7 TYPES OF SYSTEM EARTHING

10 SELECTION OF DEVICES FOR AUTOMATIC DISCONNECTION OF SUPPLY

10.1 General

In general, every circuit is provided with a means of overcurrent protection. If the earth fault loop impedance is low enough to cause these devices to operate within the specified times (that is, sufficient current can flow to earth under fault conditions), such devices may be relied upon to give the requisite automatic disconnection of supply. If the earth fault loop impedance does not permit the overcurrent protective devices to give automatic disconnection of the supply under earth fault conditions, the first option is to reduce that impedance. It may be permissible for this to be achieved by the use of protective multiple earthing or by additional earth electrodes. There are practical limitations to both approaches.

In case of impedance/arcing faults, series protective devices may be ineffective to clear the faults. An alternate approach is to be adopted for the complete safety of the operating personnel and equipment from the hazards that may result from earth faults. This is to use residual current devices with appropriate settings to clear the faults within the permissible time, based on the probable contact potential. This method is equally applicable where earth loop impedances cannot be improved.

In TT systems, there is an additional option of the use of fault voltage operated protective devices; whilst these devices will always give protection against shock risk, provided they are correctly installed, the presence of parallel earths from the bonding will reduce the effectiveness of the fire risk protection they offer. These are, therefore, more suited for isolated installations that do not have interconnections to other installations. It should also be remembered that every socket outlet circuit that do not have earthing facility in a household or similar installation should be protected by a residual current device having a rated residual operating current not exceeding 30 mA.

On all other systems where equipment is supplied by means of a socket outlet not having earthing facility or by means of a flexible cable or cord used outside the protective zone created by the main equipotential bonding of the installation such equipment should be protected by a residual current operated device having an operating current of 30 mA or less.

NOTE — Information on cascading, limitation and discrimination is given at Annex C.

10.2 Use of Over-Current Protective Devices for Earth Fault Protection

Where over-current protective devices are used to give automatic disconnection of supply in case of earth fault in order to give shock risk protection, the basic requirement is that any voltage occurring between simultaneously accessible conductive parts during a fault should be of such magnitude and duration as not to cause danger. The duration will depend on the characteristic of the overcurrent device and the earth fault current which, in turn, depends on the total earth fault loop impedance. The magnitude will depend on the impedance of that part of the earth fault loop path that lies between the simultaneously accessible parts.

The basic requirement can be met if,

a) a contact potential of 65 V is within the tolerable limits of human body for 10 s. Hence protective relay or device characteristic should be such that this 65 V contact potential should be eliminated within 10 s and higher voltages with shorter times.
b) a voltage of 250 V can be withstood by a human body for about 100 ms, which requires instantaneous disconnection of such faults, giving rise to potential rise of 250 V or more above the ground potential.

The maximum earth fault loop impedance corresponding to specific ratings of fuse or miniature circuit-breaker that will meet the criteria can be calculated on the basis of a nominal voltage to earth (U_o) and the time current characteristics of the device assuming worst case conditions, that is, the slowest operating time accepted by the relevant standards. Thus, if these values are not exceeded, compliance with this Code covering automatic disconnection in case of an earth fault is assured.

Where it is required to know the maximum earth fault loop impedance acceptable in a circuit feeding, a fixed appliance or set of appliances and protected by an over current device, the minimum current that may be necessary to ensure operation of the overcurrent device within the permissible time of 10 s for a contact potential of 65 V is found from the characteristic curve of the device concerned. Application of the Ohm's Law then enables the corresponding earth fault loop impedance to be calculated.

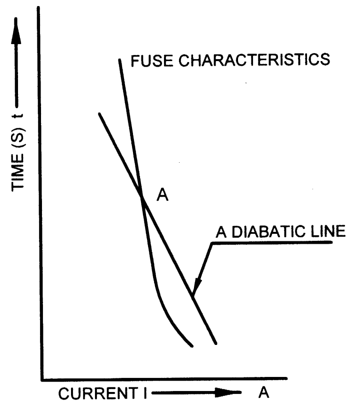
For circuits supplying socket outlets, the corresponding earth fault loop impedance can be found by a similar calculation for earthed equipment. When equipment are not earthed and connected to socket outlets without earthing facility, disconnection should be ensured for 30 mA within 10 s and with appropriate decrements in time for higher currents.

This method requires a knowledge of the total earth loop impedance alone (rather than individual components) and is, therefore, quick and direct in application. Its simplicity does exclude some circuit arrangements that could give the required protection.

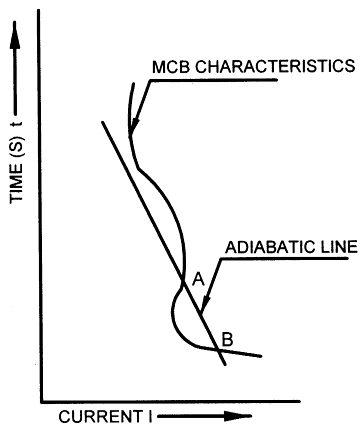
While calculations give the maximum earth fault loop or protective conductor impedance to ensure shock risk protection under fault conditions it is also necessary to ensure that the circuit protective earth conductor is protected against the thermal effects of the fault current. The earth fault loop impedance should, therefore, be low enough to cause the protective device to operate quickly enough to give that protection as well. This consideration places a second limit on the maximum earth loop impedance permissible and can be checked by superimposing on the time current characteristic of the overload device, the 'adiabatic' line having the equation:

$$t = \frac{k^2 A^2}{I^2} \text{ or } A = \frac{I\sqrt{t}}{k}$$

Details of the maximum permissible earth loop impedance for the thermal protection of cables by fuses can also be computed. However, the time current characteristics of a miniature circuit-breaker are such that if the loop impedance is low enough to give automatic disconnection within safe disconnecting time so providing shock risk protection, it will also give the necessary thermal protection to the earth conductor likely to be used with a breaker of that specific rating. Figure 8 shows the relationship between the adiabatic line and the characteristic of fuses and miniature circuit-breaker.



8A Fuses



8B Miniature Circuit-breaker

FIG. 8 RELATIONSHIP BETWEEN ADIABATIC LINES AND CHARACTERISTICS

In order that the devices will give thermal protection to the protective conductor, operation has to be restricted to the area to the right of point *A* where these curves cross. Thus, the maximum earth fault loop impedance for thermal protection of the cable is that corresponding to the minimum earth fault current for which the device gives protection. The value of this current can be read from the curve and the corresponding loop impedance can be calculated from:

$$Z_s = \frac{U_o}{I_t}$$

where

Z_s = earth fault loop impedance,

U_o = nominal voltage to earth, and

I_t = earth fault current.

For a given application, the maximum permitted earth fault loop impedance would be the lower of the two values calculated for shock risk protection or thermal restraint respectively.

It will be noted that the adiabatic line crosses the characteristic curve for a miniature circuit-breaker at a second point *B*. This denotes the maximum fault current for which a breaker will give thermal protection but it will generally be found in practice that this value is higher than the prospective short circuit current that occurs in the circuit involved and cannot, therefore, be realized.

10.3 Earth Fault Protective Devices

There are two basic forms of such devices that can be used for individual non-earthed/earthed (with limited application) equipment as follows:

10.3.1 *Residual Current Operated Devices (RCD)*

An RCD incorporates two component items. A core balance transformer assembly with a winding for each recognizing the out of balance current that the fault produces in the main conductors. This induces a current that is used to operate the tripping mechanism of a contact system. For operating currents of 0.5 A or more, the output from such a transformer assembly can operate a conventional trip coil directly. For lower values of operating current, it is necessary to interpose a delay device, either magnetic or solid state.

Devices for load currents greater than 100 A usually comprise a separate transformer assembly with a circuit-breaker or contact relay, mounted together within a common enclosure. Devices for load currents below 100 A usually include the transformer and contact system within the same single unit, which is then described as a residual current operated circuit- breaker (RCB). Such an RCB should be considered a particular type of RCB although it is the most usual form.

A wide choice of operating currents is available (typical values are between 10 mA and 20 A) RCB's are normally non-adjustable whilst RCD's are often manufactured so that one of several operating currents may be chosen. Single phase and multiphase devices with or without integral overcurrent facilities are available.

Where residual current breakers of 30 mA operating current or less are being used, there is a choice between devices that are entirely electromechanical in operation and those that employ a solid state detector. The electromechanical types are generally small and compact and will operate on the power being fed to the fault alone whereas the solid state type which tend to be bulkier to require a power supply to ensure operation. Where this power supply is derived from the mains, it may be necessary to take added precaution against failures of part of that mains supply. Devices suitable for time grading are more likely to be of the solid state form as are those having higher through fault capacity.

A test device is incorporated to allow the operation of the RCD to be checked. Operation of this device creates an out of balance condition within the device. Tripping of the RCD by means of the test device establishes the following:

a) The integrity of the electrical and mechanical elements of the tripping device; and
b) That the device is operating at approximately the correct order of operating current.

It should be noted that the test device does not provide a means of checking the continuity of the earthing lead or the earth continuity conductor, nor does it impose any test on the earth electrode or any other part of the earthing circuit.

Although an RCD will operate on currents equal to or exceeding its operating current, it should be noted that it will only restrict the time for which a fault current flows. It cannot restrict the magnitude of the fault percent current which depends solely on the circuit conditions.

10.3.2 *Fault Voltage Operated Earth Leakage Circuit Breakers (ELCB)*

A voltage operated earth leakage circuit-breaker comprises a contact switching system together with a voltage sensitive trip coil. On installations, this coil is connected between the metal-work to be protected and as good a connection with earth as can be obtained. Any voltage rise above earth on that metal-work exceeding the setting of the coil will cause the breaker to trip so giving indirect shock risk protection.

Tripping coils are designed so that a fault voltage operated device will operate on a 40 V rise when the earth electrode resistance is 500 W or 24 V on a 200 W electrode. Single and multiphase units, with or without overcurrent facilities, are available for load currents up to 100 A.

A test device is provided on a voltage operated unit to enable the operation of the circuit breaker to be checked, operation of the device applies a voltage to the trip coil so simulating a fault. Tripping of the circuit breaker by means of the test device shows the integrity of the electrical mechanical elements that the unit is operating with the correct order of operating voltage and, in addition, proves the conductor from the circuit breaker to the earth electrode. It can not prove other features of the installation.

Whilst the voltage operated (ELCB) will operate when subjected to a fault voltage of 20 V or more, it should be noted that it cannot restrict the voltage in magnitude only in duration.

10.3.3 *Current Operated Earth Leakage Circuit -Breakers*

For industrial applications, earth leakage circuit-breakers operating on milliampere residual currents or working on fault voltage principle are of little use, since milliamperes of earth leakage current for an extensive industrial system is a normal operating situation. Tripping based on these currents will result in nuisance for the normal operation. Milliamperes of current in a system, where exposed conductive parts of equipments are effectively earthed and fault loop impedance is within reasonable values, will give rise only to a ground potential/contact potential rise of a few millivolts. This will in no way contribute to shock or fire hazard. Here objectionable fault currents will be a few or a few tenths of amperes. In such cases, residual current operated devices sensitive to these currents must be made use of for earth fault current and stable operation of the plant without nuisance tripping. This is achieved either by separate relays or in-built releases initiating trip signals to the circuit-breakers

10.4 Selection of Earth Fault Protective Devices

In general, residual current operated devices are preferred and may be divided into two groups according to their final current operating characteristics.

10.4.1 *RCDs having Minimum Operating Currents Greater than 30 mA*

These devices are intended to give indirect shock risk protection to persons in contact with earthed metal.

10.4.2 *RCDs having Minimum Operating Current of 30 mA and Below*

These devices are generally referred to as having 'high sensitivity' and can give direct shock risk protection to persons who may come in contact with live conductors and earth provided that the RCD operating times are better than those given in IS 8437 (Part 1) and IS 8437 (Part 2). It should be noted that such RCDs can only be used to supplement an earth conductor and not replace one.

In addition to giving protection against indirect contact or direct contact RCDs may also give fire risk protection, the degree of protection being related to the sensitivity of the device.

An RCD should be chosen having the lowest suitable operating current. The lower the operating current the greater the degree of protection given, it can also introduce possibilities of nuisance tripping and may become unnecessarily expensive. The minimum operating current will be above any standing leakage that may be unavoidable on the system. A further consideration arises if it is intended to have several devices in series. It is not always possible to introduce time grading to give discrimination whereas a limited amount of current discrimination can be obtained by grading the sensitivities along the distribution chain.

The maximum permitted operating current depends on the earth fault loop impedance. The product of the net residual operating current loop impedance should not exceed 65 V.

It is often acceptable on commercial grounds to have several final circuits protected by the same residual current devices. This, however, does result in several circuits being affected if a fault occurs on one of the circuits so protected and the financial advantages have to be weighed against the effects of loosing more than one circuit.

It should also be noted that different types of RCD in different circuits may react differently to the presence of a neutral to earth fault on the load side. Such an earth connection together with the earthing of the supply at the neutral point will constitute a shunt across the neutral winding on the RCD transformer. Consequently, a portion of the neutral load current will be shunted away from the transformer and it may result in the device tripping. On the other hand, such a shunt may reduce the sensitivity of the device and prevent its tripping even under line to earth fault conditions. In general, therefore, care should be taken to avoid a neutral to earth fault where RCDs are in use, although there are some designs being developed that will detect and operate under such conditions. On installations with several RCDs, care should be taken to ensure that neutral currents are returned via the same device that carries the corresponding phase current and no other. Failure to observe this point could result in devices tripping even in the absence of a fault on the circuit they are protecting.

When using fault voltage operated ELCBs, the metal-work to be protected should be isolated from earth so that any fault current passes through the tripping coil gives both shock and fire risk protection. However, this isolation is not always practicable and the presence of a second parallel path to earth will reduce the amount of fire risk protection offered. Because the coil is voltage sensitive, the presence of such a parallel path will not reduce the shock risk protection offered provided that this second path goes to earth well clear of the point at which the earth leakage circuit-breaker trip coil is earthed. It is required that the earthing conductor is insulated to avoid contact with other protective conductors or any exposed conductive parts or extraneous conductive parts so as to prevent the voltage sensitivity element from being shunted, also the metal-work being protected should be isolated from that associated with other circuits in order to prevent imported faults.

NOTE — For hybrid Indian TN-S system it is recommended that RCD protection is provided in addition to the overcurrent protection provided for earth fault protection. This will ensure required protection in case of any break in continuity of the protective earth conductor.

ANNEX A

(*Clause* 1)

ADDITIONAL RULES FOR EARTHINGS

A-1 ADDITIONAL RULES APPLYING TO THE DIRECT EARTHING SYSTEM

Where a driven or buried electrode is used, the earth resistance shall be as low as possible.

NOTE — The value of earth resistance is under consideration.

A-2 ADDITIONAL RULES APPLYING TO THE MULTIPLE EARTH NEUTRAL SYSTEM

This system shall be used only where the neutral and earth is low enough to preclude the possibility of a dangerous rise of potential in the neutral.

A-3 ADDITIONAL RULES APPLYING TO THE EARTH LEAKAGE CIRCUIT-BREAKER SYSTEM

A-3.1 Installation of the Earth Leakage Circuit-Breaker System (*see* Fig. 9)

All parts required to be earthed shall be connected to an earth electrode through the coil of an earth leakage circuit-breaker which controls the supply to all those parts of the installation which are to be protected; and to a separate earth electrode.

A-3.2 Selective Protection

If selective operation of earth leakage circuit-breaker is required, the circuit-breaker, electrodes and earthing conductors shall be installed in one of the following ways:

a) *Arrangement Giving Complete Selectivity* — All metal frames, conduits, earthing conductors, etc, which are to be protected as a unit shall be electrically separated from all other such parts and from any other earthed metal. Each part to be protected as a unit shall

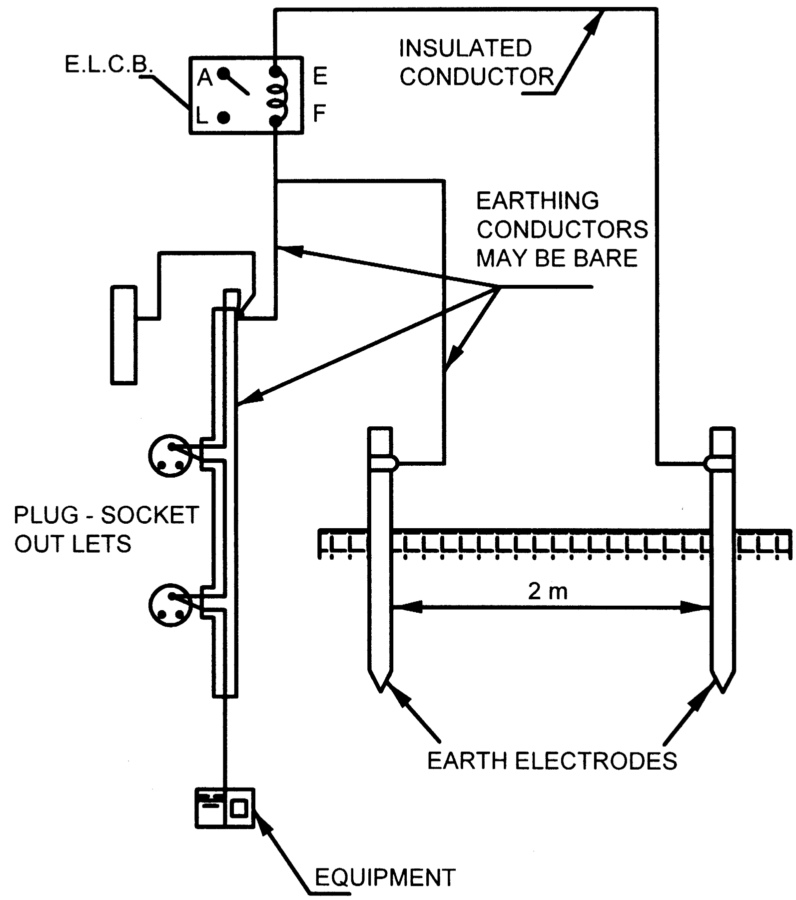
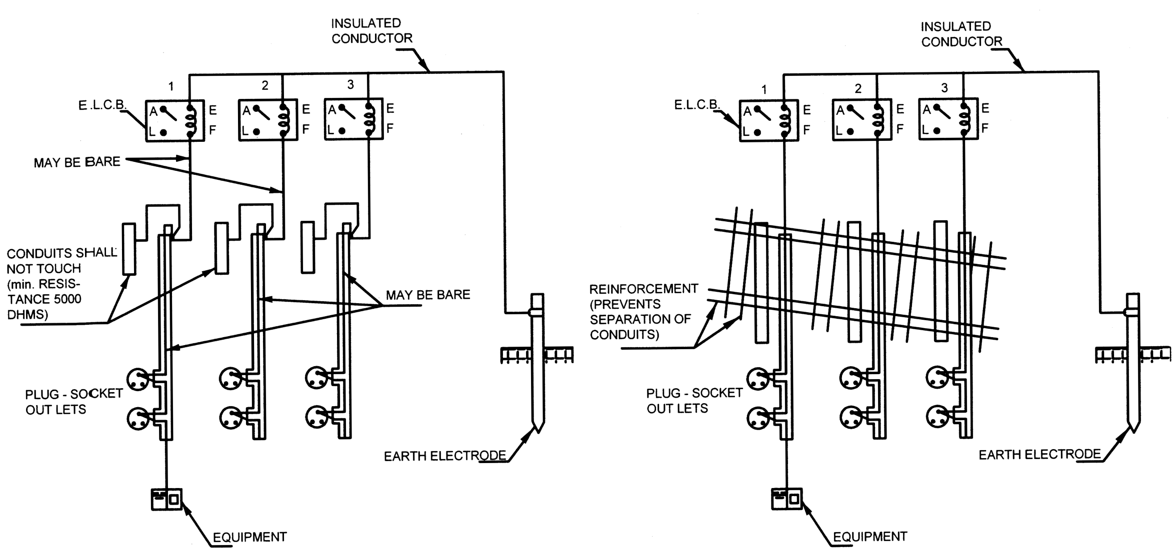


FIG. 9 CONNECTION OF EARTH LEAKAGE CIRCUIT-BREAKER SIMPLE INSTALLATION



10A Complete Separation of the Exposed Metal of One Installation from that of Other Installation

10B By Use of a Double-Insulated Wiring System, Where There are no Conduits to be Earthed

FIG. 10 CONNECTION OF EARTH LEAKAGE CIRCUIT-BREAKER FOR COMPLETE SELECTIVITY be connected to an earth electrode through the coil of an earth leakage circuit-breaker. (*see* Fig. 10)

All the separately protected portions of the installations may be connected to one electrode to the earth leakage circuit-breaker.

b) *Arrangement Giving Partial Selectivity (Complete Selectivity with Respect to Faults in Apparatus, but no Selectivity with Respect to Faults in Wiring in Conduit)* (*see* Fig. 9) — All the conduits and associated fittings shall be bonded together and connected to an earth electrode, all shall also be connected to another earth electrode through an earth leakage circuit-breaker which controls all the active conductors supplying the whole or portions of the installations concerned. Each part to be protected as a unit shall be connected to an earth electrode through the coil of a separate earth leakage circuit-breaker which controls all the active conductors supplying that portion of the installation only. All these portions may be connected to one electrode, but this electrode shall be separated from the electrode to which the conduits are connected.

NOTES

1 A double-insulated wiring system is used, for example, tough rubber-sheathed cables. Any conduit used does not then need to be earthed.

2 The earthing conductor is insulated from the conduit.

ANNEX B

(*Clause* 3.1.3.2)

REPRESENTATIVE VALUES OF SOIL RESISTIVITY IN VARIOUS PARTS OF INDIA

Sl No.	*Locality*	*Type of Soil*	*Order of Resistivity* Ω m	*Remarks*
(1)	(2)	(3)	(4)	(5)
1.	Kakarapar, Distt Surat, Gujarat	Clayey black soil	6-23	Underlying bedrock-Deccan trap
2.	Taptee Valley	Alluvium	6-24	do
3.	Narmada Valley	Alluvium	4-11	Underlying bedrock-sand-stone shale and lime-stones, Deccan trap and gneisses
4.	Purna Valley (Deogaon)	Agricultural	3-6	Underlying bedrock-Deccan trap
5.	Dhond, Mumbai	Alluvium	6-40	do
6.	Bijapur Distt, Karnataka	a) Black cotton soil	2-10	do
		b) Moorm	10-50	do
7.	Garimenapenta, Distt Nellore Andhra Pradesh	Alluvium (highly clayey)	2	Underlying bedrock-gneisses
8.	Kartee	a) Alluvium	3-5	Underlying bedrock-sand-stone, trap or gneisses
		b) Alluvium	9-21	
9.	Delhi			
	a) Najafgarh	a) Alluvium (dry sandy soil)	75-170	do
		b) Loamy to clayey soil	38-50	do
		c) Alluvium (saline)	1.5-9	do
	b) Chhatarpur	Dry soil	36-109	Underlying bedrock-quartzites

Sl No.	*Locality*	*Type of Soil*	*Order of Resistivity* Ω m	*Remarks*
(1)	(2)	(3)	(4)	(5)
10.	Korba, M.P.	a) Moist clay	2-3	Underlying bedrock-sand-stone or shale
		b) Alluvium soil	10-20	
11.	Cossipur, Kolkata	Alluvium	25 (approx)	—
12.	Bhagalpur, Bihar	a) Alluvium	9-14	Underlying bedrock-traps, sand-stone or gneisses
13.	Kerala (Trivandrum Distt)	Lateritic clay	2-5	Underlying bedrock-laterite, charnockite or granites
14.	Bharatpur	Sandy loam (saline)	6-14	—
15.	Kalyadi, Mysore	Alluvium	60-150	Underlying bedrock-gneisses
16.	Kolar Gold Fields	Sandy surface	45-185	do
17.	Wajrakarur, Andhra Pradesh	Alluvium	50-150	do
18.	Koyana, Satara Distt	Lateritic	800-1 200 (dry)	Underlying bedrock-sand-laterite or trap
19.	Kutch-Kandla (Amjar Area)	a) Alluvium (clayey)	4-50	Underlying bedrock-sand-stone, shale or tap
		b) Alluvium (sandy)	60-200	do
20.	Villupuram, Chennai	Clayey sands	11	Underlying bedrock-granite
21.	Ambaji, Banaskantha, Gujarat	Alluvium	170	Underlying bedrock-granites and gneisses
22.	Ramanathapuram Distt, Chennai	a) Alluvium	2-5	Underlying bedrock-sand-stones and gneisses
		b) Lateritic soil	300 (approx)	do

NOTE — The soil resistivities are subject to wide seasonal variation as they depend very much on the moisture content.

ANNEX C

(*Clause* 10.1)

CASCADING, DISCRIMINATION AND LIMITATION

C-1 CASCADING

The utilization of the current limiting capacity of a circuit-breaker at a given point to enable installation of lower-rated circuit-breakers in branch is known as 'cascading' or 'back-up protection'. The main (upstream) circuit-breakers acts as a barrier against short-circuit currents and branch (downstream) circuit-breakers with lower breaking capacities than the prospective short-circuit (at their point of installation) operate under their normal breaking conditions. The limiting circuit-breaker helps the circuit-breaker placed downstream by limiting high short-circuit currents thus enabling use of downstream circuit-breaker with a breaking capacity lower than the short-circuit current calculated at its installation point thus enabling economical selection of circuit-breakers.

Cascading concerns all devices installed downstream of the circuit-breaker, and can be extended to several consecutive devices, even if they are used in different switchboards. The upstream device must have an ultimate breaking capacity greater than or equal to the assumed short-circuit current at the installation point. For downstream circuit-breakers, the ultimate breaking capacity to be considered is the ultimate breaking capacity enhanced by coordination.

The association of the upstream and downstream circuit-breakers allows an increase in performance of the breakers. Thus, the electromagnetic, electrodynamic and thermal effects of short-circuit currents are reduced. Installation of a single limiting circuit-breaker alongwith lower rated circuit-breakers results in considerable economy and simplification of installation work.

D_1 and D_2 are the two circuit-breakers (*see* Fig. 11). As soon as the two circuit-breakers trip (as from point I_B), an arc voltage U_{AD1} on separation of the contacts of D_1 is added to voltage U_{AD2} and helps, by additional limitation, circuit-breaker D_2 to open.

The association $D_1 + D_2$ allows an increase in performance of D_2 as shown in Fig. 12, which depicts,

limitation curve of D_2,

enhanced limitation curve of D_2 by D_1,

I_{cu} D_2 enhanced by D_1.

Annex A of IS/IEC 60947-2 defines coordination under short-circuit conditions between circuit-breaker and another short-circuit protective device (SCPD) associated in the same circuit and the tests to be performed. Cascading is normally verified by tests for critical points. The tests are performed with an upstream circuit-breaker D_2 with a maximum overcurrent setting and a downstream circuit-breaker D_2 with a minimum setting.

C-2 LIMITATION

C-2.1 The technique of limitation allows the circuit-breaker to considerably reduce short-circuit currents. It ensures attenuation of the harmful electromagnetic, thermal and mechanical effects of short-circuits and is the basis of the cascading technique.

The assumed fault current I_{sc} is the short-circuit current that would flow at the point of the installation where the circuit-breaker is placed, if there were no limitation. Since the fault current is eliminated in less than one half-period, only the first peak current (asymmetrical peak I) is considered. This is a function of the installation fault cos θ. Reduction of this peak I to

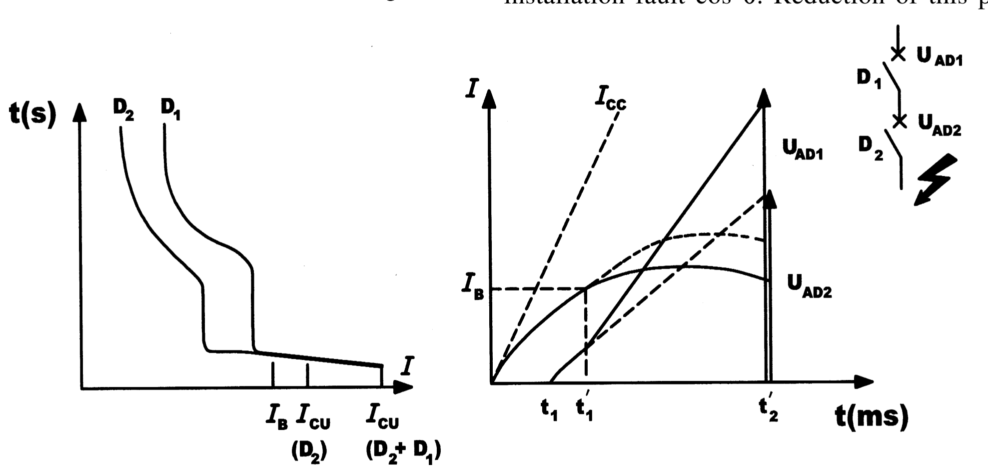


FIG. 11 OPERATION OF CIRCUIT-BREAKERS IN CASCADE

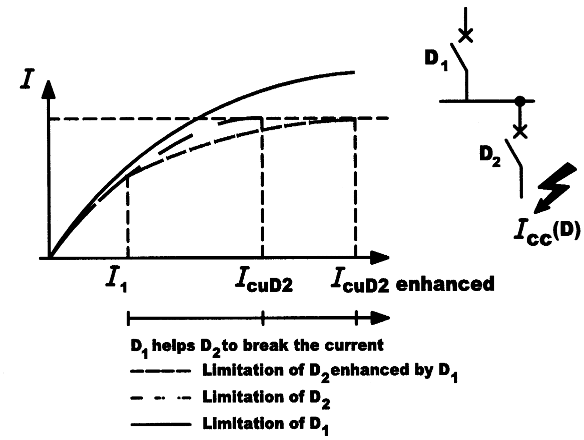


FIG. 12 LIMITATION CURVES FOR CIRCUIT-BREAKERS

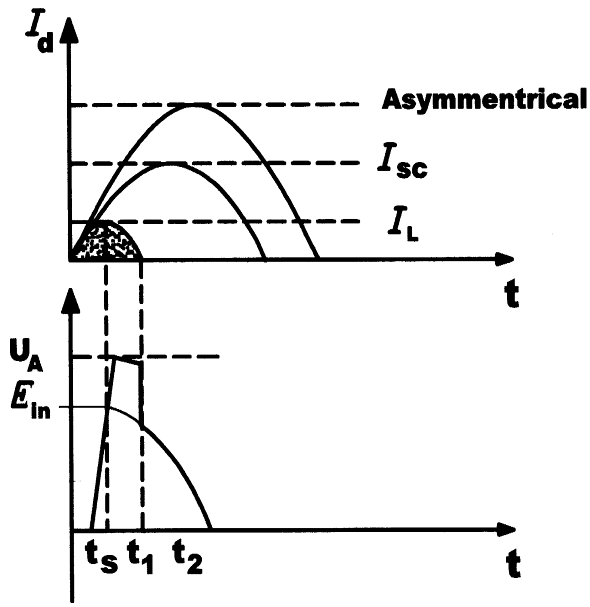


FIG. 13 EFFECT OF LIMITATION ON FAULT CURRENT

limited I_L characterizes circuit-breaker limitation. Limitation consists of creating a back-electromotive force opposing the growth of the short-circuit current. Effectiveness of limitation depends on intervention time, that is the time t_s when the back-electromotive force (b_{emf}) appears, the rate at which b_{emf} increases and the value of b_{emf}. The back-electromotive force is the arc voltage U_a due to the resistance of the arc developing between the contacts on separation. Its speed of development depends on the contact separation speed. As shown in Fig. 13, as from the time t_s when the contacts separate, the back less than the assumed fault current flow through when a short-circuit occurs.

C-2.2 Circuit-Breaker Limitation Capacity

The circuit-breaker limitation capacity defines the way how it reduces the let through current in short-circuit conditions (*see* Fig. 14 and 15). The thermal stress of the limited current is the area (shaded) defined by the curve of the square of the limited current $I_{sc}^2(t)$. If there is no limitation, this stress would be the area, far larger, that would be defined by the curve of the square of the assumed current. For an assumed short-circuit current I_{sc}, limitation of this current to 10 percent results in less than 1 percent of assumed thermal stress. The cable temperature rise is directly proportional to the thermal stress.

NOTE — On a short-circuit, adiabatic temperature-rise of conductors occurs (without heat exchange with the outside due to the speed of the energy supply). The increased temperature for a conductor with a cross-section S is:

$$B_e = \frac{K}{S^2} V_o^1 I^2 dt$$

where $I^2\,dt$ is the thermal stress (A^2s)

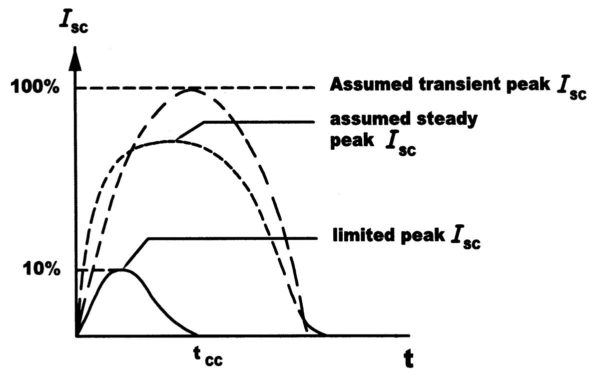


FIG. 14 CURRENT LIMITATION

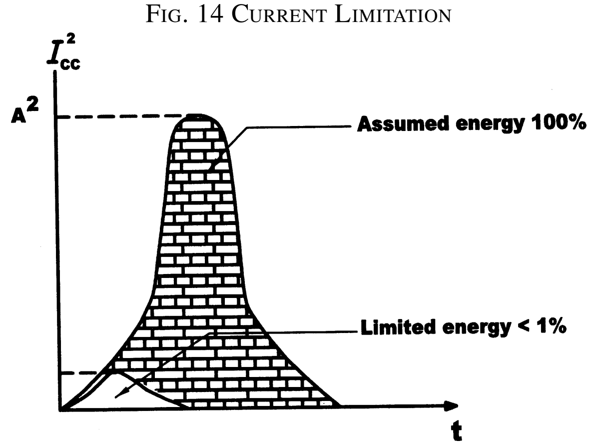


FIG. 15 THERMAL STRESS LIMITATION

Limitation considerably attenuates the harmful effects of short-circuits on the installation. Consequently, limitation contributes to the durability of electrical installations. Due to limitation, the harmful effects of short-circuits on a motor feeder are greatly attenuated. Proper limitation ensures easy access to a Type 2 coordination as per IS/IEC 60947-4-1, without oversizing of components. This type of coordination ensures optimum use of their motor feeders.

C-2.3 Limitation Curves

A circuit-breaker's limiting capacity is expressed by limitation curves that give,

a) the limited peak current as a function of the rms current of the assumed short-circuit current. For example on a 160 A feeder where the assumed lsc is 90 kA rms, the non-limited peak lsc is 200 kA (asymmetry factor of 2.2) and the limited I_{sc} is 26 kA peak.

b) the limited thermal stress (in A2s) as a function of the rms current of the assumed short-circuit current. For example, on the previous feeder, the thermal stress moves from more than 100 × 106 A2s to 6 × 106 A2s.

C-3 DISCRIMINATION

C-3.1 Discrimination is the co-ordination of the operating characteristics of two or more over-current protective devices such that, on the incidence of over-currents within stated limits, the device intended to operate within these limits does so, while the other(s) does (do) not (*see* Fig. 16).

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. In LV networks, discrimination is recommended in order to obtain higher levels of supply continuity and protection, ensuring better safety of installations and minimum cost overruns.

Cascading principle in limiting CBs can enhance the discrimination levels. It is recommended that the manufacturer provide the relevant data in terms of discrimination charts and cascading levels for various combination of CBs (upstream and downstream) and fault current as per the laboratory test results.

A discrimination current I_s is defined such that if;

a) $I_{fault} > I_s$: both circuit-breakers trip, and

b) $I_{fault} < I_s$: only D_2 eliminates the fault.

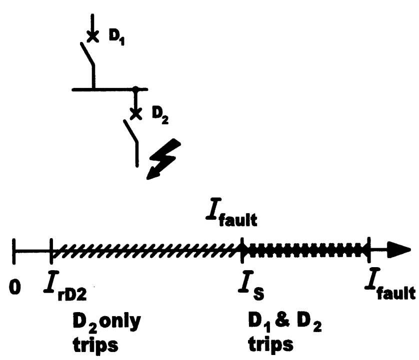


FIG. 16 DISCIMINATION AND SEQUENCE OF TRIPPING

C-3.2 Discrimination Quality

The value I_s is compared with assumed I_{sc} (D_2) at point D_2 of the installation.

a) total discrimination: $I_s > I_{sc}(D_2)$; discrimination is qualified as total, that is whatever the value of the fault current, D_2 only will eliminate it.

b) partial discrimination: $I_s < I_{sc}$ (D_2); discrimination is qualified as partial, that is up to I_s, only D_2 eliminates the fault. Beyond I_s, both D_1 and D_2 open.

where

I_{sc} (D_1): short-circuit current at the point where D_1 is installed,

I_{cu} D_1: ultimate breaking capacity of D_1.

C-3.3 Types of Discriminations

C-3.3.1 *Current Discrimination*

This technique is directly linked to the staging of the Long Time (LT) tripping curves of two serial-connected circuit-breakers (*see* Fig. 17).

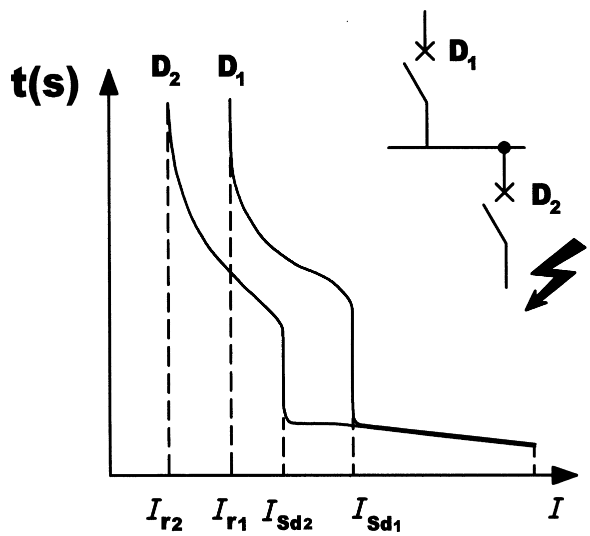


FIG. 17 CURRENT DISCRIMINATION

The discrimination limit I_s is,

a) $I_s = I_{sd2}$ if the thresholds I_{sd1} and I_{sd2} are too close or merge, and

b) $I_s = I_{sd1}$ if the thresholds I_{sd1} and I_{sd2} are sufficiently far apart.

Current discrimination is achieved when,

a) $I_{r1} / I_{r2} < 2$

b) $I_{sd1} / I_{sd2} > 2$

The discrimination limit being

$I_s = I_{sd1}$

C-3.3.1.1 *Discrimination quality*

Discrimination is total if $I_s > I_{sc}(D_2)$, that is $I_{s\,d1} > I_{sc}(D_2)$.

This normally implies,

a relatively low level $I_{sc}(D_2)$,

a large difference between the ratings of circuit-breakers D_1 and D_2.

Current discrimination is normally used in final distribution.

C-3.3.2 *Time Discrimination*

This is the extension of current discrimination and is obtained by staging over time of the tripping curves. This technique consists of giving a time delay of t to the Short Time (ST) tripping of D_1 (*see* Fig. 18).

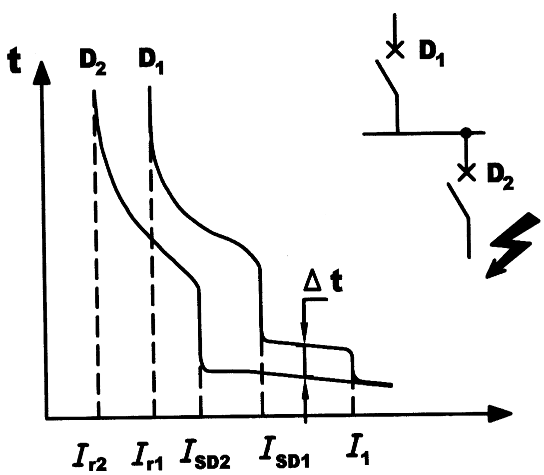


FIG. 18 TIME DISCRIMINATION

The thresholds (I_{r1}, I_{sd1}) of D_1 and (I_{r2}, I_{sd2}) comply with the staging rules of current discrimination. The discrimination limit I_s of the association is at least equal to I_{i1}, the instantaneous threshold of D_1.

C-3.3.2.1 *Discrimination quality*

For discrimination on final and/or intermediate feeders, A category circuit-breakers can be used with time-delayed tripping of the upstream circuit-breaker. This allows extension of current discrimination up to the instantaneous threshold I_{i1} of the upstream circuit-breaker: $I_s > I_{i1}$. If $I_{sc}(D_2)$ is not too high (case of a final feeder) total discrimination can be obtained.

On the incomers and feeders of the MSB, as continuity of supply takes priority, the installation characteristics allow use of B category circuit-breakers designed for time-delayed tripping. These circuit-breakers have a high thermal withstand ($I_{cw} > 50$ percent I_{cn} for $t = I_s$): $I_s > I_{cw1}$. Even for high $I_{sc}(D_2)$, time discrimination normally provides total discrimination: $I_{cw1} > I_{sc}(D_2)$.

NOTE — Use of B category circuit-breakers means that the installation must withstand high electrodynamic and thermal stresses. Consequently, these circuit-breakers have a high instantaneous threshold I_i that can be adjusted and disabled in order to protect the busbars if necessary.

C-3.4 Enhancement of Current and Time Discrimination

C-3.4.1 *Enhancement by Limiting Downstream Circuit-Breakers*

Use of a limiting downstream circuit-breaker enables the discrimination limit to be pushed back.

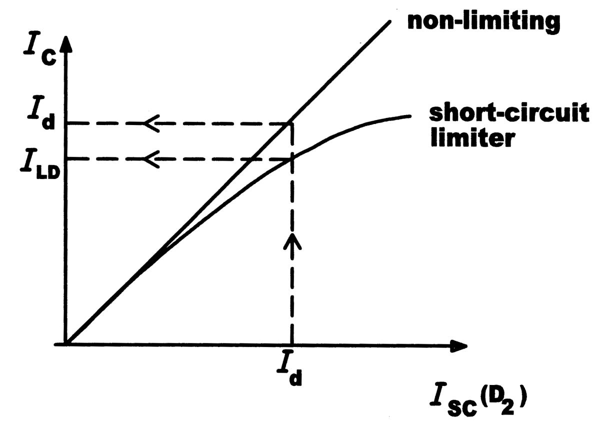


FIG. 19 ENHANCEMENT OF DISCRIMINATION

On referring to Fig. 19, a fault current I_d will be seen by D_1,

equal to I_d for a non-limiting circuit-breaker, and equal to $I_{Ld} < I_d$ for a limiting circuit-breaker.

The limit of current and time discrimination I_s of the association $D_1 + D_2$ is thus pushed back to a value that increases when the downstream circuit-breaker is rapid and limiting.

C-3.4.2 *Discrimination Quality*

Use of a limiting circuit-breaker is extremely effective for achievement of total discrimination when threshold settings (current discrimination) and/or the instantaneous tripping threshold (time discrimination) of the upstream circuit-breaker D_1 are too low with respect to the fault current I_d in $D_2 - I_{sc}(D_2)$.

C-3.4.2.1 *Logic discrimination or "Logic Discrimination Zone (ZSI)"*

This type of discrimination can be achieved with circuit-breakers equipped with specially designed electronic trip units. Only the Short Time Protection (STP) and Ground Fault Protection (GFP) functions of the controlled devices are managed by Logic Discrimination. In particular, the Instantaneous Protection function (inherent protection function) is not concerned.

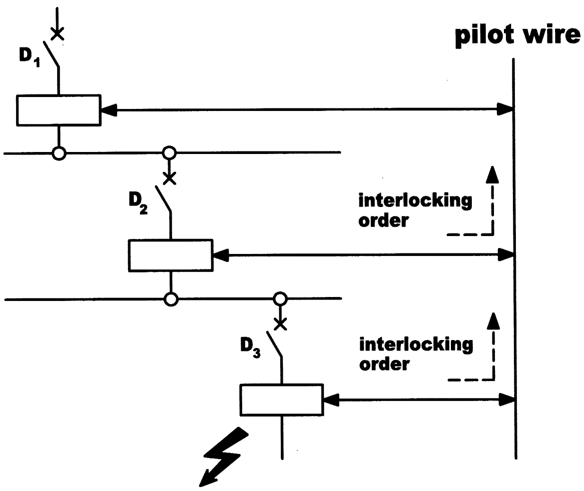


FIG. 20 LOGIC DISCRIMINATION(ZSI)

C-3.4.2.2 *Settings of controlled circuit-breakers*

a) *Time delay*: staging (if any) of the time delays of time discrimination to be applied (t D_1 > t D_2 > t D_3)

b) *Thresholds*: natural staging of the protection device ratings must be complied with ($I_{cr}D_1 > I_{cr}D_2 > I_{cr}D_2$).

NOTE — This technique ensures discrimination even with circuit-breakers of similar ratings.

C-3.4.2.3 *Principles*

Activation of the Logic Discrimination function is via transmission of information on the pilot wire for ZSI input,

a) *Low level (no downstream faults)*: the Protection function is on standby with a reduced time delay (< 0.1)

b) *High level (presence of downstream faults)*: the relevant Protection function moves to the time delay status set on the device.

Activation of the Logic Discrimination function is via transmission of information on the pilot wire for ZSI output,

a) *Low level*: the trip unit detects no faults and sends no orders.

b) *High level*: the trip unit detects a fault and sends an order.

C-3.4.2.4 *Operation*

A pilot wire connects in cascading form the protection devices of an installation (*see* Fig. 20). When a fault occurs, each circuit-breaker upstream of the fault (detecting a fault) sends an order (high level output) and moves the upstream circuit-breaker to its natural time delay (high level input). The circuit breaker placed just above the fault does not receive any orders (low level input) and thus trips almost instantaneously.

C-3.4.2.5 *Discrimination quality*

This technique enables easy achievement as standard of discrimination on 3 levels or more, easy achievement of downstream discrimination with non-controlled circuit-breakers, elimination of important stresses on the installation, relating to time-delayed tripping of the protection device, in event of a fault directly on the upstream busbars. All the protection devices are thus virtually instantaneous.

C-3.5 Discrimination Rules

C-3.5.1 *Overload Protection*

For any overcurrent value, discrimination is guaranteed on overload if the non-tripping time of the upstream circuit-breaker D_1 is greater than the maximum breaking time of circuit-breaker D_2.

The condition is fulfilled if the ratio of Long Time (LT) and Short Time (ST) settings is greater than 2. The discrimination limit I_s is at least equal to the setting threshold of the upstream Short Time (ST) time delay.

C-3.5.2 *Short-circuit Protection*

C-3.5.2.1 *Time discrimination*

Tripping of the upstream device D_1 is time delayed by *t*, the conditions required for current discrimination must be fulfilled and the time delay *t* of the upstream device D_1 must be sufficient for the downstream device to be able to eliminate the fault. Time discrimination increases the discrimination limit I_s up to the instantaneous tripping threshold of the upstream circuit-breaker D_1 (*see* Fig. 21).

Discrimination is always total if circuit-breaker D_1 is of category B, has an I_{cw} characteristic equal to its I_{cu}.

Discrimination is total in the other cases if the instantaneous tripping threshold of the upstream circuit-breaker D_1 is greater than the assumed I_{sc} in D_2.

C-3.5.2.2 *Logic discrimination*

Discrimination is always total.

C-3.5.2.3 *General case*

There are no general discrimination rules. The time/current curves clearly supply a value of I_{sc} (limited or assumed) less than the Short Time tripping of the upstream circuit-breaker; discrimination is then total. If this is not the case, only tests can indicate discrimination limits of coordination, in particular when circuit-breakers are of the limiting type. The discrimination limit I_s is determined by comparison of curves,

a) in tripping energy for the downstream circuit-breaker, and

b) in non-tripping energy for the upstream circuit-breaker.

The potential intersection point of the curves gives the discrimination limit I_s. The manufacturers indicate in tables the tested performance of coordination.

C-3.6 Earth Leakage Protection Discrimination

C-3.6.1 According to the Earthing System, discrimination only uses coordination of overcurrent protection devices. When the insulation fault is treated specifically by earth leakage protection devices (for example in the TT system), discrimination of the residual current devices (RCDs) with one another must also be guaranteed. Discrimination of earth leakage protection devices must ensure that, should an insulation fault occur, only the feeder concerned by the fault is de-energized. The aim is to optimize energy availability.

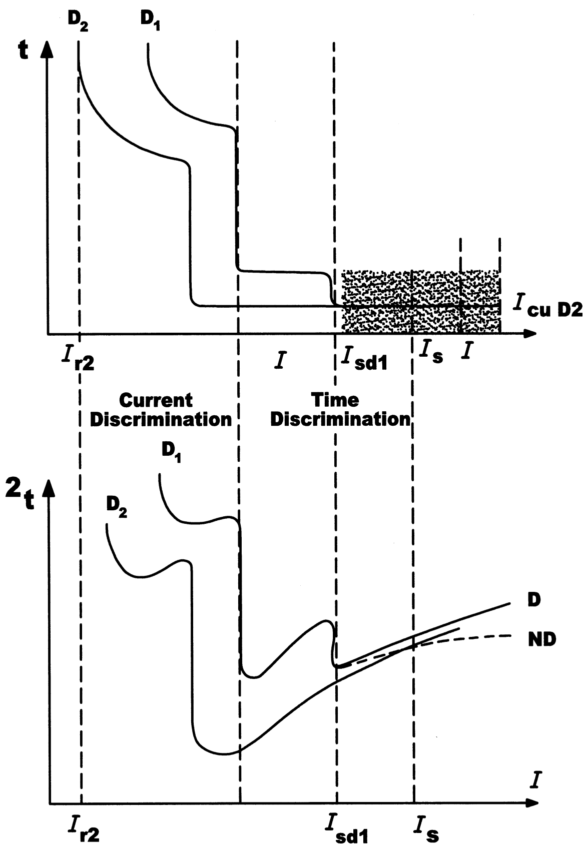


FIG. 21 DISCRIMINATION AT VARIOUS FAULT CURRENTS

C-3.6.2 *Types of Earth Leakage Protection Discrimination*

C-3.6.2.1 *Vertical discrimination*

In view of requirements and operating standards, discrimination must simultaneously meet both the time and current conditions (*see* Fig. 22).

C-3.6.2.1.1 *Current condition*

The RCD must trip between I_n and $I_n/2$, where I_n is the declared operating current. There must therefore exist a minimum ratio of 2 between the sensitivities of the upstream device and the downstream device. In practice, the standardized values indicate a ratio of 3.

C-3.6.2.1.2 *Time condition*

The minimum non-tripping time of the upstream device must be greater than the maximum tripping time of the downstream device for all current values.

NOTE — The tripping time of RCDs must always be less than or equal to the time specified in the installation standards to guarantee protection of people against indirect contacts.

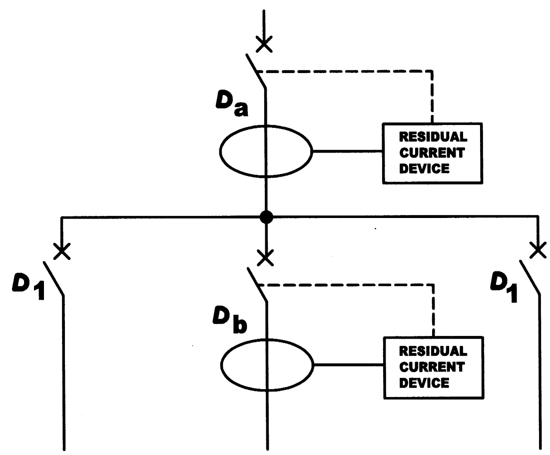


FIG. 22 VERTICAL DISCRIMINATION

For the domestic area, standards IS 12640 (Part 1) (residual current circuit-breakers) and IS 12640 (Part 2) (residual current devices) define operating times. The values in the table correspond to curves G and S. Curve G (General) correspond to non-delayed RCDs and S (Selective) to those that are voluntarily delayed (*see* Fig. 23).

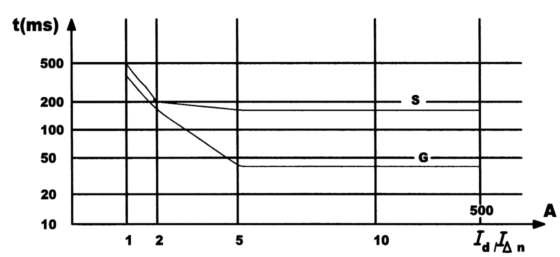


FIG. 23 OPERATING TIME CURVES

C-3.6.2.2 *Horizontal discrimination*

Sometimes known as circuit selection, it allows savings at the supply end of the installation of an RCD placed in the cubicle if all its feeders are protected by RCDs. Only the faulty feeder is de-energized, the devices placed on the other feeders do not see the fault (*see* Fig. 24).

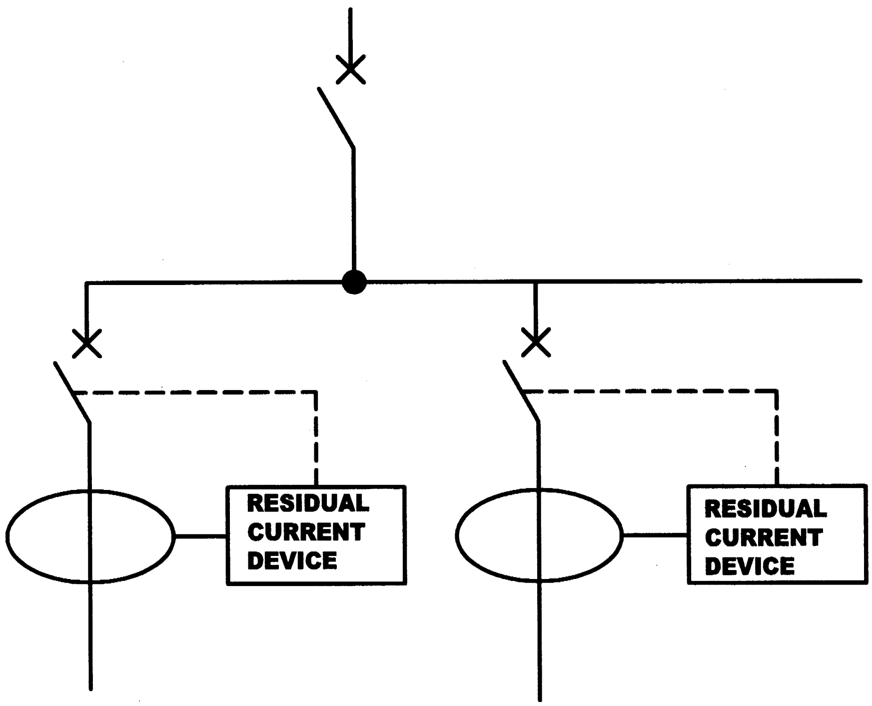


FIG. 24 HORIZONTAL DISCRIMINATION

Table 2 Standardized Values of Operating Times

Type	I_n	$I_{\Delta n}$	Standardized Values of Operating Time and Non-operating Time (in s) at:				
			$I_{\Delta n}$	$2I_{\Delta n}$	$5I_{\Delta n}$	500A	
General instantaneous	All values	All values	0.3	0.15	0.04	0.04	Maximum operating time
Selective	>25	>0.030	0.5	0.2	0.15	0.15	Maximum operating time
			0.13	0.06	0.05	0.04	Maximum operating time

SECTION 15 LIGHTNING PROTECTION

0 FOREWORD

For the purposes of the National Electrical Code, the fixed installation for lightning protection is considered part of the electrical installation design and constitutes a major area where the installation design engineer has to ensure proper coordination.

This Section covers the essential design and construction details of lightning protective systems. It is, however, intended to serve only as a guide of general nature on the principles and practices in the protection of structures against lightning, and account has to be taken of several other local conditions such as variations in the architecture, topography of the region, atmospheric conditions, etc.

Lightning protection of industrial installations which are categorized as hazardous, require special considerations. These are summarised in Part 7 of the Code.

Assistance has been derived from IS 2309 : 1989 'Code of practice for the protection of buildings and allied structures against lightning (*second revision*)' for this Section.

1 SCOPE

1.1 This (Part 1/Section 15) of the Code covers guidelines on the basic electrical aspects of lightning protective systems for buildings and the electrical installation forming part of the system.

1.2 Additional guidelines if any, for specific occupancies from the point of lightning protection are covered in respective sections of the Code.

2 REFERENCES

The following Indian Standards on lightning protection may be referred for further details:

IS No.	*Title*
IS 2309 : 1989	Code of practice for the protection of buildings and allied structures against lightning (*second revision*)
IS 15086 : Part 5/ IEC 60099-5 : 1996	Surge arresters : Part 5 Selection and application recommendations

3 TERMINOLOGY

For the purposes of this Section, the following definitions shall apply.

3.1 Air Termination (Lightning Conductor) or Air Termination Network — Those parts of a lightning protective system that are intended to collect the lightning discharges from the atmosphere.

3.2 Bonds — Electrical connection between the lightning protective system and other metal work, and between various portions of the latter.

3.3 Down Conductors — Conductors which connect the air terminations with the earth terminations.

3.4 Earth Terminations or Earth Terminations Network — Those part of the lightning protective system which are intended to distribute the lightning discharges into the general mass of the earth. All parts below the testing point in a down conductor are included in this term.

3.5 Earth Electrodes — A metal plate, pipe or other conductor or any array of conductors electrically connected to the general mass of the earth; these include those portions of the earth terminations that make direct electrical contact with the earth.

3.6 Fasteners — Devices used to fasten the conductors to the structures.

3.7 Isoceraunic Level — It is the number of days in a year on which the thunder is heard in the particular region averaged over a number of years.

3.8 Joints — The mechanical and electrical junctions between two or more portions of the lightning protective system or other metal bonded to the system or both.

3.9 Lightning Protective System — The whole system of interconnected conductors used to protect a structure from the effects of lightning.

3.10 Metal-clad Building — A building with sides made of or covered with sheet metal.

3.11 Metal-roofed Building — A building with roof made of or covered with sheet metal.

3.12 Side Flash — A spark occurring between nearby metallic objects or between such objects and the lightning protective system or to earth.

3.13 Testing Points — Joints in down conductors or in bonds or in earth conductors connecting earth electrodes, so designed and situated as to enable resistance measurements to be made.

3.14 Zone of Protection — The space within which the lightning conductor is expected to provide protection against a direct lightning stroke.

4 EXCHANGE OF INFORMATION

4.1 The architect should exchange information with the engineer concerned when the building plans are being prepared. The primary object of such an exchange is to obtain information regarding the architectural features of the structure so that due provision may be made to retain the aesthetic features of the building while planning the location of the lightning conductors and down conductors of the lightning protective system. Information may also be obtained at an early stage regarding other services, such as electrical installation, gas and water pipes as well as climatic and soil conditions.

4.2 Scale drawings showing plans and elevations of the structure should be obtained, and the nature, size and position of all the metal component parts of the lightning protective system should be indicated on them. In addition, a ground plan should show all the tall objects, such as, buildings, masts, transmission towers, tall trees, etc, within the zone of protection.

5 CHARACTERISTICS OF LIGHTNING DISCHARGES

5.1 The principal effects of lightning discharge to structure are electrical, thermal and mechanical. These effects are determined by the current which is discharged into the structure. These currents are unidirectional and may vary in amplitude from a few hundred amperes to about 200 kA. The current in any lightning discharge rises steeply to its crest value in a few microseconds and decays to zero in a few milliseconds. Many lightning discharges consist of a single stroke but some others involve a sequence of strokes which follow the same path and which discharge separate currents of amplitude and duration as mentioned above. A complete lightning discharge may thus last a second or even longer.

5.2 Electrical Effects

The principal electrical effects of a lightning discharge are two-fold.

5.2.1 The lightning current which is discharged to earth through the resistance of the lightning conductor and earth electrode provided for a lightning protective system, produces a resistive voltage drop which momentarily raises the potential of the protective system with respect to the absolute earth potential to a very high value. The lightning current also produces, around the earth electrode, a high voltage gradient which may be dangerous to persons and animals.

5.2.2 The lightning current rises steeply to its crest value (approximate at the rate of 10 kA/ms) and as a first approximation may be regarded as equivalent to high frequency discharge. A vertical conductor of the dimensions generally used in a lightning protective system has an inductance of about 16×10^{-5} H/100 m. The rate of rise of current in conjunction with the inductance of the discharge path produces an inductive voltage drop which would be added, with due regard to the time relationship, to the resistive (ohmic) voltage drop across the earthing system.

5.3 Thermal Effects

The thermal effect of lightning discharge results in rise in temperature of the conductor through which the lightning current is discharged to the earth. Although the amplitude of the lightning current may be very high, its duration is so short that the thermal effect on a lightning protective system is usually negligible. This ignores the fusing or welding effects which occur locally consequent upon the rupture of a conductor which was previously damaged or was of inadequate cross-sectional area. In practice the cross-sectional area of a lightning conductor is determined primarily by mechanical considerations.

5.4 Mechanical Effects

When a high electric current is discharged through parallel conductors which are in close proximity to each other, these are subjected to large mechanical forces. The lightning conductors should, therefore, be provided with adequate mechanical fixings.

5.4.1 A different mechanical effect exerted by a lightning discharge is due to the fact that the air channel, that is, the space between the thunder cloud and the lightning conductor, along which the discharge is propagated, is suddenly raised to a very high temperature. This results in a strong air pressure wave which is responsible for damages to buildings and other structures. It is not possible to provide protection against such an effect.

6 DETERMINATION OF THE NEED FOR PROTECTION

6.1 Risk Index

In determining how far to go in providing lightning protection for specific cases or whether or not it is needed at all, it is necessary to take into account the following factors:

a) Usage of structure,
b) Type of construction,
c) Contents or consequential effects,
d) Degree of isolation,
e) Type of isolation,
f) Height of structure, and
g) Lightning prevalance.

6.1.1 IS 2309 gives the details of various factors that affect the risk of the structure being struck and the consequential effects of a stroke. Certain values called 'index figures', have been assigned to these factors which help in arriving at an overall 'risk index' to serve as an aid to judging whether lightning protection. The examples of such structures are:

a) those in or near which large number of people congregate.
b) those concerned with the maintenance of essential public services,
c) those in areas where lightning strokes are prevalent,
d) very tall or isolated structures,
e) structures of historic or cultural importance, and
f) structures containing explosives and highly flammable materials.

7 ZONE OF PROTECTION

7.1 The zone of protection of a lightning conductor denotes the space within which a lightning conductor provides protection against a direct lightning stroke by diverting the stroke to itself. Examples of the protection of different types and shapes of buildings along with zone of protection provided by their lightning protective systems are given in **8.2** of IS 2309.

8 MATERIALS AND DIMENSIONS

8.1 Materials

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

a) *Copper* — When solid or stranded copper wire or flat copper strips are used, they shall be of grade ordinarily required for commercial electrical work, generally designated as being of 98 percent conductivity when annealed. They shall conform to relevant Indian Standards.
b) *Copper-clad Steel* — Where copper-clad steel is used, the copper covering shall be permanently and effectively welded to the steel core. The proportion of copper and steel shall be such that the conductance of the material is not less than 30 percent of the conductance of solid copper of the same total cross-sectional area.
c) *Galvanized Steel* — If there is any difficulty in the use of copper or aluminium, galvanized steel of the same cross section as recommended for copper may be used, in line with the provisions of IS 2309. Where steel is used it shall be thoroughly protected against corrosion by a zinc coating. Galvanized steel may be preferred for some short life installations, such as exhibitions. Copper is preferred to galvanized iron where corrosive gases, industrial pollution or saltaden atmospheric conditions are encountered.
d) *Aluminium* — Aluminium wire and strips are increasingly finding favour for use as lightning conductors in view of the fact that aluminium has a conductivity almost double that of copper mass for mass. When used, it shall be least 99 percent pure, of sufficient mechanical strength and effectively protected against corrosion.
e) *Alloys* — Where alloys of metals are used they shall be substantially as resistant to corrosion as copper under similar conditions.

NOTE — Aluminium should not be used underground or in direct contact with walls.

8.2 Shapes and Sizes

The recommended shape and minimum sizes of conductors for use above ground and below ground are given in Table 1 and Table 2 respectively.

Table 1 Shapes and Minimum Sizes of Conductors for Use Above Ground
(*Clause* 8.2)

Sl No. (1)	Material and Shape (2)	Minimum Size (3)
i)	Round copper wire or copper-clad steel wire	6 mm diameter
ii)	Stranded copper wire	50 mm^2 (or 7/3.00 mm diameter)
iii)	Copper strip	20 mm × 3 mm
iv)	Round galvanized iron wire	8 mm diameter
v)	Galvanized iron strip	20 mm × 3 mm
vi)	Round aluminium wire	9 mm diameter
vii)	Aluminium strip	25 mm × 3.15 mm

8.3 Corrosion

Where corrosion due to atmospheric, chemical, electrolytic or other causes is likely to impair any part of the lightning protective system, suitable precautions should be taken to prevent its occurrence. The contact of dissimilar metals is likely to initiate and accelerate corrosion unless the contact surfaces are kept completely dry and protected against the ingress of moisture.

Table 2 Shapes and Minimum Sizes of Conductors for Use Below Ground
(*Clause* 8.2)

Sl No.	Material and Shape	Minimum Size
(1)	(2)	(3)
i)	Round copper wire or copper-clad steel wire	8 mm diameter
ii)	Copper strip	32 mm × 6 mm
iii)	Round galvanized iron wire	10 mm diameter
iv)	Galvanized iron strip	32 mm × 6 mm

8.3.1 Dissimilar metal contacts can exist where a conductor is held by fixing devices or against external metal surfaces. Corrosion can arise also where water passing over one metal comes into contact with another. Run-off water from copper, copper alloys and lead can attack aluminium alloys and zinc. The metal of the lightning protective system should be compatible with the metal or metals used externally on the structure over which the system passes or with which it may make contact.

9 DESIGN

9.0 General

Lightning protective systems should be installed with a view to offering least impedance to the passage of lightning current between air-terminals and earth. There shall be at least two parts, and more if practicable. This is done by connecting the conductors to form a cage enclosing the building. The basic design considerations for lightning protective systems are given in IS 2309.

The principal component of a lightning protective system are:

a) air terminations,
b) down conductors,
c) joints and bends,
d) testing points,
e) earth terminations,
f) earth electrodes, and
g) fasteners.

9.1 Air Terminations

For the purpose of lightning protection, the vertical and horizontal conductors are considered equivalent and the use of pointed air terminations or vertical finials is, therefore, not regarded as essential except when dictated by practical considerations. An air termination may consist for a vertical conductor as for a spire, a single horizontal and vertical conductors for the protection of bigger buildings.

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

9.1.2 Horizontal air terminations should be so interconnected that no part of the roof is more than 9 m away from the nearest horizontal conductor except that an additional 30 cm may be allowed for each 30 cm by which the part to be protected is below the nearest protective conductor. For a flat roof, horizontal air terminations along the outer perimeter of the roof are used. For a roof of building with larger horizontal dimensions a network of parallel horizontal conductors should be installed as shown in IS 2309.

NOTE — Salient points even if less than 9 m apart should each be provided with an air termination.

9.1.3 Horizontal air terminations should be coursed along contours, such as ridges, parapets and edges of flat roofs, and where necessary over flat surfaces in such a way as to join each air termination to the rest and should themselves form a closed network.

9.1.4 The layout of the network may be designed to suit the shape of the roof and architectural features of the buildings.

9.1.5 The air termination network should cover all salient points of the structure.

9.1.6 All metallic finials, chimneys, ducts, vent pipes, railings, gutters and the like, on or above the main surface of the roof of the structure shall be bonded to, and form part of, the air termination network. If portions of a structure vary considerably in height, any necessary air termination or air termination network of the lower portions should, in addition to their own conductors, be bonded to the down conductors of the taller portions.

9.1.7 All air terminals shall be effectively secured against overturning either by attachment to the object to be protected or by means of substantial braces and fixings which shall be permanently and rigidly attached to the building. The method and nature of the fixings should be simple, solid and permanent, due attention being given to climatic conditions and possible corrosion.

9.2 Down Conductors

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

a) A structure having a base area not exceeding 100 m^2 may have one down conductor only if the height of the air termination provides sufficient protection. However, it is advisable to have at least two down conductors except for very small buildings.

b) For structures having a base area exceeding 100 m^2, the number of down conductors required should be worked out as follows:

   1) One for the first 100 m^2 plus one more for every additional 300 m^2 or part thereof, or

   2) One for every 30 m of perimeter.

   The small of the two shall apply.

c) For a structure exceeding 30 m in height additional consideration as given in IS 2309 shall apply.

9.2.1 Down conductors should be distributed round the outside walls of the structure. They shall preferably be run along the corners and other projections, due consideration being given to the location of air terminations and earth terminations. Lift shaft shall not be used for fixing down conductors.

9.2.2 It is very important that the down conductors shall follow the most direct path possible between the air termination and the earth termination, avoiding sharp bends, upturns and kinks. Joints shall as far as possible be avoided in down conductors. Adequate protection may be provided to the conductors against mechanical damage. Metal pipes should not be used as protection for the conductors.

9.2.3 Metal pipes leading rainwater from the roof to the ground may be connected to the down conductors but cannot replace them. Such connections shall have disconnecting joints for testing purposes.

9.2.4 Where the provision of suitable external routes for down conductors is impracticable or inadvisable, as in buildings of cantilever construction, from the first floor upwards, down conductors may be used in an air space provided by a non-metallic non-combustible internal duct. Any covered recess not smaller than 75 mm × 15 mm or any vertical service duct running the full height of the building may be used for this purpose, provided it does not contain an unarmoured or non-metal-sheathed cable.

9.2.5 Any extended metal running vertically through the structure should be bonded to the lightning conductor at the top and the bottom unless the clearance are in accordance with IS 2309 for tall structures.

9.2.6 A structure on bare rock, should be provided with at least down conductors equally spaced.

9.2.7 In deciding on the routing of the down conductor, its accessibility for inspection, testing and maintenance should be taken into account.

9.3 Joints and Bonds

9.3.1 *Joints*

The lightning protective system shall have as few joints in it as necessary. In the down conductors below ground level these shall be mechanically and electrically effective and shall be so made as to exclude moisture completely. The joints may be clamped, screwed, bolted, crimped, riverted or welded. With overlapping joints the length of the overlap should not be less than 20 mm for all types of conductors. Contact surfaces should first be cleaned and then inhibited from oxidation with a suitable non-corrosive compound. Joints of dissimilar metal should be suitably protected against bimetallic action and corrosion.

9.3.1.1 In general, joints for strips shall be tinned, soldered, welded or brazed and at least double-riveted, welded or brazed and at least double-riveted. Clamped or bolted joints shall only be used on test points or on bonds to existing metal, but joints shall only be of the clamped or screwed type.

9.3.2 *Bonds*

External metal on or forming part of a structure may have to discharge the full lightning current. Therefore, the bond to the lightning protective system shall have a cross-sectional area not less than that employed for the main conductors. On the other hand, internal metal is not so vulnerable and its associated bonds are, at most, only likely to carry a portion of the total lightning current, apart from their function of equalizing potential. These latter bonds may, therefore, be smaller in cross-sectional area than those used for the main conductors. All the bonds should be suitably protected against corrosion. Bonds shall be as short as possible.

9.4 Testing Points

Each down conductor shall be provided with a testing point in a position convenient for testing but inaccessible for interference. No connection, other than one direct to an earth electrode, shall be made below a testing point. Testing points shall be phosphorbronze, gunmetal, copper or any other suitable material.

9.5 Earth Terminations

Each down conductor shall have an independent earth termination. It should be capable of isolation for testing purposes. Suitable location for the earth termination shall be selected after testing and assessing the specific resistivity of the soil and with due regard to reliability of the sub-soil water to ensure minimum soil moistness.

9.5.1 Water pipe system should not be bonded to the earth termination system. However, if adequate clearance between the two cannot be obtained, they may be effective bonded and the bonds should be capable of isolation and testing. The gas pipes, however, should in no case be bonded to the earth termination system.

9.5.2 It is recommended that all earth terminations should be interconnected. Common earthing, besides equalizing the voltage at various earth terminations also minimizes any risk to it of mechanical damage. The condition for limiting earthing resistance given in **12** does not apply and in such a case no provision need be made for isolation in earth.

9.5.3 A structure standing on bare rock should be equipped with a conductor encircling and fixed to the structure at ground level and following reasonably closely the contour of the ground. This conductor should be installed so as to minimize any risk to it of mechanical damage. The condition for limiting earthing resistance given in **12** does not apply and in such a case no provision need be made for isolation in earth termination for testing. Where there is a risk to persons or to valuable equipment, expert advice should be sought.

9.6 Earth Electrodes

Earth electrodes shall be constructed and installed in accordance with Part 1/Section 14 of the Code.

9.6.1 Earth electrodes shall consist of rods, strips or plates. Metal sheaths of cables shall not be used as earth electrodes.

9.6.2 When rods or pipes are used they should be driven into the ground as close as practicable but outside the circumference of the structure. Long lengths in sections coupled by screwed connectors or socket joints can be built up where necessary to penetrate the substrate of low resistivity. Where ground conditions are more favourable for the use of shorter lengths of rods in parallel, the distance between the rods should preferably be not less than twice the length of the rods. The arrangement of earth electrodes are given in Fig. 24 of IS 2309.

9.6.3 When strips are used, these should be buried in trenches or beneath the structure at a suitable depth, but not less than 0.5 m deep to avoid damage by building or agricultural operations. The strips should preferably be laid radially in two or more directions from the point of connection to a down conductor. But if this is not possible they may extend in one direction only. However, if the space restriction requires the strips to be laid in parallel or in grid formation the distance between two strips should not be less than 2 m.

9.6.4 When plate electrodes are used they shall be buried into the ground so that the top edge of the plate is at a depth not less than 1.5 m from the surface of the ground. If two plate electrodes are to be used in parallel the distance between the two shall not be less than 8 m.

9.6.5 In the neighbourhood of structure where high temperatures are likely to be the encountered in the sub-soil, for example brick kilns, the earth electrodes may have to be installed at such a distance from the structure where the ground is not likely to be dried out.

9.7 Fasteners

Conductors shall be securely attached to the building or other object to be protected by fastners which shall be substantial in construction, not subject to breakage, and shall be made of galvanized steel or other suitable material. If fasteners are made of steel, they should be galvanized to protect them against corrosion. If they are made of any other material suitable precautions should be taken to avoid corrosion. Some samples of fasteners are shown in IS 2309.

9.8 Earth Resistance

Each earth termination should have a resistance in ohms to earth not exceeding numerically the product of 10 and the number of earth terminations to be provided. The whole of the lightning protective system should have a combined resistance to earth not exceeding 10 ohms before any bonding has been effected to metal in or on the structure or to surface below ground.

10 ISOLATION AND BONDING

10.0 When a lightning protective system is struck with a lightning discharge, its electrical potential with respect to earth is raised, and unless suitable precautions are taken, the discharge may seek alternative paths to earth by side flashing to other metal in the structure. Side flashing may be avoided by the following two methods:

a) Isolation, and
b) Bonding.

10.1 Isolation

Isolation requires large clearances between the lightning protective system and other metal parts in the structure. To find out the approximate clearances, the following two factors should be taken into account:

a) The resistive voltage drop in the earth termination, and
b) The inductive voltage drop in the down conductors.

10.1.1 The resistive voltage drop requires a clearance of 0.3 m ohm of earthing resistance while the inductive voltage drop requires a clearance of 1 m for each 15 m of structure height. For two or more down conductors with a common air termination this distance should be divided by the number of down conductors. The total clearance required is the sum of the two distances and may be expressed by the following simple equation:

$$D = 0.3R \frac{H}{15n}$$

where

D = required clearance in m;

R = combined earthing resistance of the earth termination, in ohms;

H = structure height in m, and

n = number of down conductors connected to a common air termination.

10.1.2 The above clearance may be halved if a slight risk of occurrence of a side flash can be accepted.

10.1.3 The drawback of isolation lies in obtaining and maintaining the necessary safe clearance and in ensuring that isolated metal has no connection via the water pipes or other services with the earth. In general, isolation can be practised only in small buildings.

10.2 Bonding

In structures which contain electrically continuous metal, for example, a roof, wall, floor or covering, this metal, suitably bonded, may be used as part of the lightning protective system, provided the amount and arrangement of the metal render it suitable for use in accordance with **9**.

10.2.1 If a structure is simply a continuous metal frame without external coverings it may not require any air termination or down conductors provided it can be ensured that the conducting path is electrically continuous and the base of the structure is adequately earthed.

10.2.2 A reinforced concrete structure or a reinforced concrete frame structure may have sufficiently low inherent resistance to earth to provide protection against lightning and if connections are brought out from the reinforcement at the highest points during construction, a test may be made to varify this at the completion of the structure.

10.2.3 If the resistance to earth of the steel frame of a structure or the reinforcement of a reinforced concrete structure is found to be satisfactory a suitable air termination should be installed at the top of the structure and bonded to the steel frame or to the reinforcement. Where regular inspection is not possible, it is recommended that a corrosion resistant material be used for bonding to the steel or to the reinforcement and this should be brought out for connection to the air termination. Down conductor and earth terminations will, of course, be required if the inherent resistance of the structure is found to be unsatisfactory when tested.

10.2.4 Where metal exists in a structure as reinforcement which cannot be bonded into a continuous conducting network, and which is not or cannot be equipped with external earthing connections, its presence should be disgarded. The danger inseparable from the presence of such metal can be minimized by keeping it entirely isolated from the lightning protective system.

10.2.5 Where the roof structure is wholly or partly covered by metal, care should be taken that such metal is provided with a continuous conducting path to earth.

10.2.6 In any structure, metal which is attached to the outer surface or projects through a wall or a roof and has insufficient clearance from the lightning protective system, and is unsuitable for use as part of it, should preferably be bonded as directly as possible to the lightning protectives system. If the metal has considerable length (for example, cables, pipes, gutters, rain-water pipes, stair-ways, etc) and runs approximately parallel to a down conductor or bond, it should be bonded at each and but not below the test point. If the metal is in discontinuous lengths, each portion should be bonded to the lightning protective system; alternatively, where the clearance permits, the presence of the metal may be disregarded.

10.2.7 Bonding of metal entering or leaving a structure in the form of sheathing or armouring of cable, electric conduit, telephone, steam, compressed air or other services with earth termination system, should be avoided. However, if they are required to be bonded, the bonding should be done as directly as possible to the earth termination at the point of entry or exist outside the structure on the supply side of the service. The gap pipes should in no case be bonded with other metal parts. However, water pipes may be bonded to other metal parts, if isolation and adequate clearance cannot be obtained. In this operation all the statutory rules or regulations which may be in force should be followed and the competent authority should be consulted for providing lightning protection in such cases.

10.2.8 Masses of metal in a building, such as bell-frame in a tower, should be bonded to the nearest down conductor by the most direct route available.

10.2.9 Metal cladding or curtain walling having a continuous conducting path in all directions may be used as part of a lightning protective system.

10.2.10 In bonding adjacent metalwork to the lightning protective system careful consideration should be given to the possible effects such bonding would have upon metalwork which may be cathodically protected.

11 PROTECTION OF SPECIAL STRUCTURES

For guidance on design of lightning protection systems for special structures, reference shall be made to IS 2309. Guidance for the appropriate authorities shall also be obtained.

12 INSPECTION AND TESTING

12.1 Inspection

All lightning protective systems shall be examined by a competent engineer after completion, alteration or extensions, in order to verify that they are in accordance with the recommendations of the Code. A routine inspection shall be made at least once a year.

12.2 Testing

12.2.1 On completion of the installation or of any modification, the resistance of each earth termination or section thereof, shall, if possible, be measured and the continuity of all conductors and the efficiency of all bonds and joints shall be verified.

12.2.2 Normally annual measurement of earth resistance shall be carried out but local circumstances in the light of experience may justify increase or decrease in this interval but it should not be less than once in two years. In the case of structures housing explosives or flammable materials, the interval shall be six months.

12.2.3 Earth resistance shall be measured in accordance with Part 1/Section 14 of the Code.

12.2.4 The actual procedure adopted for the test shall be recorded in detail so that future tests may be carried out under similar conditions. The highest value of resistance measured shall be noted as the resistance of the soil and details of salting or other soil treatment, should be recorded.

12.2.5 The record shall also contain particulars of the engineer, contractor or owner responsible for the installation or upkeep or both of the lightning protective system. Details of additions or alterations to the system, and dates of testing together with the test results and reports, shall be carefully recorded.

12.3 Deterioration

If the resistance to earth of a lightning protective system or any section of it exceeds the lowest value obtained at the first installation by more than 100 percent, appropriate steps shall be taken to ascertain the causes and to remedy defects, if any.

12.4 Testing Continuity and Efficacy of Conductors and Joints

12.4.1 The ohmic resistance of the lightning protective system complete with air termination, but without the earth connection should be measured and this should be a fraction of an ohm. If it exceeds 1 ohm, then there shall be some fault either electrical or mechanical, which shall be inspected and the defect rectified.

12.4.2 For this system is best divided into convenient sections at testing points by suitable joints. A continuous current of about 10 A shall be passed through the portion of the system under test and the resistance verified against its calculated or recorded value. Suitable portable precision testing sets for this purposes should be used.

SECTION 16 PROTECTION AGAINST VOLTAGE SURGES

FOREWORD

A sudden change in the established operating conditions in an electrical network causes transient phenomena to occur. Transients may be generated outside of the home or business by lightning, other utility customers, animals, and even normal utility switching operations. Inside the home or business, transients are generated by motors starting and stopping, flourescent lighting, copiers, vending machines, welders, and many other sources. In a dry environment, electrical charges accumulate and create a very strong electrostatic field. Protection to mitigate the larger transients coming from outside the home or business, and point-of-use surge protection for equipment sensitive to transients generated within the building need to be considered.

Assistance for this Section has been derived from IEC 61643-12-2008 'Low-voltage surge protective devices — Part 12: Surge protective devices connected to low-voltage power distribution systems — Selection and application principles'.

1 SCOPE

1.1 This Part 1/Section 16 covers the protection requirements in low voltage electrical installation of buildings.

1.2 This part does not cover the primary protection against lightning which is covered under Part 1/ Section 15.

2 REFERENCES

A list of Indian Standards relevant to protection against voltage surges is given at Annex A.

3 TERMINOLOGY

The definitions given in Part 1/Section 2 of this Code and the following shall apply.

3.1 Continuous Operating Current (I_c) — Current that flows in an SPD when supplied at its permament full withstand operating voltage (U_c) for each mode. I_c corresponds to the sum of the currents that flow in the SPD's protection component and in all the internal circuits connected in parallel.

3.2 Disruptive Discharge — The phenomena associated with the failure of insulation under electrical stress which include a collapse of voltage and the passage of current; the term applies to electrical breakdown in solid, liquid and gaseous dielectrics and combinations of these.

NOTE — A disruptive discharge in a solid dielectric produces permanent loss of electrical strength; in a liquid or gaseous dielectric the loss maybe only temporary.

3.3 Flashover — A disruptive discharge over a solid surface.

3.4 Impulse — A unidirectional wave of voltage or current which, without appreciable oscillations, rises rapidly to a maximum value and falls, usually less rapidly, to zero with small, if any, loops of opposite polarity. The parameters which define a voltage or current impulse are polarity, peak value, front time, and time to half value on the tail.

3.5 Impulse Current (I_{imp}) — It is defined by a current peak value I_{peak} and the charge a tested according to the test sequence of the operating duty test. This is used for the classification of the SPD for Class I test.

3.6 Maximum Continuous Operating Voltage (U_c) — The maximum r.m.s. or d.c. voltage which may be continuously applied to the SPDs mode of protection. This is equal to the rated voltage.

3.7 Maximum Discharge Current for Class II Test (I_{Max}) — Crest value of a current through the SPD having an 8/20 waveshape and magnitude according to the test sequence of the Class II operating duty test. I_{Max} is greater than I_n.

3.8 Nominal Discharge Current (I_n) — The crest value of the current through the SPD having a current waveshape of 8/20. This is used for the classification of the SPD for the Class II test and also for pre-conditioning of the SPD for Class I and II tests.

3.9 Puncture — A disruptive discharge through a solid.

3.10 Rated Network Voltage (U_n) — The rated voltage of the network.

3.11 Residual Voltage (U_{res}) — The peak value of the voltage that appears between the terminals of an SPD due to the passage of discharge current.

3.12 Sparkover of an Arrester — A disruptive discharge between the electrodes of the gaps of an arrester.

3.13 Surge Arrester — A device designed to protect electrical apparatus from high transient voltage and to limit the duration and frequently the amplitude of follow-current. The term 'surge arrester' includes any external series gap which is essential for the proper functioning of the device as installed for service, regardless of whether or not it is supplied as an integral part of the device.

NOTE — Surge arresters are usually connected between the electrical conductors of a network and earth although they may sometimes be connected across the windings of apparatus or between electrical conductors.

3.14 Surge Protective Device (SPD) — A device that limits transient voltage surges and runs current waves to ground to limit the amplitude of the voltage surge to a safe level for electrical installations and equipment. Surge protective devices (SPDs) are used to protect, under specified conditions, electrical systems and equipment against various overvoltages and impulse currents, such as lightning and switching surges.

3.15 Switching Overvoltages — These stresses are usually lower than lightning stresses in terms of peak current and voltage, but may have longer duration. However, in some cases, particularly deep inside a structure or close to switching overvoltage sources, the switching stress can be higher than the stresses caused by lightning. The energy related to these switching surges needs to be known to permit the choice of appropriate SPDs. The time duration of the switching surges, including transients due to faults and fuse operations, can be much longer than the lightning surge duration.

3.16 Temporary Overvoltages (U_{TOV}) — Any SPD can be exposed to a temporary overvoltage U_{TOV} during its lifetime that exceeds the maximum continuous operating voltage of the power system. A temporary overvoltage has two dimensions, magnitude and time. The time duration of the overvoltage primarily depends upon the earthing of the supply system (this includes both the high-voltage supply system as well as the low-voltage system to which the SPD is connected). In determining the temporary overvoltages, consideration should be given to the maximum continuous operating voltage of the power system (U_{cs}).

3.17 Voltage Protection Level (U_p) — A parameter that characterizes the performance of the SPD in limiting the voltage across its terminals, which is selected from a list of preferred values. This value shall be greater than the highest value of the measured limiting voltages.

The most common values for a 230/400 V network are:

1 kV -1.2 kV -1.5 kV -1.8 kV - 2 kV - 2.5 kV

3.18 Voltage Surge — A voltage impulse or wave which is superposed on the rated network voltage (*see* Fig. 1). A voltage surge disturbs equipment and causes electromagnetic radiation. The duration of the voltage surge (T) causes a surge of energy in the electrical circuits which is likely to destroy the equipment.

4 GENERAL

4.1 Voltage Surges

A voltage surge disturbs equipment and causes electromagnetic radiation. Furthermore, the duration of the voltage surge (T) causes a surge of energy in the electrical circuits which is likely to destroy the equipment. There are four types of voltage surges which may disturb electrical installations and loads:

a) Atmospheric voltage surges,
b) Operating voltage surges,
c) Transient overvoltage at industrial frequency, and
d) Voltage surges caused by electrostatic discharge.

4.1.1 *Atmospheric Voltage Surges*

Atmospheric voltage surges, that is, lightning, comes from the discharge of electrical charges accumulated in the cumulo-nimbus clouds which form a capacitor with the ground. Storm phenomena cause serious damage. Lightning is a high frequency electrical phenomenon which produces voltage surges on all conductive elements, and especially on electrical loads and wires. Protection against lightning is covered under Part 1/Section 15.

4.1.2 *Operating Voltage Surges*

A sudden change in the established operating conditions in an electrical network causes transient phenomena to occur. These are generally high frequency or damped oscillation voltage surge waves (*see* Fig. 1).

They are said to have a slow gradient — their frequency varies from several ten to several hundred kilohertz.

Operating voltage surges may be created by:

The opening of protection devices (fuse, circuit-breaker), and the opening or closing of control devices (relays, contactors, etc).

Inductive circuits due to motors starting and stopping, or the opening of transformers such as MVILV substations

Capacitive circuits due to the connection of capacitor banks to the network

All devices that contain a coil, a capacitor or a transformer at the power supply inlet: relays, contactors, television sets, printers, computers, electric ovens, filters, etc.

4.1.3 *Transient Overvoltages at Industrial Frequency*

These overvoltages (*see* Fig. 2) have the same frequency as the network (50, 60 or 400 Hz); and can be caused by:

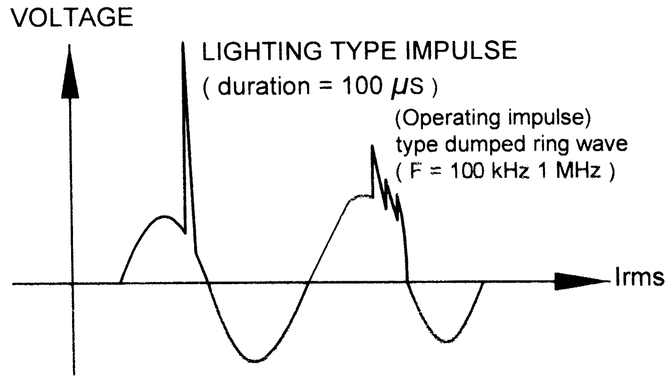


FIG. 1 VOLTAGE SURGE EXAMPLES

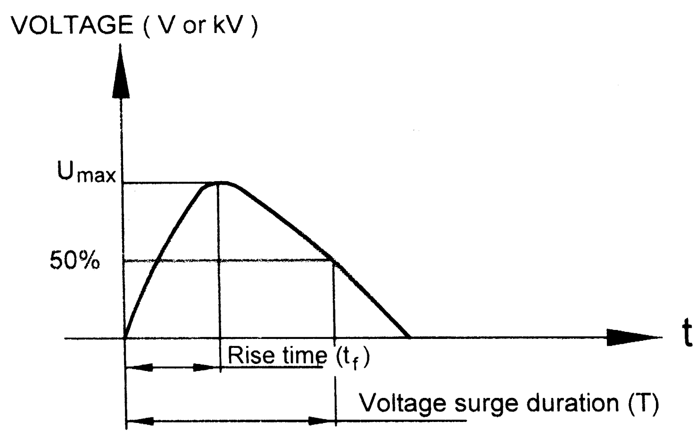


FIG. 2 TRANSIENT OVERVOLTAGE AT INDUSTRIAL FREQUENCY

a) Phase/frame or phase/earth insulating faults on a network with an insulated or impedant neutral, or by the breakdown of the neutral conductor. When this happens, single phase devices will be supplied in 400 V instead of 230 V.
b) A cable breakdown, for example a medium voltage cable which falls on a low voltage line.
c) The arcing of a high or medium voltage protective spark-gap causing a rise in earth potential during the action of the protection devices. These protection devices follow automatic switching cycles which will recreate a fault, if it persists.

4.1.4 *Voltage Surges Caused by Electrical Discharge*

In a dry environment, electrical charges accumulate and create a very strong electrostatic field. For example, a person walking on carpet with insulating soles will become electrically charged to a voltage of several kilovolts. If the person walks close to a conductive structure, he will give off an electrical discharge of several amperes in a very short rise time of a few nanoseconds. If the structure contains sensitive electronics, a computer for example, its components or circuit boards may be damaged.

4.2 Main Characteristics of Voltage Surges

The surge protective device includes one or several non-linear components. The surge protective device eliminates voltage surges:

a) *In common mode*: Phase to earth or neutral to earth.
b) *In differential mode*: Phase to phase or phase to neutral.

When a voltage surge exceeds the U_c threshold, the surge protective device (SDP) conducts the energy to earth in common mode. In differential mode the diverted energy is directed to another active conductor (*see* Annex B). Table 1 sums up the main characteristics of voltage surges.

The surge protective device has an internal thermal protection device which protects against burnout at its end of life. Gradually, over normal use after withstanding several voltage surges, the SPD degrades into a conductive device. An indicator informs the user when end-of-life is close.

Some surge protective devices have a remote indication. In addition, protection against short-circuits is ensured by an external circuit-breaker.

4.3 Basic Functions of Surge Protection Devices (SPDs)

The functions of surge protection devices are as follows:

a) *In power systems in the absence of surges*: the SPD shall not have a significant influence on the operational characteristics of the system to which it is applied.
b) *In power systems during the occurrence of surges*: the SPD responds to surges by lowering its impedance and thus diverting surge current through it to limit the voltage to its protective level. The surges may initiate a power follow current through the SPD.
c) *In power systems after the occurrence of surges*: the SPD recovers to a high-impedance state after the surges and extinguishes any possible power follow current.

The characteristics of SPDs are specified to achieve the above functions under normal service conditions. The normal service conditions are specified by the frequency of the power-system voltage, load current, altitude (that is, air pressure), humidity and ambient air temperature.

4.4 Surge Protective Device Tests

4.4.1 Three test classes are defined for surge protective devices connected to low-voltage power distribution systems:

a) *Class I tests*: They are conducted using nominal discharge current (I_n), voltage impulse with 1.2/50 µs waveshape and impulse current I_{imp}.
   The Class I tests is intended to simulate partial conducted lightning current impulses. SPDs subjected to Class I test methods are generally recommended for locations at points of high exposure, for example line entrances to buildings protected by lightning protection systems.
b) *Class II tests*: They are conducted using nominal discharge current (I_n), voltage impulse with 1.2/50 µs waveshape.
c) *Class III tests*: They are conducted using the combination waveform (1.2/50 and 8/20 µs).

4.4.2 SPDs tested to Class II or III test methods are subjected to impulses of shorter duration. These SPDs are generally recommended for locations with lesser exposure. SPDs are classified in the following three categories:

a) *Type* 1: SPD tested to Class I,
b) *Type* 2: SPD tested to Class II, and
c) *Type* 3: SPD tested to Class III.

4.4.3 The SPD is characterised by U_c, U_p, I_n and I_{Max} (*see* Fig. 3).

4.4.4 To test the surge arrester, standardized voltage and current waves have been defined Voltage wave for example, 1.2/50 µs (*see* Fig. 4) Current wave for example, 8/20 µs (*see* Fig. 5).

Other possible wave characteristics 4/10 µs, 10/1 000 µs, 30/60 µs, 10/350 µs.

Comparison between different surge protective devices must be carried out using the same wave characteristics, in order to get relevant results.

Table 1 Characteristics of Voltage Surges
(*Clause* 4.2)

Sl No.	Type of Voltage Surge	Voltage Surge Coefficient	Duration	Front Gradient or Frequency
(1)	(2)	(3)	(4)	(5)
i)	Industrial frequency (insulation fault)	≤ 1.7	Long 30 to 1 000 ms	Industrial frequency (50-60-400 Hz)
ii)	Operation	2 to 4	Short 1 to 100 ms	Average 1 to 200 kHz
iii)	Atmospheric	> 4	Very short 1 to 100 µs	Very high 1 to 1 000 kV/µs

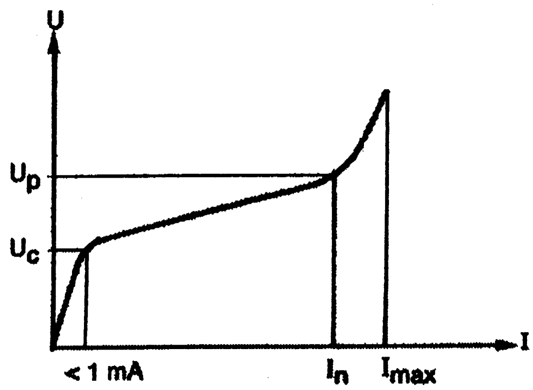


FIG. 3 VOLTAGE/CURRENT CHARACTERISTICS

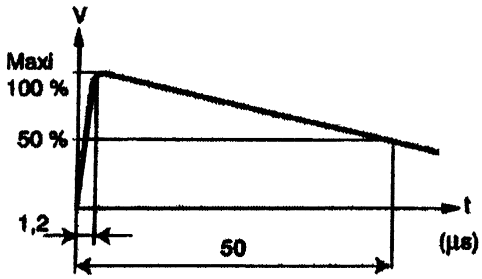


FIG. 4 1.2/50 µs WAVE

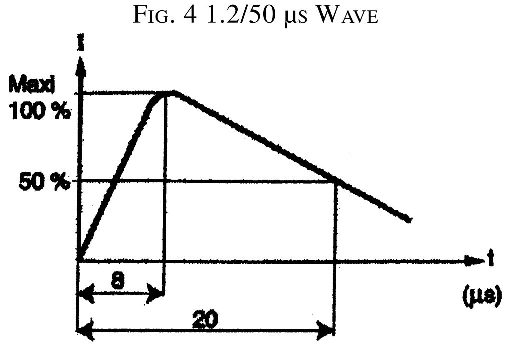


FIG. 5 8/20 µs WAVE

5 SELECTION OF PROTECTION DEVICE

5.1 For the selection of protection device, the value of the equipment to be protected should be estimated. To estimate its value, the cost of the equipment in financial terms and the economic impact if the equipment goes down needs to be taken into account. Protection devices shall be selected according to their environmental conditions and the acceptable failure rate of the equipment and the protective device. These factors include equipment to be protected and system characteristics, insulation levels, overvoltages, method of installation, location of SPDs, co-ordination of SPDs, failure mode of SPDs and equipment failure consequences etc.

5.2 Rated residual voltage U_{res} of protection devices must not be higher than the value in the voltage impulse withstand category II (*see* Table 2).

5.3 Choice of Disconnector

The disconnector is necessary to ensure the safety of the installation.

One of the surge arrester parameters is the maximum current (I_{Max} 8/20 µs wave) that it can withstand without degradation. If this current is exceeded, the surge arrester will be destroyed; it will be permanently short circuited and it is essential to replace it.

The fault current must therefore be eliminated by an external disconnector installed upstream.

The disconnector provides the complete protection required by a surge arrester installation, that is:

a) it must be able to withstand standard test waves:
   1) it must not trip at 20 impulses at I_n, and
   2) it can trip at I_{Max} without being destroyed.
b) the surge arrester disconnects if it short-circuits.

Surge arrester/disconnection circuit breaker correspondence table are generally supplied by manufacturers.

5.4 Additional Requirements

5.4.0 Depending upon the application of the SPD, additional requirements may be needed such as protection of SPDs against direct contact, safety in the event of SPD failures etc. An SPD may fail subjected to a surge greater than its designed maximum energy and discharge current capability. Failure modes of SPDs are usually divided into open-circuit and short circuit mode.

5.4.1 *End-of-life Indication of the Surge Arrester*

In the open-circuit mode the system to be protected is no longer protected. In this case, failure of an SPD is usually difficult to detect since it has almost no influence on the system. To ensure that the failed SPD is replaced before the next surge, an indication function may be required. Various indication devices are provided to warn the user that the loads are no longer protected against voltage surges. Many surge arresters have a light indicating that the module is in good working order.

5.4.2 *Use of Disconnecting Devices*

In the short-circuit mode, the system is severely influenced by the failed SPD. The short-circuit current flows through the failed SPD from the power source. Energy dissipated during the conduction of short circuit current may be excessive and cause a fire hazard. The short-circuit withstand capability test of covers this problem. In cases where the system to be protected has no suitable device to disconnect the failed SPD

Table 2 Selection of Equipment for the Installation
(*Clause* 5.2)

Sl No.	Nominal Voltage of the Installation V		Required Impulse Withstand Voltage for kV			
	Three-Phase Systems	Single-Phase System with Middle Point	Equipment at the Origin of the Installation (Impulse Withstand Category IV)	Equipment at the Origin of the Installation (Impulse Withstand Category III)	Appliances (Impulse Withstand Category III)	Specially Protected Equipment (Impulse Withstand Category I)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
i)		120-240	4	2.5	1.5	0.8
ii)	230/400 277/480 (*see* Note 1)	—	6			1.5
iii)	400/690	—	8	6	4	2.5
iv)	1 000	—	Values subject to system engineers			

NOTES

1 For voltages to earth higher than 300 V, the impulse withstand voltage corresponding to the next higher voltage in col (2) applies.

2 Category I is addressed to particular equipment engineering.

3 Category II is addressed to equipment for connection to the mains.

4 Category III is addressed to installation material and some special products.

5 Category IV is addressed to supply authorities and system engineers.

from its circuit, a suitable disconnecting device may be required to be used in conjunction with a SPD which has a short-circuit failure mode.

6 INSTALLATION OF SURGE PROTECTION DEVICES

When installing surge protective devices, several elements must be considered, such as the earthing system, positioning with respect to residual current devices, the choice of disconnection circuit-breakers and cascading.

6.1 Protection Devices According to the Earthing System

a) *Common mode overvoltage*: Basic protection involves the installation of a common mode surge arrester between phase and PE or phase and PEN, whatever type of earthing system is used.

b) *Differential mode overvoltage*: In the IT and TN-S earthing systems, earthing the neutral leads to dissymmetry due to earthing impedances, which causes differential mode voltages to appear, whereas the overvoltage induced by a lightning strike is a common mode voltage.

6.2 Internal Architecture of Surge Arresters

a) 2P, 3P, 4P surge arresters (*see* Fig. 6):

They provide protection against common-mode overvoltages only and are appropriate for TN-C and IT earthing systems.

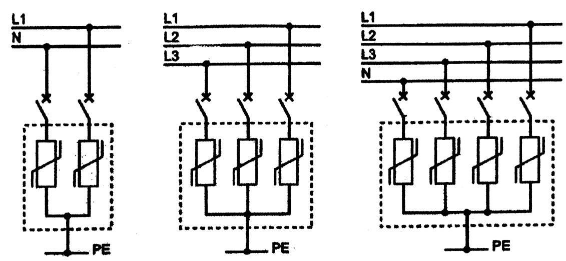


FIG. 6 2P, 3P, 4P SURGE ARRESTERS

b) 1P+N, 3P+N surge arresters (*see* Fig. 7):

They provide protection against common-mode and differential-mode overvoltages and are appropriate for TT, TN-S, and IT earthing systems.

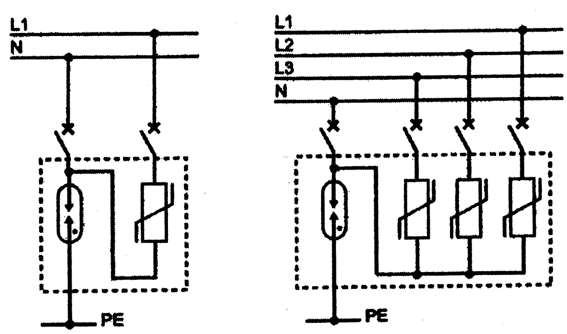


FIG. 7 1P+N, 3P+N SURGE ARRESTERS

c) Single-pole (1P) surge arresters (*see* Fig. 8).

They are used to satisfy the demand of different assemblies (according to the manufacturer's instructions) by supplying only one product.

However, special dimensioning will be required for N-PE protection.

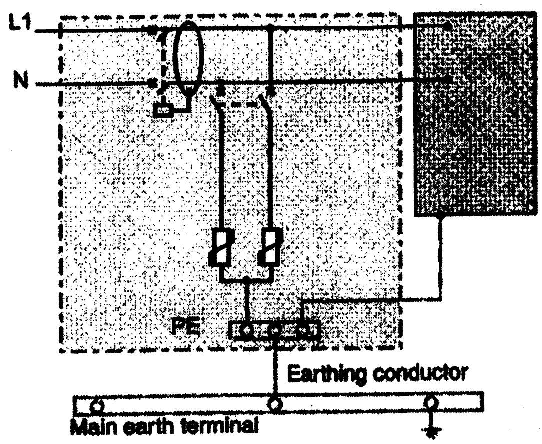


FIG. 8 CONNECTION EXAMPLE

6.3 Installation of Protection Devices

The overvoltage protection study of an installation may show that the site is highly exposed and that the equipment to be protected is sensitive. The surge arrester must be able to discharge high currents and have a low level of protection. This dual constraint cannot always be handled by a single surge arrester. A second one will therefore be required (*see* Fig. 9).

The first device, P_1 (incoming protection) will be placed at the incoming end of the installation.

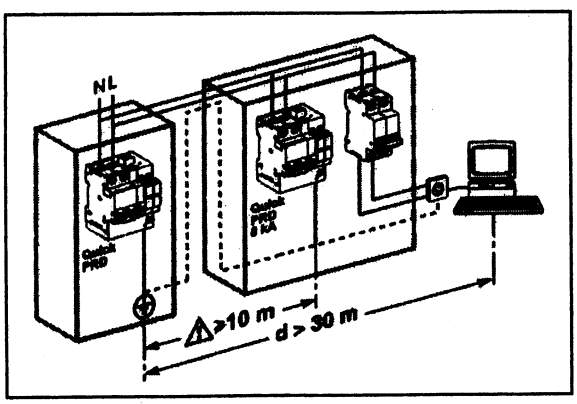


FIG. 9 CASCADING OF SURGE ARRESTERS

Its purpose will be to discharge the maximum amount of energy to earth with a level of protection = 2 000 V that can be withstood by the electrotechnical equipment (contactors, motors, etc).

The second device (fine protection) will be placed in a distribution enclosure, as close as possible to the sensitive loads. It will have a low discharge capacity and a low level of protection that will limit overvoltages significantly and therefore protect sensitive loads (= 1500 V). Cascading protection requires a minimum distance of at least 10 m between the two protection devices. This is valid whatever the field of application, domestic, tertiary or industrial.

In Fig. 10, the fine-protection device P_2 is installed in parallel with the incoming protection device P_1.

If the distance L is too small, at the incoming overvoltage, P_2 with a protection level of U_2 = 1 500 V will operate before P_1 with a level of U_1 = 2 000 V. P_2 will not withstand an excessively high current. The protection devices must therefore be coordinated to ensure that P_1 activates before P_2. This depends on length L of the cable, that is the value of the self-inductance between the two protection devices. This self-inductance will block the current flow to P_2 and cause a certain delay, which will force P_1 to operate before P_2. A metre of cable gives a self inductance of approximately 11 JH.

The rule $\Delta U = L di/dt$ causes a voltage drop of approximately 100 V/m/kA, 8/20 µs wave.

For L = 10 m, we get $UL_1 = UL_2$ = 1 000 V.

To ensure that P_2 operates with a level of protection of 1 500 V requires

$U_1 = UL_1 + UL_2 + U_2$ = 1 000 V + 1 000 V + 1 500 V = 3 500 V.

Consequently, P_1 operates before 2 000 V and therefore protects P_2.

NOTE — If the distance between the surge arrester at the incoming end of the installation and the equipment to be protected exceeds 30 m, cascading the surge arresters is recommended, as the residual voltage of the surge arrester may rise to double the residual voltage at the terminals of the incoming surge arrester; as in the above example, the fine protection surge arrester must be placed as close as possible to the loads to be protected. It should be ensured that the connection between the surge arrester and its disconnection circuit breaker does not exceed 50 cm.

6.4 Surge Protection Device Installation Conditions

a) *According to supply system configuration*: The maximum continuous operating voltage U_c of SPDs shall be equal to or higher than shown in Table 3.

b) *At the origin of the installation*: If the surge arrester is installed at the source of an electrical installation supplied by the utility distribution network, its rated discharge current may be lower than 5 kA.

   If a surge arrester is installed downstream from an earth leakage protection device, an RCD of the S type, with immunity to impulse currents of less than 3 kA (8/20 µs), must be used.

c) *Protection against overcurrent at 50 Hz and consequences of a SPD failure*: Protection

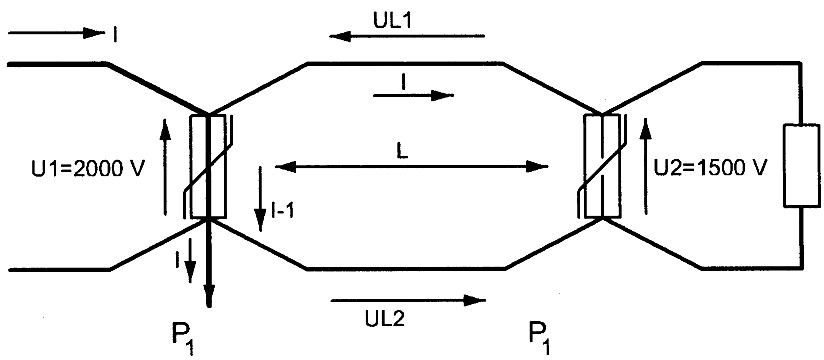


FIG. 10 COORDINATION OF SURGE ARRESTERS

against SPDs short-circuits is provided by the overcurrent protective devices which are to be selected according to the maximum recommended rating for the overcurrent protective device given in the manufacturer's SPD instructions.

Table 3 Minimum Required U_c of the SPD Dependent on Supply System Configuration
(*Clause* 6.4)

Sl No.	SPDs Connected Between	System Configuration of Distribution Network				
		TT	TN-C	TN-S	IT with Distributed Neutral	IT without Distributed Neutral
(1)	(2)	(3)	(4)	(5)	(6)	(7)
i)	Line conductor and neutral conductor	1.1 Uo	Not applicable	1.1 Uo	1.1 Uo	Not applicable
ii)	Each line conductor and PE conductor	1.1 Uo	Not applicable	1.1 Uo	3 Uo (*see* Note 3)	Line-to-the voltage (*see* Note 3)
iii)	Neutral conductor and PE conductor	Uo (*see* Note 3)	Not applicable	Uo (1)	Uo (*see* Note 3)	Not applicable
iv)	Each line conductor and PEN conductor	Not applicable	1.1 Uo	NA (*see* Note 3)	NA	Not applicable

NOTES

1 Uo is the line-to-neutral voltage of the low-voltage system.

2 These values are related to worst case fault conditions, therefore the tolerance of 10 percent is not taken into account.

3 In extended IT systems, higher values of U_c may be necessary.

ANNEX A

(*Clause* 2)

LIST OF INDIAN STANDARDS RELEVENT TO PROTECTION AGAINST VOLTAGE SURGES

IS No.	*Title*
732 : 1989	Code of practice for electrical wiring installations
2309 : 1989	Code of practice for the protection of buildings and allied structures against lightning
11548 : 1986	Capacitors for surge protection for use in voltage system above 650 V and upto 33 kV
15086 (Part 1) : 2001	Surge arresters: Part 1 Non-linear resistor type gapped surge arresters for ac systems
15086 (Part 3) : 2003/IEC 60099-3 : 1990	Surge arresters: Part 3 Artificial pollution testing of surge arresters
15086 (Part 5) : 2001/IEC 60099-5 : 1996	Surge arresters: Part 5 Selection and application recommendations
QC 420100 : 1994 /IEC QC 420100 : 1991	Varistors for use in electronic equipment — Sectional specification for surge suppression varistors
QC 420101 : 1994 /IEC QC 420101 : 1991	Varistors for use in electronic equipment — Blank detail specification for silicon carbide surge suppression varistors assessment level E
QC 420102 : 1993 /IEC QC 420102 : 1991	Varistors for use in electronic equipment — Blank detail specification for zinc oxide surge suppression varistors — Assessment level E

ANNEX B

(*Clause* 4.2)

DIFFERENT PROPAGATION MODES OF VOLTAGE SURGE

B-1 COMMON MODE

Common mode voltage surges occur between the live parts and the earth: phase/earth or neutral/earth (*see* Fig. 11). They are especially dangerous for devices whose frame is earthed due to the risk of dielectric breakdown.

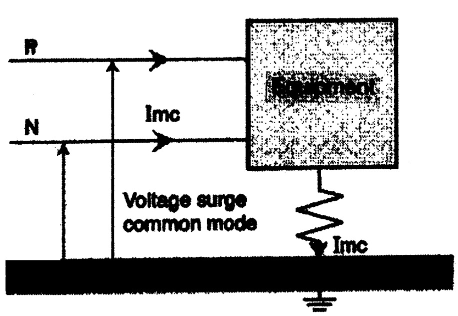


FIG. 11 COMMON MODE

B-2 DIFFERENTIAL MODE

Differential mode voltage surges circulate between live conductors: Phase to phase or phase to neutral (*see* Fig. 12). They are especially dangerous for electronic equipment, sensitive computer equipment, etc.

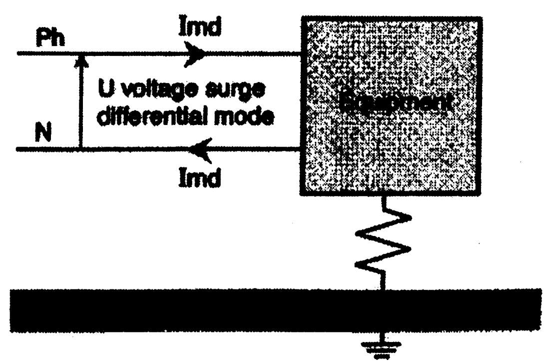


FIG. 12 DIFFERENTIAL MODE

SECTION 17 GUIDELINES FOR POWER-FACTOR IMPROVEMENT

0 FOREWORD

The various advantages of maintaining a high power factor of a system reflects on the national economy of a country. The available resources are utilized to its fullest possible extent. More useful power is available for transmission and utilization without any extra cost. Moreover, the life of individual apparatus is considerably increased and the energy losses reduced.

Guidance to the consumers of electrical energy who take supply of low and medium voltage for improvement of power factor at the installation in their premises is provided in this Section. The guidelines provided are basically intended for installation operating at voltages below 650 V. For higher voltage installations, additional or more specific rules apply.

Assistance has been derived from IS 7752 (Part 1) : 1975 'Guide for the improvement of power factor in consumer installations: Part 1 Low and medium supply voltages'.

1 SCOPE

This Part 1/Section 17 of the Code covers causes for low power factor and guidelines for use of capacitors to improve the same in consumer installations.

1.2 Specific guidelines, if any, for individual installation on improvement of power factor are covered in the respective sections of the Code.

2 REFERENCE

The following Indian Standard on power factor improvement may be referred for details:

IS 7752 (Part 1) : 1975	Guide for the improvement of power factor in consumer installations: Part 1 Low and medium supply voltages

3 GENERAL

3.1 Conditions of supply of electricity boards or licensees stipulate the lower limit of power factor which is generally 0.85 and consumer is obliged to improve and maintain the power factor of his installation to conform to these conditions.

3.1.1 When the tariffs of Electricity Boards and the licensees are based on kVA demand or kW demand with suitable penalty rebate for low high power factor, improvement in the power factor would effect savings in the energy bills.

3.2 Power factor is dependent largely on consumers' apparatus and partly on system components such as transformers, cables, transmission lines, etc. System components have fixed parameters of inductance, capacitance and resistance. The choice of these components to bring up the power factor depends on economics.

3.3 In case of ac supply, the total current taken by almost every item of electrical equipment, except that of incandescent lighting and most forms of resistance heating, is made up of two parts, namely:

a) in-phase component of the current (active or useful current) which is utilized for doing work or producing heat; and
b) quadrature component of the current (also called 'idle' or 'reactive' current) and used for creating magnetic field in the machinery or apparatus. This component is not convertible into useful output.

4 POWER FACTOR

4.1 The majority of ac electrical machines and equipment draw from the supply an apparent power (kVA) which exceeds the required useful power (kW). This is due to the reactive power (kVAR) necessary for alternating magnetic field. The ratio of useful power (kW) to apparent power (kVA) is termed the power factor of the load. The reactive power is indispensable and constitutes an additional demand on the system.

4.2 The power factor indicates the portion of the current in the system performing useful work. A power factor of unity (100 percent) denotes 100 percent utilization of the total current for useful work whereas a power factor of 0.70 shows that only 70 percent of the current is performing useful work.

4.3 Principle Causes of Lower Power Factor

4.3.1 The following electrical equipment and apparatus have a lower factor:

a) Induction motors of all types particularly when they are underloaded,
b) Power transformers and voltage regulators,
c) Arc welders,
d) Induction furnaces and heating coils,
e) Choke coils and magnetic systems, and
f) Fluorescent and discharge lamps, neon signs, etc.

4.3.2 The principal cause of a low power factor is due to the reactive power flowing in the circuit. The reactive power depends on the inductance and capacitance of the apparatus.

4.4 Effect of Power Factor to Consumer

4.4.1 The disadvantages of low power factor are as follows:

a) Overloading of cables and transformer,
b) Decreased line voltage at point of application,
c) Inefficient operation of plant, and
d) Penal power rates.

4.4.2 The advantages of high power factor are as follows:

a) Reduction in the current;
b) Reduction in power cost;
c) Reduced losses in the transformers and cables,
d) Lower loading of transformers, switchgears, cables, etc;
e) Increased capability of the 'power system' (additional load can be met without additional equipment);
f) Improvement in voltage conditions and apparatus performance; and
g) Reduction in voltage dips caused by welding and similar equipment.

4.5 Economics of Power Factor Improvement

4.5.1 Static capacitors, also called static condensers, when installed at or near the point of consumption, provide necessary capacitive reactive power, relieve distribution system before the point of its installation from carrying the inductive reactive power to that extent.

4.5.2 The use of the static capacitors is an economical way of improving power factor on account of their comparatively low cost, ease of installation loss maintenance, low losses and the advantage of extension by addition of requisite units to meet the load growth. Installation of capacitors also improve the voltage regulation and reduces amperes loading and energy losses in the supply apparatus and lines.

4.5.3 When considering the economics connected with power factor correction, it is most important to remember that any power factor improving equipment will, in general, compensate for losses and lower the loadings on supply equipment, that is, cables, transformers, switchgear, generating plant, etc.

4.5.4 The minimum permissible power factor prescribed in the conditions of supply of Electricity Boards or Licensees and the reduction in charges offered in supply tariffs for further improvement of power factor shall, along with other considerations such as reduction of losses, etc, determine the kVAR capacity of the capacitors to be installed.

4.5.5 In case of two port tariff with kVA demand charged, the value of economic improved power factor ($\cos \phi_2$) may be obtained as follows:

Let the tariff be Rs. *A* per kVA of maximum demand per annum plus Rs. *P* per kWh.

$\cos \phi_1$ is the initial power factor,

$\cos \phi_2$ is the improved power factor after installing the capacitors

The economic power factor $\cos \phi_2$ is obtained from the expression

$$\cos \phi = \sqrt{1 - \frac{B^2}{A^2}}$$

where

B = total cost per kVAR per year of capacitor installation inclusive of interest, depreciation and maintenance.

NOTE — The explanation for the derivation of the formula for economic power factor cos f_2 is given in Annex A of IS 7752 (Part 1).

5 USE OF CAPACITORS

5.1 In order to improve the power factor, the consumer shall install capacitors where the natural power factor of this installation is low.

5.2 The average values of the power factor for different types of 3 phase electrical installations as measured by one of major utilities in the country are given in respective Sections of the Code.

5.3 Capacitors for power factor improvement may be arranged as described in IS 7752 (Part 1). The successful operation of power factor improvement depends very largely on the positioning of the capacitor on the system. Ideal conditions are achieved when the highest power factor is maintained under all load conditions.

5.4 Individual Compensation

Wherever possible the capacitor should be connected directly across the terminals of the low power factor appliance or equipment. This ensures the control to be automatic through the same switching devices of the apparatus of appliance.

5.5 Group Compensation

In industries where a large number of small motors or other appliances and machines are installed and whose operation is periodical it is economical to dispense with individual installation of capacitors. A bank of capacitors may be installed to connect them to the distribution centre of main bus-bars of the group of machines.

5.6 Central Compensation

Capacitors may also be installed at a central point, that is, at the incoming supply or service position. In order to overcome problems of drawing leading currents on light loads, these capacitors may be operated manually or automatically as required. The automatic control is preferred as it eliminates human errors. Automatic operation may be arranged by means of suitable relays in which a contractor controls the capacitors bank and maintains the correct amount of kVAR in the circuit.

5.7 Combined Compensation

Capacitors may be connected directly across the terminals of higher capacity inductive appliances or equipments, in addition to the capacitors with Automatic Power Factor Correction Relay for Central Compensation connected at the incoming supply or service position

5.8 The methods of connecting power factor capacitors to supply line and motors are given in Fig. 1 and Fig. 2.

6 SELECTION AND INSTALLATION OF CAPACITORS

6.1 Capacitor current shall not exceed magnetization current of the motor when directly connected across motor terminals.

6.2 Capacitors shall not be connected directly across motor terminals if solid state starters/soft starters are used.

6.3 Capacitors shall not be connected directly to motor terminals if variable speed drive is adopted.

6.4 Capacitors connected to same bus-bars discharge. instantaneously to uncharged capacitors, at the time of switching on, with high in-rush current. This shall be taken care of while providing central compensation with automatic power factor correction relay.

6.5 Harmonics may reduce life of capacitors.

6.6 Switching/controlling devices for capacitors shall have required capacitor switching duty.

6.7 Chances of resonating shall be considered.

6.8 Energy loss/Power consumption of capacitors shall be taken care of.

6.9 Capacitor banks shall be properly ventilated.

6.10 Chances of over voltage shall be looked into.

6.11 Resistors shall be provided across capacitor terminals for discharging.

7 POWER FACTOR IMPROVEMENT AND CAPACITOR RATING

For calculating the size of the capacitor for power factor improvement reference should be made to Table 5 of Part 1/Section 20 of the Code.

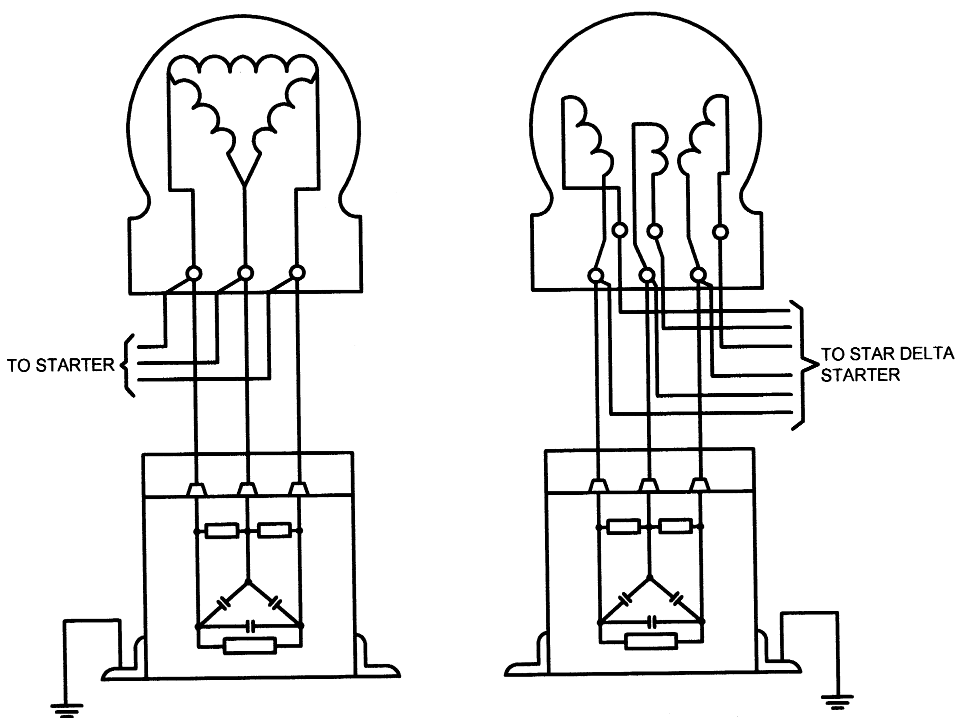


FIG. 1 METHODS OF CONNECTING CAPACITORS TO MOTORS FOR IMPROVEMENT OF POWER FACTOR

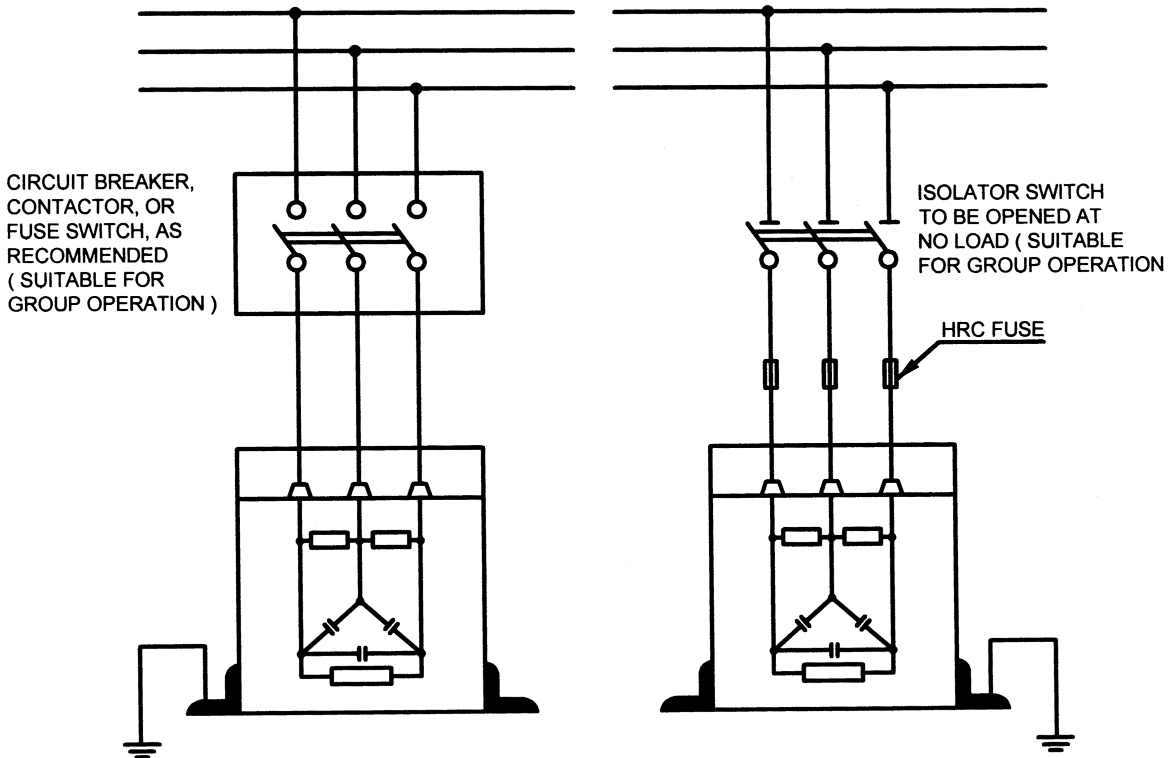


FIG. 2 METHODS OF CONNECTING CAPACITORS TO SUPPLY LINE FOR IMPROVEMENT OF POWER FACTOR

SECTION 18 ENERGY EFFICIENCY ASPECTS

0 FOREWORD

Efficient use of energy inputs acquires added significance since energy saved is energy generated. Economic growth is desirable for developing countries and energy is essential for economic growth. This means commensurate input of energy is required. However, due to the fact that our fossil fuel reserves are limited, energy conservation is essential. Electrical energy input is utilized in various industrial plants, agricultural sector, commercial buildings and establishments, in the form of mechanical motive power, heating, lighting, air conditioning and ventilation etc. The Indian Industrial Sector accounts for half of the total commercial energy used in the country. Energy conservation aims at eliminating the waste of energy and minimization of losses. In this context proper selection of electrical equipment assumes greater importance. The *Energy Conservation Act*, 2001, also emphasises the need of energy conservation.

This Section provides guidance to the consumers of electrical energy, with regard to the selection of equipment from energy conservation point of view and on energy audits.

1 SCOPE

This Part 1/Section 18 of the Code covers the aspects to be considered for selection of equipment from energy conservation point of view and guidance on energy audit.

2 REFERENCE

The following Indian Standard has been referred to in this Section:

IS No	*Title*
IS 12615 : 2004	Energy efficient induction motors — Three phase squirrel cage

3 GENERAL

Energy conservation aims at eliminating wastage of energy and minimizing losses. The major factors to be looked into in this regard include system design, selection of equipment, operation and maintenance practices, capacity utilization factors etc. Improving efficiency typically costs less than the energy tariffs.

In order to standardize and benchmark the level of efficiency of various electrical and other energy consuming equipment, the Bureau of Energy Efficiency was instituted in March 2002. The standards and labelling/rating standards for various equipment proposed by Bureau of Energy Efficiency shall be followed while selecting equipment. Provisions of the *Energy Conservation Act*, 2001 may also be taken into account.

4 EQUIPMENT SELECTION

The main criterion for equipment selection, from energy conservation point of view, is that the power loss has to be minimum. In other words the operating efficiency should be high. Proper sizing of equipment is essential to ensure optimum utilization of energy. It is also necessary to avoid over rating or under rating the equipment. It should be ensured that operating power factor of equipment is high.

Most commonly encountered equipments in electrical systems are mentioned below:

4.1 Motor

Motors should preferably be energy efficient motors, conforming to IS 12615. Preferably, motors shall conform to efficiency class 'eff 1' as per IS 12615 as these are more efficient than motors with efficiency class 'eff 2'. Motors with higher operating power factor shall be considered during selection as this results in lower current and consequently lower losses. Use of variable speed drives will bring substantial energy saving wherever different flow conditions/speeds are encountered in the process industry. Use of variable speed drives is a highly efficient means of achieving flow control etc. as compared to throttling of valves, dampers etc. or the use of stepped pulleys.

4.2 Transformers

While procuring transformers, normal loading shall be indicated so as to optimize transformer efficiency to be maximum at projected load for minimizing losses under normal operating conditions. Losses should be accounted while selecting equipment, by way of loss capitalization or specifying the minimum acceptable value for maximum efficiency.

4.3 Cables Equipment

Optimizing cable route/length can best reduce cable losses. Though the losses can also be reduced by over sizing the conductors, this is not recommended due to the practical problems encountered with termination of over sized cables.

4.4 Lighting

An efficient lighting system can substantially reduce the energy consumption. The selection criteria for lighting shall include among other factors, luminaries with light sources of higher luminous efficiency such as tubular fluorescent as well as compact fluorescent lighting. Street lighting and other tasks where colour rendering properties of light are not of significance can be more efficiently achieved by the use of sodium vapour lamps compared to mercury vapour lamps. The use of incandescent lamps should be avoided except for DC lighting in critical areas such as escape routes. Newer technologies such as LED based lighting systems, building automation systems for optimizing power consumption through natural lighting, reduction in HVAC load demand through the use of solar films, lights controlled by sensors which get activated by movement/human presence etc. which can significantly optimize the use of electrical energy, also need to be promoted. The use of solar energy for lighting, heating etc. also needs to be maximized.

Low loss electronic ballasts can be employed, where feasible, after taking care that the harmonic distortion is within permissible limits.

5 ENERGY AUDIT

5.1 'Energy Audit' means the verification, monitoring and analysis of the use of energy including submission of a technical report containing recommendations for improving energy efficiency with cost benefit analysis and an action plan to reduce energy consumption.

5.2 The function of an energy audit broadly includes:

— Review of level of energy consumption.
— Creating a data base.
— Identifying energy conservation potential.
— Preparation of norms/guidelines for implementation of energy conservation measures.
— Recommending the use of energy efficient appliances.

5.3 *Energy Conservation Act*, 2001 has been enacted and the regulations issued under the said act shall be complied with, with reference to Energy Audit. Accordingly, designated consumers as notified under *Energy Conservation Act*, 2001, shall get the energy audit carried out through an accredited energy auditor/firms and implement techno-economic viable recommendations/measures. Every designated consumer shall appoint or designate a certified energy manager, whose responsibility shall be to assist the designated consumer in complying with the energy consumption norms and standards and other mandatory provisions.

5.4 Energy Conservation Building Code formulated by the Bureau of Energy Efficiency and prescribed by the Central Government shall be implemented for new buildings having connected load of 500 kW and above or contract demand of 600 kVA and above, once the same or modified version has been notified by the respective State Governments. List of energy intensive industries and other establishments specified as designated consumers is given in the *Energy Conservation Act*, 2001.

SECTION 19 SAFETY IN ELECTRICAL WORK

0 FOREWORD

Safety procedures and practices are essential in electrical work. Basic approaches to electrical work from the point of view of ensuring safety which include inbuilt safety in procedures such as permit-to-work system, safety instructions and safety practices are covered in this Section.

It is essential that safety should be preached and practiced at all times in the installation, operation and maintenance work. The real benefit to be derived from the guidelines covered in this Section will be realized only when the safety instructions it contains are regarded as normal routine duty and not as involving extra and laborious operations.

1 SCOPE

This Part 1/Section 19 of the Code covers guidelines on safety procedures and practices in electrical work.

2 REFERENCES

A list of Indian Standards on safety in electrical work are as follows:

IS No.	*Title*
2551 : 1982	Specification for danger notice plates
IS 5216 (Part 1) : 1982	Recommendations on safety procedures and practices in electrical work: Part 1 General
IS 5216 (Part 2) : 1982	Recommendations on safety procedures and practices in electrical work: Part 2 Life saving techniques
8923 : 1978	Warning symbol for dangerous voltages
SP 31 : 1986	Method of treatment of electric shock

3 PERMIT-TO-WORK SYSTEM

3.1 All work on major electrical installations shall be carried out under permit-to-work system which is now well established, unless standing instructions are issued by the competent authority to follow other procedures. In extenuating circumstance, such as for the purpose of saving life or time in the event of an emergency, it may become necessary to start the work without being able to obtain the necessary permit-to-work; in such cases, the action taken shall be reported to the person-in-charge as soon as possible. The permit-to-work certificate from the person-in-charge of operation to the person-in-charge of the men selected to carry out any particular work ensure that the portion of the installation where the work is to be carried out is rendered dead and safe for working. All work shall be carried out under the personal supervision of a competent person. If more than one department is working on the same apparatus, a permit-to-work should be issued to the person-in-charge of each department.

NOTE — The words 'permit-to-work' and 'permit' are synonymous for the purpose of this Section.

3.2 No work shall be commenced on live mains unless it is specifically intended to be so done by specially trained staff. In such cases all possible precautions shall be taken to ensure the safety of the staff engaged for such work, and also of others who may be directly or indirectly connected with the work. Such work shall only be carried out with proper equipment provided for the purpose and, after taking necessary precautions, by specially trained and experienced persons who are aware of the danger that exists when working on or near live mains or apparatus.

3.3 On completion of the work for which the permit-to-work is issued, the person-in-charge of the maintenance staff should return the permit duly discharged to the issuing authority.

3.4 In all cases, the issue and return of permits shall be recorded in a special register provided for that purpose.

3.5 The permits shall be issued not only to the staff of the supply undertakings, but also to the staff of other departments, contractors, engineers, etc, who might be required to work adjacent to live electrical mains or apparatus.

3.6 A model form of permit-to-work certificate is given in IS 5216 (Part 1).

NOTES

1 The permit is to be prepared in duplicate by the person-in-charge of operation on the basis of message, duly logged, from the person-in-charge of the work.

2 The original permit will be issued to the person-in-charge of work and the duplicate will be retained in the permit book. For further allocation of work by the permit receiving officer, tokens may be issued to the workers authorizing them individually to carry out the prescribed work.

3 On completion of the work, the original shall be returned to the issuing officer duly discharged for cancellation.

3.7 Permit books should be treated as important records. All sheets in the permit books and the books themselves should be serially numbered. No page should be detached or used for any other except bonafide work. If any sheet is detached, a dated and initiated statement shall then and there be recorded in the book by the person responsible for it.

3.8 Permit books shall be kept only by the person-in-charge of operation who shall maintain a record of the receipts and issues made by him.

4 SAFETY INSTRUCTIONS

4.1 Safety Instructions for Working on Mains and Apparatus Up to and Including 650 V

4.1.1 *Work on Dead Low and Medium Voltage Mains and Apparatus*

Unless a person is authorized to work on live mains and apparatus all mains and apparatus to be worked upon shall be isolated from all sources of supply before starting the work, proved dead, earthed and short-circuited. For earthing and short-circuiting, only recognized methods should be used. Measures shall be taken against, the inadvertent energizing of the mains and apparatus.

4.1.2 *Work on Live Mains and Apparatus*

Only competent, experienced and authorized persons shall work on live mains and apparatus, and such persons should take all safety measures as may be required.

Warning boards shall be attached on or adjacent to the live apparatus and at the limits of the zone in which work may be carried out.

Immediately before starting work, rubber gauntlets, if used, shall be thoroughly examined to see whether they are in sound condition. Under no circumstances shall be person work with unsound gauntlets, mass, stools, platforms or other accessories and safety devices.

No live part should be within unsafe distance of a person working on live low and medium voltage mains so that he does not come in contact with it unless he is properly protected.

4.1.3 *Testing of Mains and Apparatus*

No person shall apply test voltage to any mains unless he has received a permit-to-work and has warned all persons working on the mains of the proposed application of test voltage. If any part which will thus become alive is exposed, the person-in-charge of the test shall take due precautions to ensure that the exposed live portion does not constitute danger to any person. It should also be ensured before the application of test voltage, that no other permit-to-work has been issued for working on this mains.

4.1.4 *Connecting Dead Mains to Live Mains*

When dead mains are connected to live mains, all connections to the live parts shall be made last, and in all cases the phase sequence should be checked to ensure that only like phases are connected together. Before inserting fuses or links in a feeder or distribution pillar controlling the cable on which a fault has been cleared, each phase shall first be connected through a test switch fuse.

4.2 Safety Instructions for Working on Mains and Apparatus at Voltages Above 650 V

4.2.1 *General*

All mains and apparatus shall be regarded as live and a source of danger and treated accordingly, unless it is positively known to be dead and earthed.

a) No person shall work on, test or earth mains or apparatus unless covered by a permit-to-work and after proving the mains dead except for the purpose of connecting the testing apparatus, etc. which is specially designed for connecting to the live parts.
b) The operations of proving dead, earthing and short-circuiting of any mains shall be carried out only by an authorized person under the instructions of the person-in-charge of maintenance;
c) While working on mains, the following precautions shall be taken:
   1) No person, after receiving a permit-to-work, shall work on, or in any way interfere with, any mains or conduits or through containing a live mains except under the personal instructions and supervision, on the site of work, of competent person,
   2) When any live mains is to be earthed, the procedure prescribed in **4.2.4** shall be scrupulously followed, and
   3) The earths and short-circuits, specified on the permit-to-work shall not be removed or interfered with except by authority from the person-in-charge of the work.

4.2.2 *Minimum Working Distance*

No person shall work within the minimum working distance from the exposed live mains and apparatus. The minimum working distance depends upon the actual voltages. It does not apply to operations carried out on mains and apparatus which are so constructed as to permit sale operation within these distances. Exposed live equipment in the vicinity shall be cordoned off so that persons working on the released equipment in service. The cordoning off shall be done in such a way that it does not hinder the movement of the maintenance personnel. If necessary, a safety sergeant could be posted.

4.2.3 *Isolation of Mains*

Isolation of mains shall be effected by the following methods:

a) The electrical circuits shall be broken only by authorized persons by disconnecting switches, isolating links, unbolting connections or switches which are racked out. Where possible, the isolation should be visibly checked, and

b) Where the means of isolation are provided with a device to prevent their reclosure by unauthorized persons, such a device shall be used.

4.2.4 *Devices for Proving Mains and Apparatus Dead*

4.2.4.1 High voltage neon lamp contact indicators rods are often used for proving exposed mains and apparatus dead. Each rod is fitted with an indicating neon tube or other means which glows when the contact end of the rod comes in contact with exposed live parts. Each rod is clearly marked for the maximum voltage on which it may be safely used and shall not, under any circumstances, be used on higher voltages.

4.2.4.2 Contact indicator and phasing rods are provided for phasing and proving exposed mains and apparatus dead. A set consists of two rods connected in series by a length of insulated cables. Both rods are fitted with contact tips and indicating tubes. When the contact tip of one rod is applied to exposed live parts and that of the other earth or other exposed live parts provided there is sufficient voltage difference between the two, the indicating tubes should glow. Each set of rods is normally marked for the maximum voltage on which it may be used and shall not, under any circumstances, be used on higher voltages.

4.2.4.3 *Use of contact indicator and phasing rods*

While using the high voltage contact indicator and phasing rods for proving the mains or apparatus dead, following precautions should be taken:

a) Ensure that the rod is clean and dry,

b) Check the rod by applying it to known live parts of the correct voltage, the indicating tube shall glow,

c) Apply the rod to each phase required to be proved dead, the indicating tube shall not glow. Be very careful to be in a position to see the glow, if any, appearing in the indicating tube, and

d) Again check the rod by applying it to live parts as in **4.2.4.3** (b). Again the indicating tubes shall glow.

NOTES

1 All the above operations shall be carried out at the same place and at the same time, if no live parts are available on the site, rods up to 11 kV may be tested by applying them to the top of the spark plug in a running motor car engine. If the rod is in order the indicating tube will glow each time the plug sparks. Therefore, the glow will to intermittent, but the indicating tube should glow on this test or the rod is useless as a means of proving the mains or apparatus dead.

2 The rod should be tested both before and after the use.

4.2.4.4 *Testing and marking of devices*

It shall be ensured that all devices for proving high voltage mains and apparatus dead are marked clearly with the maximum voltage for which they are intended and should be tested periodically.

4.2.4.5 *Identification of cables to be worked upon*

A cable shall be identified as that having been proved dead prior to cutting or carrying out any operation which may involve work on or movement of the cable. A non-contact indicating rod, induction testing set or spiking device may be used for proving the cable dead.

4.2.4.6 *Earthing and short-circuiting mains*

a) High voltage mains shall not be worked upon unless they are discharged to earth after making them dead and are earthed and short-circuited with earthing and short-circuiting equipment is adequate to carry possible short-circuit currents and specially meant for the purpose. All earthing switches wherever installed should be locked up.

b) If a cable is required to be cut, steel wedge shall be carefully driven through it at the point where it is to be cut or preferably by means of a spiking gun of approved design.

c) After testing the cable with dc voltage, the cable shall be discharged through a 2 megohm resistance and not directly, owing to dielectric absorption which is particularly prominent in the dc voltage testing of high voltage cables. The cable shall be discharged for a sufficiently long period to prevent rebuilding up of voltage.

d) The earthing device when used shall be first connected to an effective earth. The other end of the device shall then be connected to the conductors to be earthed.

e) Except for the purpose of testing, phasing, etc, the earthing and short-circuiting devices shall remain connected for the duration of the work.

4.2.4.7 *Removing the earth connections*

On completion of work, removal of the earthing and short-circuiting devices shall be carried out in the reverse order to that adopted for placing them (*see* **4.2.4.6**), that is, the end of the earthing device attached to the conductors of the earthed mains or apparatus shall be removed first and the other and connected to earths shall be removed last. The conductor shall not be touched after the earthing device has been removed from it.

4.2.4.8 *Safety precautions for earthing*

The precautions mentioned below should be adopted to the extent applicable and possible:

a) Examine earthing devices periodically and always prior to their use,
b) Use only earthing switches or any other special apparatus where provided for earthing,
c) Verify that the circuit is dead by means of discharging rod or potential indicator. The indicator itself should first be tested on a live circuit before and after the verification,
d) Earthing should be done in such a manner that the persons doing the job are protected by earth connections on both sides of their working zone, and
e) All the three phases should be effectively earthed and short-circuited though work may be proceeding on one phase only.

4.2.4.9 *Working on mains where visible isolation cannot be carried out*

Where the electrical circuit cannot be broken visibly as set out in **4.2.3** the circuit may be broken by two circuit opening devices, one on each side of the work zone, where duplicate feed is available and by one circuit opening device where duplicate feed is not available provided the following conditions are fulfilled:

a) The position of the contacts of the circuit opening device(s) — 'open' or 'closed' — is clearly indicated by the position of the operating handle or by signal lights or by other means.
b) The circuit opening device(s) can be locked mechanically in the open position.
c) The mains and apparatus to be worked on are adequately earthed and short-circuited between the circuit opening device and the position of the work.
d) In cases where duplicate feed is available, both the circuit opening devices are in series between the mains and apparatus to be worked on and any source of supply.
e) In cases where duplicate feed is not available, the circuit opening device is between the mains to be worked on and any source of supply.

The circuit opening devices mentioned above shall be locked in the open position before the work on the mains and apparatus is commenced. The locking devices shall be removed only by a competent person and not until the work has been completed, any short-circuiting and earthing removed and the permit-to-work form duly returned and cancelled.

4.2.4.10 *Work on mains with two or more sections*

When the mains to be worked upon are to be divided into two or more sections, the provisions of **4.2.3**, **4.2.4.6** and **4.2.4.9** shall be observed with regard to each section.

5 SAFETY PRACTICES

5.1 In all electrical works, it is very necessary that certain elementary safety practices are observed. It has been found that quite a large number of accidents occur due to the neglect of these practices. The details of such practices are given in Annex C of IS 5216 (Part 1).

5.2 Equipment, Devices and Appliances

General guidelines on equipment, devices and appliances are given in IS 5216 (Part 1).

6 SAFETY POSTERS

6.1 The owner of every medium, high and extra high voltage installation is required to fix permanently, in a conspicuous position a danger notice in Hindi or English and the local language of the district on every motor, generator, transformer, all supports or high and extra high voltage etc. The danger notice plate shall conform to IS 2551.

6.2 It is also recognized as good practice to indicate by means of the symbol recommended in IS 8923 on electrical equipment where the hazards arising out of dangerous voltage exist.

7 ACCIDENTS AND TREATMENT FOR ELECTRIC SHOCK

See SP 31 and IS 5216 (Part 2).

SECTION 20 TABLES

0 FOREWORD

In electrical engineering work, frequent need arises to make reference to certain data, which, when made available in the form of ready reference tables facilitates the work. Those tables which basically provide fundamental data not necessarily required for the understanding of the Code but are required to be referred to in designing the installation are given in this Section.

1 SCOPE

This Part 1/Section 20 gives frequently referrred tables in electrical engineering work.

2 REFERENCES

The following Indian Standards may be referred for further details:

IS No.	*Title*
3961	Recommended current ratings for cables:
(Part 1) : 1967	Paper insulated lead sheathed cables
(Part 2) : 1967	PVC insulated and PVC sheathed heavy duty cables
(Part 3) : 1968	Rubber insulated cables
(Part 4) : 1968	Polyethylene insulated cables
IS 11955 : 1987	Preferred current ratings

Table 1 Diameter and Maximum Allowable Resistance of Fuse-Wire, Tinned Copper

Sl No.	Rated Current of Fuse-Wire	Nominal Diameter	Tolerance	Permissible Resistance at 20ºC	
				Max	*Min*
	A	mm	mm	Ω/m	Ω/m
(1)	(2)	(3)	(4)	(5)	(6)
i)	6	0.20	± 0.003	0.564 4	0.525 0
ii)	10	0.35	± 0.004	0.183 4	0.173 0
iii)	16	0.50	± 0.005	0.089 8	0.084 8
iv)	20	0.63	± 0.006	0.056 6	0.053 5
v)	25	0.75	± 0.008	0.040 0	0.037 6
vi)	32	0.85	± 0.009	0.031 1	0.029 3
vii)	40	1.25	± 0.011	0.014 3	0.013 6
viii)	63	1.50	± 0.015	0.009 9	0.009 4
ix)	80	1.80	± 0.018	0.006 9	0.006 5
x)	100	2.00	± 0.020	0.005 6	0.005 3

Table 2 Size of Wood Casing and Capping, and Number of Cables that may be Drawn in One Groove of the Casing

Sl No.	**Width of Casing of Capping,** mm	38	44	51	64	76	89	102
i)	No. of grooves	2	2	2	2	2	2	2
ii)	Width of grooves, mm	6	6	9	13	16	16	19
iii)	Width of dividing fillet, mm	12	12	13	18	24	35	38
iv)	Thickness of outer wall, mm	7	10	10	10	10	11	13
v)	Thickness of casing, mm	16	16	19	19	25	32	32
vi)	Thickness of capping, mm	6	6	10	10	10	13	13
vii)	Thickness of the back under the groove, mm	6	6	6	10	10	10	13
viii)	Length, m	2.5 to 3.0						

Table 2 — (*Concluded*)

Size of Cable		Number of Cables that may be Drawn in One Groove						
Nominal Cross-Sectional Area, mm^2	Number and Diameter (in mm) of Wires							
1.0	1/1.12[1]	2	2	3	3	9	12	12
1.5	1/1.40	1	1	2	2	8	12	12
2.5	1/1.80	1	1	2	2	5	10	10
	3/1.60[1]							
4	1/2.24	—	—	2	2	5	8	9
	7/1.85[1]							
6	1/2.80	—	—	1	1	4	6	6
	7/1.06							
10	1/3.55[2]	—	—	1	1	3	5	5
	7/1.40							
16	7/1.70	—	—	—	—	1	2	2
25	7/2.24	—	—	—	—	1	1	1
35	7/2.50	—	—	—	—	1	1	1
50	7/3.00[2]	—	—	—	—	1	1	1

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

Table 3 Maximum Permissible Number of 1.1 kV Grade Cables that can be Drawn into Rigid Steel Conduits

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)
1.0	1/1.12[1]	5	4	6	5	13	10	20	14	—	—	—	—	—	—
1.5	1/1.40	4	3	7	5	12	10	20	14	—	—	—	—	—	—
2.5	1/1.80	3	2	0	5	10	8	18	12	—	—	—	—	—	—
	3/1.06[1]														
4	1/2.24	3	2	4	3	7	0	12	10	—	—	—	—	—	—
	7/0.85[1]														
6	11/2.80	2	—	3	2	6	5	10	8	—	—	—	—	—	—
	7/0.6[1]														
10	11/3.55[2]	—	—	2	—	5	4	8	7	—	—	—	—	—	—
	7/1.40[1]	—	—	2	—	4	3	6	5	8	6	—	—	—	—
16	7/1.70	—	—	—	—	2	—	4	3	7	6	—	—	—	—
25	7/2.24	—	—	—	—	—	—	3	2	5	4	8	6	9	7
35	7/2.50	—	—	—	—	—	—	2	—	4	3	7	5	8	6
60	19/1.80	—	—	—	—	—	—	—	—	2	—	5	4	9	5
	7/3.007[2]														

NOTE — The table shows the maximum capacity of conduits of the simultaneous drawing of cables. the table applies to 1.1 kV grade 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 15º. The columns headed B apply to runs of conduit which deflect from the straight by an angle of more than 15º.

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

Table 4 Maximum Permissible Number of 1.1 kV Grade Single-Core Cables that may be Drawn into Rigid Non-metallic Conduits

Size of Cable		Size of Conduit, mm					
Nominal Cross-Sectional Area mm^2	Number and Diameter of Wires, mm	16	20	25	32	40	50
		Number of Cables, *Max*					
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1.0	1/1.12[1)]	5	7	13	20	—	—
1.5	1/1.40	4	6	10	14	—	—
2.5	1/1.80	3	5	10	14	—	—
	3/1.06[1)]						
4	1/2.24	2	3	6	10	14	—
	7/0.85[1)]						
6	1/2.80	—	2	5	9	11	—
	7/1.40[1)]						
10	1/3.55[2)]	—	—	4	7	9	—
	7/1.40[1)]						
16	7/1.70	—	—	2	4	5	12
25	7/2.24	—	—	—	2	2	6
35	7/2.50	—	—	—	—	2	5
50	7/3.00[2)]	—	—	—	—	2	5
	19/1.80						

1) For copper conductors only.

2) For aluminium conductors only.

Table 5 Capacitor Sizes for Power Factor Improvement

Existing Power Factor	Improved Power Factor												
	0.80	0.85	0.90	0.91	0.92	0.93	0.94	0.95	0.96	0.97	0.98	0.99	1.00
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
	Multiplying Factors												
0.40	1.537	1.668	1.805	1.832	1.861	1.895	1.924	1.959	1.998	2.037	2.085	2.146	2.288
0.41	1.474	1.605	1.742	1.769	1.798	1.831	1.860	1.896	1.935	1.973	2.021	2.082	2.225
0.42	1.413	1.544	1.681	1.709	1.738	1.771	1.800	1.836	1.874	1.913	1.961	2.022	2.164
0.43	1.356	1.487	1.624	1.651	1.680	1.713	1.742	1.778	1.816	1.855	1.903	1.964	2.107
0.44	1.290	1.421	1.558	1.585	1.614	1.647	1.677	1.712	1.751	1.790	1.837	1.899	2.041
0.45	1.230	1.360	1.501	1.532	1.561	1.592	1.626	1.659	1.695	1.737	1.784	1.846	1.988
0.46	1.179	1.309	1.446	1.473	1.502	1.533	1.567	1.600	1.636	1.677	1.725	1.786	1.929
0.47	1.130	1.260	1.397	1.425	1.454	1.485	1.519	1.552	1.588	1.629	1.677	1.758	1.881
0.48	1.076	1.206	1.343	1.370	1.400	1.430	1.464	1.497	1.534	1.575	1.623	1.684	1.826
0.49	1.030	1.160	1.297	1.326	1.355	1.386	1.420	1.453	1.489	1.530	1.578	1.639	1.782
0.50	0.982	1.112	1.248	.276	1.303	1.337	1.369	1.403	1.441	1.481	1.529	1.590	1.732
0.51	0.936	1.066	1.202	1.230	1.257	1.291	1.323	1.357	1.395	1.435	1.483	1.544	1.686
0.52	0.894	1.024	1.160	1.188	1.215	1.149	1.281	1.315	1.353	1.393	1.441	1.502	1.644
0.53	0.850	0.980	1.116	1.144	1.171	1.205	1.237	1.271	1.309	1.349	1.397	1.458	1.600
0.54	0.809	0.939	1.075	1.103	1.130	1.164	1.196	1.230	1.268	1.308	1.356	1.417	1.559
0.55	0.769	0.899	1.035	1.063	1.090	1.124	1.136	1.190	1.228	1.268	1.316	1.377	1.519
0.56	0.730	0.860	0.996	1.024	1.051	1.085	1.117	1.151	1.189	1.229	1.277	1.338	1.480
0.57	0.692	0.822	0.958	0.986	1.013	1.047	1.079	1.113	1.151	1.191	1.239	1.300	1.442
0.58	0.655	0.785	0.921	0.949	0.976	1.010	1.042	1.076	1.114	1.154	1.202	1.263	1.405
0.59	0.618	0.748	0.884	0.912	0.939	0.973	1.005	1.039	1.077	1.117	1.165	1.226	1.368
0.60	0.584	0.714	0.849	0.878	0.905	0.939	0.971	1.005	1.043	1.083	1.131	1.192	1.334
0.61	0.549	0.679	0.815	0.843	0.870	0.904	0.936	0.970	1.008	1.048	1.096	1.157	1.299

Table 5 — (*Concluded*)

Existing Power Factor	Improved Power Factor												
	0.80	0.85	0.90	0.91	0.92	0.93	0.94	0.95	0.96	0.97	0.98	0.99	1.00
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
0.62	0.515	0.645	0.781	0.809	0.836	0.870	0.902	0.936	0.974	1.014	1.062	1.123	1.265
0.63	0.483	0.613	0.749	0.777	0.804	0.838	0.870	0.902	0.942	0.982	1.030	1.091	1.233
0.64	0.450	0.580	0.716	0.744	0.771	0.805	0.837	0.871	0.909	0.949	0.997	1.058	1.200
0.65	0.419	0.549	0.685	0.713	0.740	0.774	0.806	0.840	0.878	0.918	0.966	1.027	1.169
0.66	0.388	0.518	0.654	0.682	0.709	0.743	0.775	0.809	0.847	0.887	0.935	0.996	1.138
0.67	0.358	0.488	0.624	0.652	0.679	0.713	0.745	0.779	0.817	0.857	0.905	0.966	1.108
0.68	0.329	0.459	0.595	0.623	0.650	0.684	0.716	0.750	0.788	0.828	0.876	0.937	1.079
0.69	0.299	0.429	0.565	0.593	0.620	0.654	0.686	0.720	0.758	0.798	0.840	0.907	1.049
0.70	0.270	0.400	0.536	0.564	0.591	0.625	0.657	0.691	0.729	0.769	0.811	0.878	1.020
0.71	0.242	0.372	0.508	0.536	0.563	0.597	0.629	0.663	0.701	0.741	0.785	0.850	0.992
0.72	0.213	0.343	0.479	0.507	0.534	0.568	0.600	0.634	0.672	0.712	0.754	0.821	0.963
0.73	0.186	0.316	0.452	0.480	0.507	0.541	0.573	0.607	0.648	0.685	0.727	0.794	0.936
0.74	0.159	0.289	0.425	0.453	0.480	0.514	0.546	0.580	0.618	0.658	0.700	0.740	0.909
0.75	0.132	0.262	0.398	0.426	0.453	0.487	0.519	0.553	0.591	0.631	0.673	0.713	0.882
0.76	0.105	0.235	0.371	0.399	0.426	0.460	0.492	0.526	0.564	0.604	0.652	0.687	0.855
0.77	0.079	0.209	0.345	0.373	0.400	0.434	0.466	0.500	0.538	0.578	0.620	0.661	0.829
0.78	0.053	0.183	0.319	0.347	0.374	0.408	0.440	0.474	0.512	0.552	0.592	0.634	0.803
0.79	0.026	0.156	0.292	0.320	0.347	0.381	0.413	0.447	0.485	0.525	0.567	0.608	0.776
0.80	—	0.130	0.266	2.294	0.321	0.355	0.387	0.421	0.459	0.499	0.541	0.582	0.750
0.81	—	0.104	0.240	0.268	0.295	0.329	0.361	0.395	0.433	0.473	0.515	0.556	0.724
0.82	—	0.078	0.214	0.242	0.269	0.303	0.335	0.369	0.407	0.447	0.489	0.530	0.698
0.83	—	0.052	0.188	0.216	0.243	0.277	0.309	0.343	0.381	0.421	0.463	0.504	0.672
0.84	—	0.026	0.162	0.190	0.217	0.251	0.283	0.317	0.355	0.395	0.417	0.450	0.620
0.85	—	—	0.136	0.164	0.191	0.225	0.257	0.291	0.329	0.369	0.417	0.450	0.620
0.86	—	—	0.109	0.140	0.167	0.198	0.230	0.264	0.301	0.343	0.390	0.424	0.593
0.87	—	—	0.083	0.114	0.141	0.172	0.204	0.238	0.275	0.317	0.364	0.395	0.567
0.88	—	—	0.054	0.085	0.112	0.143	0.175	0.209	0.246	0.288	0.309	0.369	0.512
0.89	—	—	0.028	0.059	0.086	0.117	0.149	0.183	0.230	0.262	0.309	0.369	0.512
0.90	—	—	—	0.031	0.058	0.089	0.121	0.155	0.192	0.234	0.281	0.341	0.484
0.91	—	—	—	—	0.027	0.058	0.090	0.124	0.161	0.203	0.250	0.310	0.453
0.92	—	—	—	—	—	0.027	0.063	0.097	0.134	0.176	0.223	0.283	0.426
0.93	—	—	—	—	—	—	0.032	0.066	0.103	0.145	0.192	0.252	0.395
0.94	—	—	—	—	—	—	—	0.034	0.071	0.113	0.160	0.220	0.363
0.95	—	—	—	—	—	—	—	—	0.037	0.079	0.126	0.186	0.329
0.96	—	—	—	—	—	—	—	—	—	0.042	0.089	0.149	0.292
0.97	—	—	—	—	—	—	—	—	—	—	0.047	0.107	0.250
0.98	—	—	—	—	—	—	—	—	—	—	—	0.060	0.203
0.99	—	—	—	—	—	—	—	—	—	—	—	—	0.143

NOTE — The consumer is advised to make proper allowance for lower supply voltages where these exist during the working hours and may choose slightly higher kVAR than recommended in the table for such cases.

NATIONAL ELECTRICAL CODE

PART 2

PART 2 ELECTRICAL INSTALLATIONS IN STAND-BY GENERATING STATIONS AND CAPTIVE SUBSTATIONS

0 FOREWORD

This National Electrical Code (Part 2) is primarily intended to cover the requirements relating to stand-by generating stations and captive substations intended for serving an individual occupancy. As the general provisions relating to such installations are common and are themselves elaborate in nature, it was felt essential to cover them in a separate part preceding the other parts which cover the requirements for specific installations.

Generating stations covered by this Part 2 are the stand-by or emergency supply and captive substations normally housed in or around the building in question. This Code does not include the switching stations and other large generating plants coming solely under the preview of the electric supply authority of a metropolis even though to some extent the requirements stipulated herein could also be applicable to them.

Specific requirements if any, for generating and switching substations for individual buildings that might vary depending on the nature of the occupancy or the size of the building are enumerated in the respective sections of the Code.

In the formulation of this Code, note has been taken of the requirements stipulated in installation Codes of individual equipment as well as the fire-safety Codes for generating stations and substations. It is generally not feasible to draw very strict guidelines for the design and layout for such installations owing to the complexity of the needs of building installations and hence only the essential safety considerations are listed out for compliance. It is essential to take recourse to the assistance of local authorities for further details.

Specific requirements pertaining to stand-by generating stations and captive substations for multistoreyed/high-rise buildings are covered in Part 3/Section 7 of this Code.

1 SCOPE

1.1 This Code (Part 2) covers essential requirements for electrical installations in stand-by generating stations and captive substations intended to serve a building or group of buildings.

1.2 This Part is not intended to cover 'captive generator sets' of very large capacities. This Part 2 covers only the stand-by generating sets upto the capacity of 5 MW. Similarly the substations upto the capacities of 10 MVA and 33 kV are covered. This Part 2 also does not apply to the generating stations coming under the jurisdiction of the Electric Supply Authority in a city or metropolis.

2 REFERENCES

This Part 2 should be read in conjunction with the following Indian Standards:

IS No.	*Title*
1641 : 1988	Code of practice for fire-safety of buildings (general): General principles of fire grading and classification
1642 : 1989	Code of practice for fire safety of buildings (general): Details of construction (*first revision*)
1646 : 1997	Code of practice for fire-safety of buildings (general): Electrical installation (*second revision*)
1946 : 1961	Code of practice for use of fixing devices in walls, ceilings and of solid construction
2309 : 1989	Code of practice for the protection of buildings and allied structures against lightning (*second revision*).
3034 : 1993	Fire-safety of industrial buildings: Electrical generating and distributing stations — Code of practice (*second revision*)
3043 : 1987	Code of practice for earthing (*first revision*)
10028 (Part 2) : 1981	Code of practice for selection, installation and maintenance of transformers: Part 2 Installations
10118 (Part 3) : 1982	Code of practice for selection, installation and maintenance of switchgear: Part 3 Installation

3 TERMINOLOGY

For the purpose of this Part, the definitions given in Part 1/Section 2 of this Code shall apply.

4 GENERAL CHARACTERISTICS OF STATION INSTALLATIONS

4.1 In determining the general characteristics of stand-by generating plants and building substations in a building, the assessment of characteristics of the buildings based on its occupancy shall be taken note of as specified in individual Parts/Sections of this Code.

4.2 Depending on the exact location of the station in the building premises, and depending on whether the equipment are installed indoor or outdoor, the degree of external influence of the environment shall be determined based on the guidelines given in Part 1/Section 8 of this Code.

4.3 It is generally presumed that generating stations and substations are restricted areas not meant for unauthorized persons, and such electrical operating areas fall under the category of BA4 utilization for instructed personnel (*see* Part 1/Section 8), which are adequately advised or supervised by skilled persons to avoid dangers that may arise owing to the use of electricity.

5 EXCHANGE OF INFORMATION

5.1 Information shall be exchanged amongst the personnel involved regarding the size and nature of substation and supply station requirements to be provided for an occupancy so that the type of equipment and their choice, as well as their installation shall be governed by the same. An assessment shall also be made of the civil construction needs of the station equipment keeping in view a possible expansion in future.

5.2 Before ordering the equipment, information shall be exchanged, regarding the installation and location conditions, including such building features as access doors, lifting beams, oil pumps, cable trenches, foundation details for heavy equipment, ventilating arrangement, etc.

6 LAYOUT AND BUILDING CONSTRUCTION ASPECTS

6.1 The constructional features of all building housing the station installation shall comply with IS 1641, IS 1642 and IS 3034. Locating of substation in lowest basement is not recommended.

6.2 Switchgears, circuit-breaker and transformers (except outdoor types) shall be housed preferably in detached single storey buildings of Type 1 construction. In the case of built up areas in cities, multistoreyed construction may also be adopted. Construction of such buildings shall conform to IS 1946.

6.3 Construction of fire separation walls shall conform with the requirements of relevant Indian Standards. Doorway openings in separating walls of transformer or switchgear rooms shall be provided with sills not less than 15 cm in height. Reference is drawn to

IS 3034. Where risk of spread of possible fire exists, interconnecting doors should have a 2 h fire rating.

6.4 The foundation of the stand-by generating sets shall preferably be isolated from that of the other structures of the building so that vibrations are not carried over.

6.5 The diesel generating (DG) set should be provided with integral acoustic enclosure conforming to the requirements as laid down in *Environment Protection Act.*

7 SELECTION OF EQUIPMENT

7.1 The selection of equipment shall be done in accordance with the guidelines provided in Part 1/ Section 9 of this Code.

8 GENERATING SETS

8.0 Stationary generating sets of 5 kVA and above are normally driven by diesel engine as this drive is most economical. Smaller sets are driven by petrol. During the planning of the building, the dimensions of the power plant room and the transport ways shall be agreed to between the architect and electrical contractor.

8.1 In case of large capacity sets which generate appreciable heat, the rooms shall be well ventilated and provided with air exhaust equipment.

8.2 The capacity of the stand-by set for an installation should be such that in an event of power failure, the essential loads can be supplied power. For instance in case of hospitals such loads comprise operation theatres and their supporting auxiliaries; intensive care units, cold storage in laboratories, emergency lifts, etc. In the case of industries having continuous processes, such loads are required to be supplied with power all the time. In commercial premises and high-rise buildings, a few lifts and circulation area lights and fire-fighting equipment have to be kept working by supply from stand-by sets. Similar is the case of essential loads in large hotels. Such sets can either be manually started and switched on to essential loads with the use of changeover switches or they could be auto-start on mains failure and loads autochanged over to generator supply.

8.3 In case of large electrical installation in which essential loads are widely scattered it becomes necessary to run the generating set supply cables to these essential loads and in the event of mains failure, changeover to generator supply, either manually or through auto-changeover connectors.

8.4 The fire safety requirements for fuel oil storage shall conform to **5.3** of IS 3034.

8.5 The fire safety requirements for oil and gas fired installations shall conform to IS 3034.

8.6 All equipment of prime mover shall conform to relevant Indian Standard (where they exist) for construction, temperature-rise, overload and performance.

8.7 The diesel generator set should meet the pollution norms of the Central and State Statutory Authorities.

9 TRANSFORMER INSTALLATIONS

9.1 Reference is drawn to the requirements given in IS 10028 (Part 2).

9.2 Transformer of capacity up to 3 MVA may be housed indoor or outdoor. The larger ones, because of their size, are usually of outdoor type.

9.3 Indoor transformer will require adequate ventilation to take away as much heat as possible. Oil drainage facilities and partition walls between transformers and between transformer and other equipment such as oil circuit-breakers are necessary to reduce the risk of spread of fire.

9.4 As a transformer station normally has a high voltage and a low voltage switchgear, all such equipment should be adequately separated.

9.5 Only dry type transformer(s) shall be used for installation inside the residential/commercial buildings. The transformer room should be located on ground floor inside a well ventilated room.

10 HIGH VOLTAGE SWITCHING STATIONS

Reference is drawn to the requirements stipulated in IS 10118 (Part 3).

11 LOW VOLTAGE SWITCHING STATIONS AND DISTRIBUTION PANELS

Reference is drawn to the requirements stipulated in IS 10118 (Part 3).

12 STATION AUXILIARIES

12.0 Station auxiliaries could consist of:

a) batteries for stand-by generating sets,
b) batteries for short time emergency lighting,
c) battery charging equipment,
d) fuel oil pumps,
e) ventilating equipment, and
f) fire-fighting equipment.

12.1 Batteries

12.1.1 Batteries shall have containers of glass or any other non-corrosive, non-flammable materials.

12.1.2 Batteries shall be installed in a separate enclosure away from any other auxiliary equipment or switchgear. The enclosure shall be free from dust and well ventilated. Care shall be taken to ensure that direct sunlight does not fall on the batteries.

NOTE — Provision shall be made for sufficient diffusion and ventilation of gases from the battery to prevent the accumulation of an explosive mixture.

12.1.3 The batteries shall stand directly on durable, non-ignitable, non-absorbent and non-conducting material, such as glass, porcelain or glazed earthenware. These materials shall rest on a bench which shall be kept dry and insulated from earth. If constructed of wood it shall be slatted and treated with anti-sulphuric enamel.

12.1.4 The batteries shall be so arranged on the bench that a potential difference exceeding 12 V shall not exist between adjoining cells. The batteries not exceeding 20V shall not be bunched or arranged in circular formation.

12.1.5 All combustible materials within a distance of 60 cm measured horizontally from, or within 2.0 m measured vertically above, any battery shall be protected with hard asbestos sheets.

12.2 Battery Charging Equipment

12.2.1 The battery charging equipment with necessary switch and controlgear shall be mounted separately and away from the batteries.

12.3 Fuel Oil Pump

12.3.1 Fuel oil pump shall be installed close to the engine room or inside the engine room.

12.3.2 The electric cable provided to run the pump motor shall be protected with oil-resistant outer sheath.

12.4 Ventilating Equipment

12.4.1 The engine room shall be fitted with hot-air extractors.

12.4.2 The battery room shall be fitted with exhaust fans. The exhaust gases be let off to atmosphere where no other equipment is installed.

13 WIRING IN STATION PREMISES

All cabling and electrical wiring inside generation or substation premises shall be done in accordance with the practice recommended in (Part 1/Section 9) of this Code.

14 EARTHING

The provision of **17** of IS 3043 shall apply *(see also* Part 1/Section 14).

15 BUILDING SERVICES

15.1 Lighting

15.1.1 The general principal of good lighting for any occupancy shall be as given in Part 1/Section 11 of this Code. For the purpose of station installations the values of lumen level and limiting value of glare index shall be as given in Table 1.

Table 1 Recommended Values of Illumination and Glare Index

Sl No.	Location	Illumination, lux	Laminating Glare Index
(1)	(2)	(3)	(4)
i)	*Indoor Locations*		
	a) Stand-by generator hall	300	25
	b) Auxiliary equipment; battery room, blowers, switchgear		25
	c) Basements	100	25
	d) Control rooms:		
	1) Vertical control panels	300	19
	2) Control desks	300	19
	3) Rear of control panel	150	19
ii)	*Outdoor Locations*		
	a) Fuel oil storage area	50	19
	b) Transformers, outdoor switchgear	50	19

15.2 The luminaires used shall be of dust-proof construction and shall be energy efficient with compact fluorescent lamps (CFL)/fluorescent lamps with electronic ballasts.

16 FIRE-SAFETY REQUIREMENTS

16.1 The provisions of IS 3034 and IS 1646 shall apply for station installations.

16.2 All wiring for automatic fire-fighting installation shall be of fire-resistant outer sheath.

17 LIGHTNING PROTECTION

The provisions of IS 2309 shall apply.

18 TESTING AND INSPECTION

The guidelines provided in Part 1/Section 13 of this Code shall apply. In the case of diesel sets which come into operation only in emergency as stand-by sets, it is necessary that such sets are regularly checked run up and mechanical and electrical system tested to ensure that the set is in operable conditions all the time.

NATIONAL ELECTRICAL CODE
PART 3

PART 3 ELECTRICAL INSTALLATIONS IN NON-INDUSTRIAL BUILDINGS

0 FOREWORD

For the purposes of this Code, electrical installations in buildings have been broadly classified as those in non-industrial and industrial . While a majority of installations could be categorically classified as non-industrial, an industrial complex would necessarily incorporate sub-units such as offices, residential quarters and support services which are either housed or fall in the category of non-industrial buildings. The requirement stipulated in Part 3 and Part 4 of this Code would therefore require judicious application.

With the current trend in power utilization, it would also be extremely difficult to classify electrical installations based on power requirement or the voltage of supply, as large buildings for non-industrial purposes consume sufficient power to consider them at par with the consumption of light industrial establishments. It is therefore necessary to consider for initial assessment of the installation the guidelines given in Part 1/Sec 8 this Code, which are better defined than the earlier terminology used for classifying installations.

Part 3 of this Code, therefore covers requirements for major types of non-industrial occupations. It is felt that a large number of occupancies would fall in one of the categories, and for typical buildings which do strictly fall into any of these, recourse shall be made to the general guidelines stipulated in Part 1.

This Part consists of the following Sections:

Section 1	Domestic Dwellings
Section 2	Office Building, Shopping and Commercial Centres and Institutions
Section 3	Recreational, Assembly Building
Section 4	Medical Establishments
Section 5	Hotels
Section 6	Sports Buildings
Section 7	Specific Requirements for Electrical Installations in Multistoried Buildings

Sections 1-6 of this Part cover requirements applicable to buildings which are of nominal heights less than 15 m. It is recognized that from the point of view fire-safety of buildings more than 15 m height require specific considerations. These are summarized in Section 7 of this Part.

SECTION 1 DOMESTIC DWELLINGS

0 FOREWORD

Electrical installations in domestic dwellings and in buildings providing living accommodation for people are by far the simplest form of installation. Use of electrical appliances, both portable and fixed has now become very common and popular even in single family dwellings. The optimum benefits from the use of electricity can be obtained only if the installation is of sufficient capacity and affords enough flexibility.

The primary considerations in planning the electrical layout in domestic dwellings are economy and safety. Besides these, other considerations such as efficiency and reliability, convenience and provisions for future expansion are also valid.

Domestic installations are characterized mainly by a circuit voltage of 250 V to earth except in the case of large power consumers where three-phase supply is given. A brief description of the type of installations covered in this Section is given in **4**. It may, however, be noted that lodging and rooming houses, though utilized as living accommodation for short periods of time (by different occupants) are covered under scope of Part 3/Section 5 of this Code.

Specific requirements for installations in rooms containing a bath tub or shower basin, namely, bathrooms are separately covered in Annex A. These requirements also apply to similar locations in other occupancies, such as hotels. For convenience, these requirements are covered in this Section.

1 SCOPE

This Part 3/Section 1 of the Code covers requirements for electrical installations in domestic dwellings.

2 REFERENCES

This Part 3/Section 1 of the Code should be read in conjunction with the following Indian Standards:

IS No.	*Title*
3646 (Part 2) : 1966	Code of practice for interior illumination: Part 2 Schedule for values of illumination and glare index
7689 : 1989	Guide for the control of undesirable static electricity
8061 : 1976	Code of practice for design, installation and maintenance of service lines upto and including 650 V
13450 (Part 1) : 1994 /IEC 60601-1 : 1988	Medical electrical equipment — Part 1: General requirements for safety
14665(Part 1) : 2000	Electric traction lifts — Part 1: Guidelines for outline dimensions of passenger, goods, service and hospital lifts
15707 : 2006	Testing, evaluation, installation and maintenance of ac electricity meters — Code of practice
SP 7 : 2005	National Building Code of India
SP 72 : 2010	National Lighting Code

3 TERMINOLOGY

For the purpose of this Section, the definitions given in Part 1/Section 2 of this Code shall apply.

4 CLASSIFICATION

4.1 The electrical installations covered in this Section, are those in buildings intended for the following purposes:

4.1.1 *Domestic Dwellings/Residential Buildings*

These shall include buildings in which sleeping accommodation is provided for normal residential (domestic) purposes with cooking and dining facilities.

Such buildings shall be further classified as follows:

a) *One or two family dwellings* — These shall include any private dwelling which is occupied by members of a single family and has a total sleeping accommodation for not more than 20 persons.

b) *Apartment houses (flats)* — These shall include any building or structure in which living quarters are provided for three or more families, living independently of each other and with independent cooking facilities. For example apartment houses, mansions and *chawls*.

NOTE — If accommodation is provided for more than 20 persons, such buildings are considered lodging or rooming houses, (dormitories) and the provisions of Part 3/Section 5 shall apply.

5 GENERAL CHARACTERISTICS OF INSTALLATIONS

General guidelines on the assessment of characteristics of installations in buildings are given in Part 1/Sec 8 of this Code. For the purposes of installations falling under the scope of this Section, the characteristics defined below specifically apply.

5.1 Environment

The following environmental factors shall apply to electrical installations in domestic dwellings:

Environment (1)	*Characteristics* (2)	*Remarks* (3)
Presence of water	Probability of presence of water is negligible	—
Presence of foreign solid bodies	The quantity or nature of dust or foreign solid bodies is not significant	—
Presence of corrosive or polluting substances	The quantity and nature of corrosive or polluting substances is not significant	Applicable for most of the locations except for dwellings situated by sea or in industrial zone in which case categorization AF2 applies (*see* Part 1/Sec 8)
Mechanical stresses	Impact and vibration of low severity	Household and similar conditions
Seismic effect and lighting		Depends on the location of the building

5.2 Utilization

The following aspects utilization shall apply:

Utilization (1)	*Characteristics* (2)	*Remarks* (3)
Capability of persons	Uninstructed persons	Applies to all domestic installations
Contact of persons	Persons in normally conducting situations	
Conditions of evacuation during emergency	Low density occupation, easy conditions of evacuation	Buildings of normal or low height used for one or two family dwellings
	Low density occupation, difficult conditions of evacuation	Apartment houses including high-rise flats
Nature of processed of stored material	No significant risks	

6 SUPPLY CHARACTERISTICS AND PARAMETERS

6.0 Exchange of Information

6.0.1 General aspects to be taken note of before designing the electrical installations are enumerated in Part 1/Section 7 of this Code. However, the following points shall be noted particularly in respect of domestic dwellings.

6.0.2 Before starting wiring and installation of fittings and accessories, information should be exchanged between the owner of the building or architect or 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, service lines, etc, and for total load requirement of lights, fans and power.

6.0.3 While planning an installation, consideration should be given to the anticipated increase in the use of electricity for lighting, general purpose socket-outlet, kitchen, 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 may otherwise be tempted to carry out extension of the installation himself or to rely upon use of multiplug adaptors and long flexible cords, both of which are not recommended. A fundamentally safe installation may be rendered dangerous, if extended in this way.

6.0.4 Electrical installation in a new building should normally begin immediately on the completion of the main structural building work. For conduit wiring system, the work should start before finishing work like plastering has begun. For surface wiring system, however, work should begin before final finishing work like white washing, painting, etc. Usually, no installation work should start until the building is reasonably weatherproof, but where electric wiring is to be concealed within the structures, the necessary conduits and ducts should be positioned after the shuttering is in place and before the concrete is poured, provision being made to protect conduits from damage. For this purpose, sufficient coordination shall be ensured amongst the concerned parties.

6.1.1 *Estimation of Load Requirements*

The extent and form of electrical installations in domestic dwellings is basically designed to cater to light and fan loads and for electrical appliances and gadgets. In estimating the current to be carried by any branch circuit unless the actual values are known, these shall be calculated based on the following recommended ratings:

Sl No.	*Item*	*Recommended Rating (W)*
(1)	(2)	(3)
i)	Incandescent lamps	60
ii)	Ceiling fans	60
iii)	Table fans	60
iv)	6A, socket-outlet point unless the actual value of loads are specified	100
v)	Fluorescent tubes:	
	Length 600 mm	25
	1 200 mm	50
	1 500 mm	90
vi)	Power socket outlet (16A) unless the actual value of loads are specified	1 000

6.1.2 *Number of Points in Branch Circuits*

The recommended yardstick for dwelling units for determining the number of points is given in Table 1.

Table 1 Number of Points for Dwelling Units

Sl No.	Description	Area for the Main Dwelling Unit (m^2)				
		35	45	55	85	140
(1)	(2)	(3)	(4)	(5)	(6)	(7)
i)	Light points	7	8	10	12	17
ii)	Ceiling fans	2-2	3-2	4-3	5-4	7-5
iii)	6A Socket outlets	2	3	4	5	7
iv)	16A Socket outlets	—	1	2	3	4
v)	Call-bell (buzzer)	—	—	1	1	1

NOTE — The figures in table against Sl No. (ii) indicate the recommended number of points and the number of fans.

Example — For main dwelling unit of 55 m^2, 4 points with 3 fans are recommended.

6.1.3 *Number of Socket-Outlets*

The recommended schedule of socket-outlets for the various sub-units of a domestic are given in Table 2.

6.1.4 *Selection of Size of Conductors*

Provisions of Part 1/Section 9 of this Code shall apply.

6.1.5 'Power' sub-circuits shall be kept separate and distinct from 'lighting-and fan' sub-circuit. All wiring shall be done on the distribution system with main and branch distribution boards located at convenient physical and electrical load centres. All types of wiring, whether recessed or surface should be capable of easy inspection. The surface wiring when run along the walls should be as near the ceiling as possible. In all types of wirings due consideration shall be given for neatness and good appearance and safety.

Table 2 Recommended Schedule of Socket-Outlets
(*Clause* 6.1.3)

Sl No.	Description	Number of Socket-Outlets	
		6A	16A
(1)	(2)	(3)	(4)
i)	Bedroom	2 - 3	1
ii)	Living room	2 - 3	2
iii)	Kitchen	1	2
iv)	Dining room	2	1
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

6.1.6 Balancing of circuits in three-wire or polyphase installation shall be planned beforehand. In each case, it is recommended that all socket-outlets in a room are connected to one phase. The conductors shall be so enclosed in earthed metal or incombustible insulating material that it is not possible to have ready access to them. If the points between which a voltage exceeding 250 V is present are 2 m or more apart, the covers or access doors shall be clearly marked to indicate the voltage present.

6.1.7 It is recommended to provide at least two lighting sub-circuits in each house. It is also recommended that a separate lighting circuit be utilized for all external lighting of steps, walkways, driveways, porch, car park, terrace, etc., with a master double-pole switch for the sub-circuit in addition to the individual switches.

6.1.8 Wherever the load to be fed is more than 1 kW, it shall be controlled by an isolator switch or miniature circuit-breaker.

6.2 Selection of Wiring

Any one of the following types of wiring may be used in a residential building (*see* Part 1/Section 9 of this Code).

a) Tough rubber sheathed or PVC insulated PVC sheathed wiring on wood batten,
b) PVC insulated wiring in steel/non-metallic surface conduits, and
c) PVC insulated wiring in steel/non-metallic recessed conduits.

However, if aesthetics is the main consideration, recessed conduit wiring system may be adopted.

The wiring for 16 A plug outlets (power circuits) shall invariably be carried out either in surface/recessed conduit wiring system where general wiring is on wood batten.

Wiring for staircase lights and garage lights may be done in recessed conduit wiring systems.

7 SWITCHGEAR FOR CONTROL AND PROTECTION

7.1 Location

7.1.1 All main switches or miniature circuit-breakers 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.

7.1.2 Open type switch boards shall be placed only in dry situation and in well ventilated rooms. They shall not be placed in the vicinity of storage batteries and exposed to chemical fumes.

7.1.3 Main switch boards shall be installed in rooms or cupboards having provision for locking so as to safeguard against operation by unauthorized persons.

7.1.4 In a damp situation or where inflammable or explosive dust, vapour or gas is likely to be present, the switch boards shall be totally enclosed or made flame-proof as may be necessitated by the particular circumstances.

7.1.5 Switch boards shall not be erected above gas stoves or sinks or within 2.5 m of any washing unit in the washing room.

7.1.6 Switch boards, if unavoidably fixed in places likely to be exposed to weather, to drip, or to abnormal moist atmosphere, their 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 cables are run. PVC and double flanged bushes shall be fitted in the holes of the switches for entry and exit of wires.

7.1.7 A switch board shall not be installed so that its bottom is within 1.25 m above the floor, unless the front of the switch board is completely enclosed by a door, or the switch board is located in a position to which only authorized persons have access.

7.1.8 Where so required, the switch boards shall be recessed in the wall. The depth of recess provided at the back for connection and the space at the front between the switchgear mountings shall be adequate.

7.1.9 Equipment's which are on the front of a switchboard shall be so arranged that inadvertent personal contact with live parts is unlikely during the manipulation of switchgears, changing of fuses or similar operations.

7.1.10 No mounting shall be mounted within 2.5 cm of any edge of the panel and no hole other than the holes by means of which the panel is fixed shall be drilled closer than 1.3 cm from any edge of the panel.

7.2 General Requirements of Switchboards

7.2.1 The various live parts, unless they are effectively screened by insulating material shall be so spaced that an arc cannot be maintained between such parts and earth.

The arrangement of the gear shall be such that they shall he readily accessible and their connections to all instruments and apparatus shall also be traceable.

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

7.2.3 No fuse other than fuses in instrument circuit shall be fixed on the back of or behind a switchboard panel or frame.

7.2.4 All metal switchgears and switchboards shall be painted and maintained during service.

7.2.5 All switchboards connected to medium voltage and above shall be installed in accordance with Part 1/Section 9 of this Code.

7.2.6 The wiring throughout the installation shall be such that there is no break in the neutral wire in the form of a switch or fuse unit.

7.2.7 The neutral shall also be distinctly marked.

7.2.8 The main switch shall be easily accessible.

7.3 Types of Switchboards

7.3.1 In dwelling units, the metal clad switchgears shall preferably be mounted on any of the following types of boards:

a) *Hinged type metal boards* — Such boards shall be suitable for mounting of metal clad switchgear consisting of not more than one switchgear and ICDB 4 way or 6 way, 15 A per way.
b) *Fixed type metal boards* — Such boards shall be suitable for large switchboards for mounting large number of switchgears and or higher capacity switchgear.
c) *Wooden hoards* — For small installations connected to a single phase 240 V supply, these boards may be used as main board or sub-boards. These shall be of seasoned and durable wood with solid back impregnated with varnish with joints dove-tailed.

NOTE — *See also* Part 1/Section 9 of this Code.

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 switchboard shall be marked to indicate the section of the installation and building it controls.

7.4 Distribution Boards

7.4.1 Distribution boards shall preferably be of metal clad type.

7.4.2 Main distribution boards shall be controlled by a linked switchfuse or circuit-breaker. Each outgoing circuit shall be provided with a fuse on the phase or live conductor.

7.4.3 Branch distribution boards shall be controlled by a switchfuse or circuit-breaker. Each outgoing circuit shall be provided with a fuse MCB on the phase or live conductor. The earthed neutral conductor shall be connected to a common link and be capable of being disconnected individually for testing purposes. At least one spare circuit of the same capacity shall be provided on each branch distribution board.

7.4.4 Triple pole distribution boards shall not generally be used for final circuit distribution. Where use of triple pole distribution boards is inevitable, individual single phase circuit shall be controlled by double pole isolator.

7.4.5 All distribution boards shall be marked 'Lighting' or 'Power' as the case may be and also with the voltage and number of phases of the supply.

7.4.6 The distribution boards for light and power circuits shall be different.

8 SERVICE LINES

The relevant provisions of IS 8061 shall apply.

9 METERING

9.1 It is recommended to have two distinct circuits, one for lights and fans and the other for high wattage (power) appliances particularly when the tariff is different for light and power.

9.2 Energymeters shall be installed at such a place which is readily accessible to both the owner of the building and the authorized representatives of the supply authority. These should be installed at a height where it is convenient to note the meter reading, it should preferably not be installed at a height less than 1 m from the ground. The energymeters should either be provided with a protective 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 a hinged or sliding doors with arrangement for locking it. The room/space where energy meters are installed shall be kept clear from any obstruction (*see also* IS 15707).

9.3 Means for isolating the supply to the building shall be provided immediately after the energymeter.

10 EARTHING IN DOMESTIC INSTALLATIONS

10.0 Means shall be provided for proper earthing of all apparatus and appliances in accordance with Part 1/Section 14 of this Code.

10.1 Plugs and Sockets

All plugs and sockets shall be of three-pin type, one of the pins being connected to earth.

10.2 Lighting Fittings

If the bracket type lamp holders are of metallic construction, it is recommended that they should be earthed. All pedestal lamp fittings of metallic construction shall be earthed.

10.3 Fans and Regulators

Bodies of all table fans, pedestal fans, exhaust fans, etc., shall be earthed by the use of three-pin plugs. The covers of the regulators, if of metallic construction shall be earthed by means of a separate earth wire.

10.4 Domestic Electric Appliances

Bodies of hot-plates, kettles, toasters, heaters, ovens and water boilers shall all be earthed by the use of three-pin plugs. However, if fixed wiring has been used, then a separate earth wire shall be used for earthing these appliances.

10.5 Bath Room

The body of automatic electric water heaters shall be earthed by the use of a three-pin plug or by a separate earth wire, if fixed wiring has been done. All non-electrical metal work including the bath tub, metal pipes, sinks and tanks shall be bonded together and earthed.

10.6 Radio Sets

From the point of view of good reception it is recommended that radio sets should be earthed through an electrode different from that of the main earth system for other electrical appliances. However, if it is not possible to have separate earth electrode, radio sets may be earthed through the main earth system.

10.7 Miscellaneous Apparatus

Where appliances utilizing gas and electricity are in use, for example, gas-heated electricity-driven washing machines, the inlet end of the gas supply shall be either fitted with a strong insulating bush, substantial enough to stand a flash test of 3 500 V and so designed as to be difficult to detach, or, where it is desirable or necessary that metal work in proximity to electrical apparatus be bonded to the earthed metal work of the latter, as for example, in kitchens, the gas supply shall be introduced through a non-conducting plastic pipe from a point not in proximity to earthed metal work. Where separation is not easily achieved, for example, as in cases of direct-coupled motor-driven gas boosters and motorized gas valves, the metal work of the electrical equipment, shall be bonded to the metal or pipework of gas equipment. In such cases the addition to the motor control gear of a differential or current-balance type of circuit-breaker, designed to operate at low values of fault current, would afford a desirable safeguard against fault current transfer specially where the rating of the plant is of a size and capacity which entails correspondingly high ratings for the normal overload protective devices.

The refrigerators, air-conditioners and coolers, electric radiators, electric irons, etc, shall all be earthed by the use of three-pin plugs.

11 BUILDING SERVICES

11.1 Lighting

The general rules laid down in Part 1/Section 11 of this Code shall apply. The choice of lamps, lighting fittings shall be based on the recommended values of illumination given in Table 3. *See* SP 72 for detailed guidance.

Table 3 Recommended Levels of Illumination for Different Parts of Domestic Dwellings

(*Clauses* 11.1 *and* 14.3)

Sl No.	Location	Illumination Level lux
(1)	(2)	(3)
i)	Entrances, hallways	100
ii)	Living room	300
iii)	Dining room	150
iv)	Bedroom:	
	a) General	300
	b) Dressing tables, bed heads	200
v)	Games or recreation room	100
vi)	Table games	300
vii)	Kitchen	200
viii)	Kitchen sink	300
ix)	Laundry	200
x)	Bathroom	100
xi)	Bathroom mirror	300
xii)	Sewing	700
xiii)	Workshop	200
xiv)	Stairs	100
xv)	Garage	70
xvi)	Study	300

11.2 Air-conditioning

11.2.1 The general rules laid down in Part 1/Section 11 of this Code shall apply. For domestic dwellings, by and large, the following types of air-cooling equipment are used:

a) Evaporative coolers,
b) Packaged air-conditioners, and
c) Room air-conditioners.

11.2.2 The power requirements, layout and design of electrical installation shall take into account the number and type of such equipment.

11.3 Lifts

11.3.1 Whenever lifts are required to be installed in residential buildings, the general rules laid down in Part 1/Section 11 of this Code shall apply. However, the design of lifts shall take into account the following recommendations.

11.3.1.1 *Occupant load*

For residential (domestic) dwellings, the occupant load (the number of persons within any floor area) expressed in gross area in m^2/person shall not be less than 12.5.

11.3.1.2 *Passenger handling capacity (H)*

Expressed as the estimated population that has to be handled in the buildings in the 5-minute peak period, the passenger handling capacity for residential buildings shall be 5 percent.

11.3.1.3 *Car speed*

Car speed for passenger lifts shall be as follows:

a) In low and medium class flats 0.5 m/s, and
b) Large flats (No. of floors served 6-12) 0.75-1.5 m/s.

11.3.2 Where a lift is arranged to serve two, three or four flats per floor, the lift may be placed adjoining the staircase, with the lift entrances serving direct on to the landings. Where the lift is to serve a considerable number of flats having access to balconies or corridors, it may be conveniently placed in a well ventilated tower adjoining the building.

12 FIRE PROTECTION

The following protection systems are recommended:

a) *One or two family private dwellings* — Fire detection/extinguishing systems not required.
b) *Apartment houses/flats*
   1) *Up to 2 storey* — Not required.
   2) *3 storey and above*
      i) Floor area less than 300 m^2 — Not required.
      ii) Floor area more than 300 m^2 — Manually operated electric fire alarm.

SP 7 may be referred for detailed guidance.

13 TESTING OF THE INSTALLATION

The provisions of Part 1/Section 13 of this Code shall apply.

14 MISCELLANEOUS PROVISIONS

14.1 Telephone Wiring

Facilities for telephone wiring shall be provided in all residential buildings where telephones are likely to be installed. In high rise residential buildings, a riser of adequate size shall be provided for telephone wiring cables.

14.2 Safety Requirements

Some of the important safety requirements in electrical installations in domestic dwellings are summarized below:

a) All outlets for domestic electrical appliances shall be of three-pin socket type, third socket being connected to the earth.
b) All the single pole switches shall be on phase or live conductor only.
c) The electrical outlets for appliances in the bathrooms shall be away from the shower or sink (*see* Annex A).
d) Wiring for power outlets in the kitchen shall be preferably done in metallic conduit wiring.
e) The electrical outlets shall not be located above the gas stove.
f) The clearance between the bottom most point of the ceiling fan and the floor shall be not less than 2.4 m.
g) The metallic body of the fan regulator if any, shall be earthed effectively.
h) Earth leakage circuit-breaker at the intake of power supply at the consumer's premises (*see* Part 1/Section 14 of this Code) shall be provided.

14.3 Guidelines on Power Factor Improvement in Domestic Dwellings

General guidelines on principal causes of low power factor and methods of compensation are given in Part 1/Section 17 of this Code. For guidance on natural power factor available for single phase appliances and equipment in domestic use, *see* Table 3.

ANNEX A

[*Clause* 14.2 (c)]

PARTICULAR REQUIREMENTS FOR LOCATIONS CONTAINING A BATH TUB OR SHOWER BASIN

A-1 SCOPE

The particular requirements of this Annex apply to bath tubs, shower basins and the surrounding zones where susceptibility of persons to electric shock is likely to be increased by a reduction in body resistance and contact with earth potential.

A-2 CLASSIFICATION OF ZONES

A-2.1 The requirements given in this Annex are based on the dimensions of four zones as described in Fig. 1 and Fig. 2.

a) *Zone 0* — is the interior of the bath tub or shower basin.
b) *Zone 1* — is limited:
   1) by the vertical plane circumscribing the bath tub or shower basin, or for a shower without basin, by the vertical plane 0.6 m from the shower head; and
   2) by the floor and the horizontal plane 2.25 m above the floor.
c) *Zone 2* — is limited:
   1) by Zone 1 and the vertical parallel plane 0.60 m external to Zone 1, and
   2) by the floor and horizontal plane 2.25 m above the floor.
d) *Zone 3* — is limited:
   1) by Zone 2 and the parallel vertical plane 2.40 m external to Zone 2, and

2) by the floor and the horizontal plane 2.25 m above the floor.

NOTE — The dimensions are measured taking account of walls and fixed partition.

A-3 PROTECTION FOR SAFETY

A-3.1 Where safety extra low voltage is used, whatever the nominal voltage, protection against direct contact shall be provided by:

a) barriers or enclosures affording at least the degree of protection IP2X, or
b) insulation capable of withstanding a test voltage of 500 V for 1 min.

A-3.2 A local supplementary equipotential bounding shall connect all extraneous conductive parts in Zones 1, 2 and 3 with protective conductors of all exposed conductive parts situated in these zones.

A-4 SELECTION OF EQUIPMENT

A-4.1 Electrical equipment shall have at least the following degrees of protection:

a) Zone 0 : IP X 7
b) Zone 1 : IP X 5
c) Zone 2 : IP X 4 IP X 5 in public baths
d) Zone 3 : IP X 1

A-4.2 In Zones 0, 1 and 2, wiring systems shall be limited to those necessary to the supply of appliances situated in those zones. Junction boxes are not permitted in Zones 0, 1 and 2. In Zone 3, they are permitted if the necessary degree of protection is available.

A-4.3 In Zones 0, 1 and 2 no switchgear and accessories shall be installed.

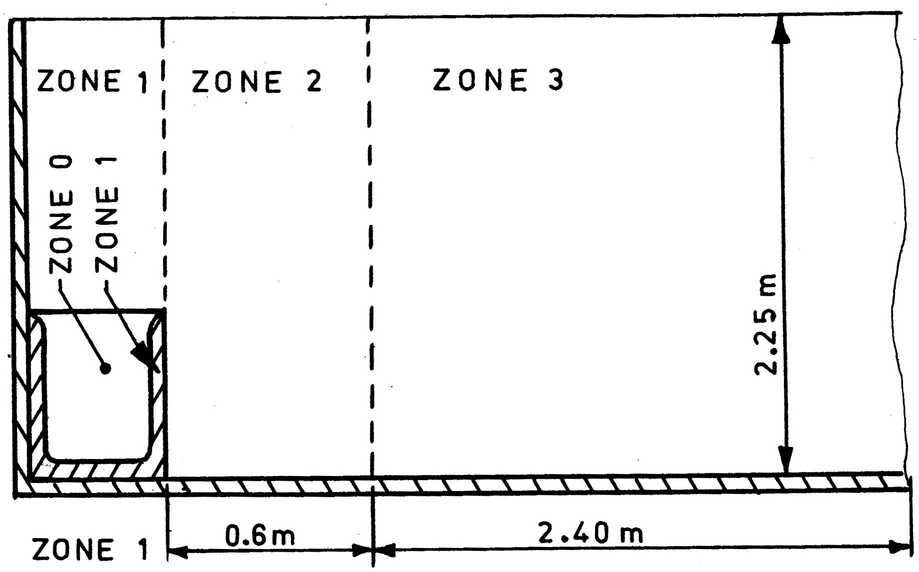
A-4.4 In Zone 3, socket-outlets are permitted, only if they are either:

a) supplied individually by an isolating transformer, or
b) supplied by safety extra-low voltage, or
c) protected by a residual current protective device.

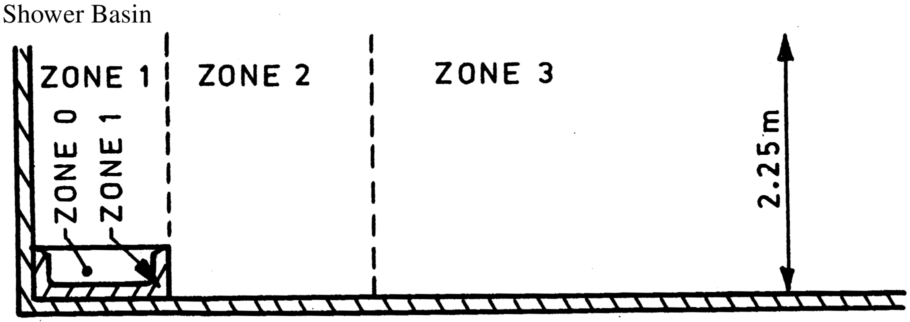
A-4.5 Any switches and socket outlets shall be at a distance of at least 0.60 m from door of the shower cabinet.

A-4.6 In Zone 0, only electrical appliances specially intended for use in the bath tub are permitted. In Zone 1 only water heaters may be installed. In Zone 2 only water heaters and Class II luminaries may be installed.

Bath Tub



Shower Basin



Shower without Basin but with fixed partition

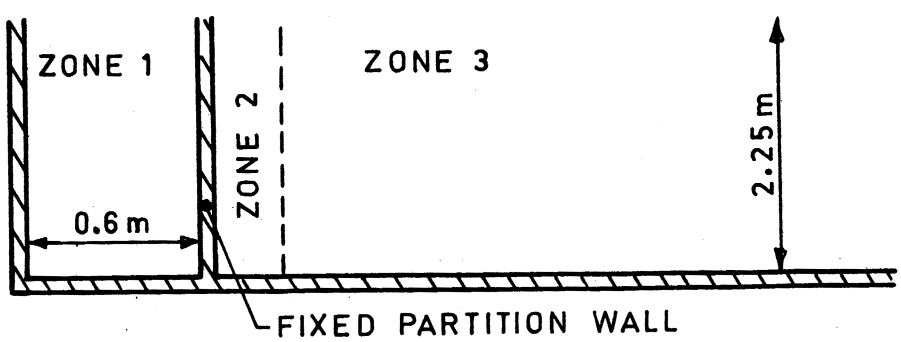


FIG. 1 ZONE DIMENSIONS (ELEVATION)

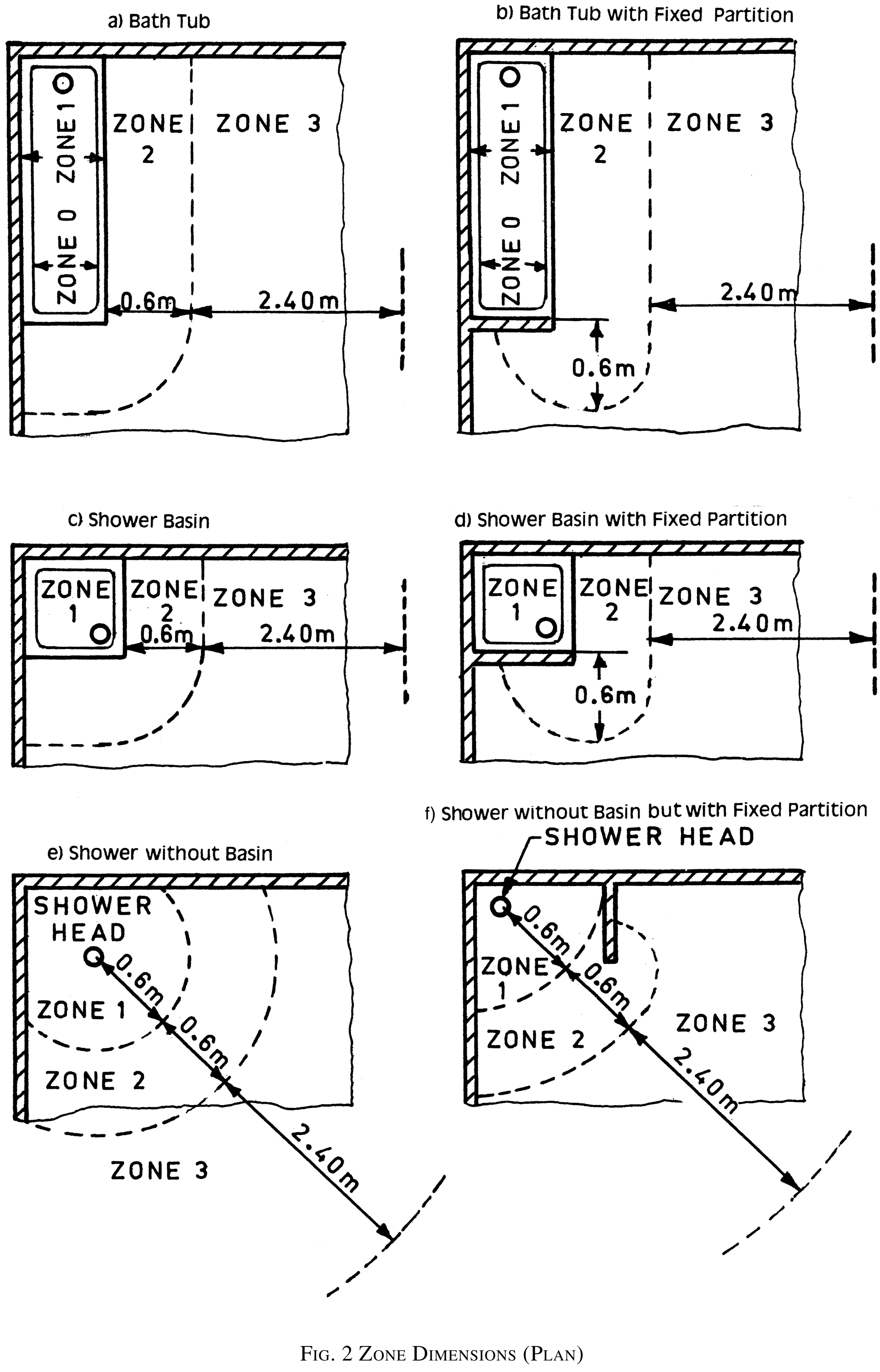


FIG. 2 ZONE DIMENSIONS (PLAN)

SECTION 2 OFFICE BUILDINGS, SHOPPING AND COMMERCIAL CENTRES AND INSTITUTIONS

0 FOREWORD

Office buildings, shopping and commercial centres can be of various types depending on the size of the civil structure or the extent of activity involved in the building. High-rise buildings housing office complexes are common, calling for a coordinated planning while designing the electrical services therein.

In small buildings with comparatively moderate loads, supply is normally at medium voltage and the distribution of power is less complex. However, in the case of multi-storied office-*cum*-commercial complex, where the large number of amenities is to be provided calls for a more complex distribution system. Some of such buildings has to incorporate a standby/emergency power plant for essential service needs.

For editorial convenience, and keeping in view the similarly with the type of buildings covered in this section, educational and other institutional buildings are also covered here. Should any special provisions apply to them, they are identified at the relevant clauses.

It is not possible to define strictly the type of buildings covered in this Section except in broad terms, an attempt has been made to identify the nature of the occupancy. Reference may, however, be made to 3 wherein a description is provided for the various types of installations covered in this Section.

1 SCOPE

This Part 3/Section 2 of this Code covers requirements for electrical installations in office buildings, shopping and commercial centres and educational and similar institutional buildings.

2 REFERENCES

This Part 3/Section 2 of the Code should be read in conjunction with the following Indian Standards:

IS No.	*Title*
3646 (Part 2) : 1966	Code of practice for interior illumination: Part 2 Schedule for values of illumination and glare index
8061 : 1976	Code of practice for design, installation and maintenance of service lines upto and including 650 V
15707 : 2006	Testing, evaluation, installation and maintenance of ac electricity meters — Code of practice

3 TERMINOLOGY

For the purpose of this Section, the definitions given in Part 1/Section 2 of this Code shall apply.

4 CLASSIFICATION

The electrical installations covered in this Section, are those in buildings intended for the following purposes:

a) *Office Buildings/Business Buildings* — These include buildings for the transaction of business, for the keeping of accounts and records and similar purposes, professional establishments, offices, banks, research establishments, data processing installations, etc.

b) *Shopping/Commercial Centres/Mercantile Buildings* — These include buildings used as shops, stores, market, for display and sale of merchandise, wholesale or retail, departmental stores, etc.

c) *Educational Buildings* — These include buildings used for schools, colleges and daycare purposes for more than 8 hours per week involving assembly of people for instruction and education (including incidental recreation), etc.

NOTE — Larger assembly buildings recreational occupancies are covered in Part 3/Section 3 of this Code.

5 GENERAL CHARACTERISTICS OF INSTALLATIONS

5.0 General guidelines on the assessment of characteristics of installations in buildings are given in Part 1/Section 8 of this Code. For the purpose of installations falling under the scope of this Section the characteristics defined below generally apply.

5.1 Environment

The following environmental factors shall apply to office buildings, shopping and commercial centres and educational/institutional buildings.

Environment (1)	*Characteristics* (2)	*Remarks* (3)
Presence of water	Probability of presence of water is negligible	
Presence of foreign solid bodies	The quantity or nature of dust or foreign solid bodies is not significant	

Environment (1)	*Characteristics* (2)	*Remarks* (3)
Presence of corrosive or polluting substances	The quantity and nature of corrosive or polluting substances is not significant	Locations where some chemical products are handled in small quantities, (for example, laboratories in schools and colleges) will be categorized as AF3. For office and other buildings covered by this Section situated by the sea or in industrial zones, producing serious pollution, the categorization AF2 applies (*see* Part 3/Section 8)
Mechanical stresses	Impact and vibration of low severity	
Seismic effect and lighting		Depends on the location of the building

5.2 Utilization

The following aspects of utilization shall apply:

Utilization (1)	*Characteristics* (2)	*Remarks* (3)
Capability of persons	Uninstructed persons	A major percentage of occupants
	Children	Applies to schools
	Persons adequately advised or supervised by skilled persons	Applies to areas such as building substations and for operating and maintenance staff
Contact of persons	Persons in non-conducting situations	
Conditions of evacuation during emergency	Low density occupation, easy conditions of evacuation.	Small offices and shops
	High density occupation, difficult conditions of evacuation	Departmental stores
	High density occupation, difficult conditions of evacuation	High rise office commercial centres, underground shopping arcades, etc
Nature of processed of stored material	No significant risks	Small shops
	Existence of fire risk	In view of large volume of paper and furniture, for example, office buildings, furniture shops, etc.

6 SUPPLY CHARACTERISTICS AND PARAMETERS

6.0 Exchange of Information

6.0.1 Proper coordination shall be ensured between the architect, building contractor and the electrical engineer on the various aspects of installations design. From the point of view of the design of the various installations, the following shall be considered.

a) Maximum demand and diversity;
b) Type of distribution system, mains and sub-mains;
c) Nature of supply (current, frequency, nominal voltages);
d) Prospective short-circuit current at the supply intake point;
e) Division of the installation;
f) Nature of the external influences (*see* **4**);
g) Maintainability of the installations;
h) Nature and details of building services;
   1) Lighting,
   2) Air-conditioning, and
   3) Lifts.
j) Other details as relevant such as, pumps for fire fighting, lighting, fire-alarm systems, telephones, call-bells, clock systems, etc;
k) Telephone circuits including extensions and intercom facilities;
m) CCTV for information display and security;
n) Computer installation facility where applicable; and
p) Metering system for different loads.

NOTE — Fire protection system shall include such details such as locations of detectors, zonal indicators, central control console, public address system for fire fighting, cable runs and their segregation from the other cable system.

A complete drawing of layout of the electrical installation shall be prepared together with associated floor plans indicating the details mentioned in (a) to (p). This wiring diagram shall include outlets for lights, sockets, bells, ceiling fans, exhaust fans, location of sectionalized control switches, distribution boards, etc. In special occupancies such as school or college laboratories, the dc circuits be identifiable in the layout diagram.

6.1 Branch Circuits

6.1.1 The general design of wiring of branch circuits shall conform to those laid down in Part 1/Section 11 of this Code. However, for special cases such as for communication networks, fire-alarm system and wiring for data-processing equipment, the recommendations of the manufacturer shall apply.

6.1.2 The branch circuit calculations shall be done according to the general provisions laid down in Part 3/ Section 1 of this Code. However, the specific demands of the lighting, appliance and motor loads as well as special loads encountered in the types of buildings covered in this Section shall be taken into account.

6.1.3 In offices and showrooms, the interior decoration normally include false ceiling, carpets and curtails. Any wiring laid above the false ceiling should be adequately protected such as by drawing the wires in metallic conduits and nor run in open. Wires shall not be covered by carpets. They shall be run at skirting level and encased for mechanical protection.

6.1.4 Adequate number of socket-outlets shall be provided for electrically operated office machines such as electrical typewriter, calculators, etc, to avoid training of wires and use of multiple outlets from one socket.

6.1.5 Areas where corrosive or polluting substance are present intermittently or continuously, such as school laboratories and other buildings located in high industrial pollution zones, socket-outlets shall preferably be of metal clad weatherproof type with covers.

6.1.6 Lighting circuits shall preferably be combined in switched groups so that lighting can be limited to desks which are occupied.

6.2 Service Lines

The general provisions laid down in IS 8061 shall apply.

6.3 Building Substations

6.3.0 *General*

The designer of power supply for office buildings and commercial centres shall take into account the great concentration of power demand of the electrical loads. Air-conditioning in office buildings absorbs an especially high proportion of the total power used. Consequently, such occupancies have to be provided with their own substation with vertical and horizontal forms of power distribution.

6.3.1 If the load demand is high, requiring supply at high voltage, accommodation for substation equipment will be required. Main switch room will serve feeders to various load centres such as air-conditioning plant, elevators, water pumps, etc. Other loads are taken to local distribution boards.

6.3.2 The transformer power rating for the supply of the building shall be sufficient to cater to the highest simultaneous power requirements of the building. Typical proportions of power usage are given as follows:

Part of Electrical Installation (1)	*Part of the Total Power Requirement Percent* (2)	*Diversity Factor* (3)
Ventilation, heating (air-conditioning)	45	1.0
Power plant (drives)	5	0.65
Lighting	30	0.95
Lifts	20	1.0

6.3.3 The location and layout of building substation shall conform to the general rules laid down in Part 2 of this Code. The substation room shall be well ventilated and inaccessible to birds and reasonably reptile-, rodent- and insect-proof. Only authorized persons be allowed to enter the substation for operations/maintenance of any kind. Cables leading from the substation to the main building shall preferably be carried underground through ducts or pipes of adequate dimensions. Such pipes shall be properly sealed at both ends to reduce the possibility of rain water flowing through the pipes and flooding the trenches.

6.3.4 *Emergency Supply*

Wherever emergency supply is considered necessary, it can be in the form of separate and independent feeder from the undertaking terminated in equipment isolated from the regular supply line. In case of standby supply from diesel generator set, it will be installed as per the general rules laid down in Part 2 of this Code.

6.3.4.1 In office buildings, certain safety and essential services shall be supplied even in the case of mains failure. These are governed by the rules and regulations of the respective authorities. Essential services include amongst others, water-pressure pumps, ventilation installations, essential lighting and lifts. The power requirement of these essential loads is generally about 25 percent of the total power requirement of the building.

6.3.5 *Switchboards and Panel Boards*

All current carrying equipment shall be totally enclosed, dust-and vermin-proof and if mounted outdoor, shall be of weatherproof construction or housed in weatherproof kiosk or cabin. Switchboards shall be of open type or cubicle type. Cubicle type boards shall be with hinged doors interlocked with switch-operating mechanisms. All switches shall bear labels indicating their functions. Switchboards shall be located away from areas likely to be crowded by the public.

6.3.6 Selection of equipment shall be made according to the guidelines laid down in Part 1/Section 9 of this Code. For the purposes of office buildings, shopping and commercial centres, miniature circuit-breakers of adequate capacity shall be preferred to switchfuse units. They can also be effectively used in place of fuses in a distribution board.

6.4 Metering

In multi-storied buildings, a number of offices, and commercial centres occupy various areas. Electrical load for each of them would have to be metered separately; the meter-room normally is situated in the ground floor (*see* IS 15707 for further guidance).

6.5 System Protection

6.5.0 *General*

The general rules for protection for safety laid down in Part 1/Section 7 of this Code shall apply. Reference is also drawn to SP 7 on guidelines for fire protection of buildings. The general rules given below shall apply.

6.5.1 The type of buildings covered in this Section fell under Group B (educational buildings). Group E (business buildings) and Group F (mercantile buildings) from the point of view of fire safety classification (*see* SP 7). Typical fire fighting installation requirements are also covered therein. The electrical needs for the appropriate type of installation shall, therefore, be decided accordingly.

6.5.1.1 *Educational buildings (Group B)*

Educational buildings above 2-storeys having an area of more than 500 m^2 per floor shall have besides fire-fighting equipment, manually operated electrical fire alarm and automatic fire alarm systems.

6.5.1.2 *Business buildings (Group E)*

Besides fire-fighting equipment, automatic fire alarm systems are recommended for offices, banks, professional establishments, etc, where the buildings are more than 2 storey with floor area above 500 m^2 per floor, and for laboratories with delicate instruments as well as computer installations.

6.5.1.3 *Mercantile buildings (Group F)*

Besides fire-fighting equipment, automatic sprinkles and automatic fire alarm systems are recommended for wholesale establishments, warehouses, transport booking agencies, etc, as well as for shopping areas inside buildings with area more than 500 m^2 on each floor. For other premises and shopping lines with central corridors open to sky, automatic fire-alarm systems shall be installed. Underground shopping centres shall be provided with automatic sprinkles.

6.6 Building Services

6.6.1 *Lighting*

6.6.1.1 The general rules laid down in Part 1/Section 11 of this Code shall apply. The choice of lamps, lighting fittings and general lighting design together with power requirement shall be planned based on the recommended values of illumination and limiting values of glare index given in Table 1.

6.6.1.2 In commercial premises, a fairly high level of glare free lighting on working planes and subdued lighting in circulation areas are necessary. Aesthetics and interior decoration also play a part. Lighting design in showrooms includes high level of lighting in the vertical and horizontal planes, depending on the merchandise exhibited and their layout. Colour temperature characteristics of the light source shall also be taken into account in the case of showroom lighting.

6.6.2 *Air-conditioning*

6.6.2.1 The general rules laid down in Part 1/Section 14 of this Code shall apply. The design of the air-conditioning system, shall take into account the requirements stipulated in the following clauses.

6.6.2.2 In case of large air-conditioning installations (500 tonne and above) it is advisable to have a separate isolated equipment room together with electrical controls. All equipment rooms shall have provision for mechanical ventilation.

6.6.3 *Lifts and Escalators*

6.6.3.1 The general rules laid down in Part 1/ Section 14, of this Code shall apply. However, the design of lifts shall take into account the following recommendations:

Table 1 Recommended Values of Illumination and Glare Index
(*Clause* 6.6.1)

Sl No.	Building	Illumination lux	Limiting Glare Index
(1)	(2)	(3)	(4)
i)	*Banks*:		
	a) Counters, typing accounting book areas	300	19
	b) Public areas	150	19
ii)	*Libraries*:		
	a) Shelves	70-150	—
	b) Reading rooms (newspaper, magazines)	150-300	19
	c) Reading tables	300-700	22
	d) Book repair and binding	300-700	22
	e) Cataloging, sorting, stock rooms	150-300	19
iii)	*Offices*:		
	a) Entrance halls and reception area	150	—
	b) Conference rooms, executive offices	300	19
	c) General offices	300	19
	d) Business machine operation	450	19
	e) Drawing offices	450	16
	f) Corridors and lift cars	70	—
	g) Stairs	100	—
	h) Lift landings	100	—
	j) Telephone exchanges;		
	1) Manual exchange rooms (on desk)	200	16
	2) Main distribution frame room	150	25
iv)	*Schools and colleges:*		
	a) Assembly halls:		
	1) General	150	16
	2) When used for exams	300	16
	3) Platforms	300	16
	b) Class and lecture rooms:		
	1) Desks	300	16
	2) Black board	200-300	—
	c) Embroidery and sewing rooms	700	10
	d) Art rooms	450	16
	e) Libraries	(*see* Sl No. ii above.)	
	f) Manual training	[*see* appropriate trades in IS 3646 (Part 2)]	
	g) Offices	300	19
	h) Staff rooms, common rooms	150	19
	j) Corridors	70	—
	k) Stairs	100	—
v)	*Shops and stores*[1)]:		
	a) General areas	150-300	22
	b) Stock rooms	200	25

[1)] Does not cover display (showroom lighting).

6.6.3.2 *Occupant load*

These shall be as follows:

Sl No.	*Occupancy*	*Occupation Load Gross Area in m^2/Person*
(1)	(2)	(3)
i)	Educational	4
ii)	Business	10
iii)	Mercantile:	
	1) Ground floor and sales	3
	2) Upper sale floor	6

6.6.3.3 *Passenger handling capacity (H)*

These are expressed in terms of percent of the estimated population that has to be handled in the building in the 5 min peak period as follows:

Sl No.	*Occupancy*	*H (Percent)*
(1)	(2)	(3)
i)	Diversified (mixed) office occupancy	10-15
ii)	Single purpose office occupancy	15-25

6.6.3.4 *Car speed* — These shall be as follows:

Sl No.	*Occupancy*	*No. of Floors Served*	*Car Speed 20 m/s*
(1)	(2)	(3)	(4)
i)	Office building	4-5	0.5-0.75
		6-12	0.75-1.5
		13-20	Above 1.5
ii)	Shops and departmental stores		2-2.5

6.6.3.5 For office buildings, it is desirable to have at least a battery of 2 lifts at two or more convenient points. If this is not possible, it is advisable to have at least two lifts side by side at the main entrance and one lift each at different sections of the building for inter-communication. When two lifts are installed side by side, the machine room shall be suitably planned. All machines and switchgear may be housed in one machine room.

7 TESTING OF INSTALLATION

The various tests on the installation shall be carried out as laid down in Part 1/Section 13 of this Code.

8 MISCELLANEOUS PROVISIONS

8.1 Group Control

8.1.1 The lighting circuits shall preferably be combined in switched groups as well as coordinated to functional groups of desks in an open plan office. The switching points may be combined centrally at the entrance passageways. In order to ensure proper co-ordination with design of the building for daylight use of devices such as photoelectric switches shall be encouraged for controlling lighting groups near windows.

8.2 Telephones/Intercoms

8.2.1 Adequate coordination shall be ensured right from the planning stages with the telephone authorities to determine the needs for the telephone system catering to the various units in office buildings. For private intercom systems, entirely under the control of the user, it is necessary to pre-plan the coordination of external and intercom systems.

8.3 Electric Call Bell System

8.3.1 The general guidelines laid down in Part 1/ Section 11, regarding installation of electric bells and call system shall be referred to. Depending on the final requirements of the type of occupancy, the type of equipment to be used, wiring and other details shall be agreed to.

8.3.2 A simple call bell system is suitable for small offices whereby service staff may be called to a particular position by the caller. A visible-*cum*-audible indicator/bell panel shall be used. When call points are too numerous on a single indicator panel, such as in large offices, multiple call system shall be preferred. The layout in such a case would be determined by the size of building and staff. Time bell systems shall be installed in schools to give Start-work and Stop-work signals.

8.4 Clock Systems

8.4.1 The general guidelines contained in Part 1/ Section 14 shall apply regarding installation and maintenance of master and slave clock systems.

8.4.2 In simple installations, impulse clocks designed to operate at the same current may be connected in one series circuit, with a battery having sufficient voltage to ensure satisfactory operation. In a more complex installation like multi-storeyed office buildings with large number of slave clocks, the impulse clocks may be arranged in number of series circuits. Each of which is connected to a pair of contact on a relay which is operated from the contacts of master clock.

8.4.3 Master clock shall be placed in a dust free location, readily accessible for maintenance at all times.

8.5 Closed Circuit TV

8.5.1 Commercial buildings may require the installations of CCTVs for one of more of the following purposes:

a) Security, and
b) Information display.

Educational/institutional buildings may use CCTV as a teaching aid for pre-recorded educational programmes. Reference shall be made to good practice for installations of such facilities.

8.6 Emergency Lights for Critical Areas

Battery powered (at least 2 h rating) emergency lights should be installed at critical and strategic locations including emergency exit points. These will provide illumination by self contained battery source even on failure of a.c. mains. On resumption of a.c. power supply, they will switch back to mains automatically and simultaneous recharge the battery to the required level.

8.7 Emergency Exit Signage

Photo luminescent safety signage should be provided at different strategic locations.

SECTION 3 RECREATIONAL, ASSEMBLY BUILDING

0 FOREWORD

A variety of buildings are being used for public assembly for purposes that are recreational, amusement, social or religious. These include cinema halls, theatres, auditoria and the like, the primary feature being a congregation of people of all age groups for a short period of time during a day or a group of days. Buildings such as those catering to display of regular programmes demands a continuous power supply. In view of the nature of use of such occupancies, certain specific safety and reliability considerations become necessary for the electrical installations.

The lighting design of such buildings are generally sophisticated, required to be properly coordinated with the electro-acoustic demands. On the physical aspects of lighting and sound systems in recreational buildings, it is recommended that assistance should be derived from specialists as such details are beyond the scope of this Code.

Sports buildings, which are also basically assembly buildings, are covered separately under Part 3/Sec 6 of this Code, in view of their unique nature. The type of buildings covered in this Section are enumerated in **4**. It shall also be noted that assembly buildings forming part of other building complex, say, educational or office-commercial-cum-cinema complex shall also comply with this Section.

1 SCOPE

1.1 This Part 3/Section 3 of the Code covers requirements for electrical installation in buildings, such as those meant for recreational and assembly purposes.

1.2 This Part 3/Section 3 does not cover sports buildings.

2 REFERENCES

This Part 3/Section 1 of the Code should be read in conjunction with the following Indian Standards:

IS No.	*Title*
8061 : 1976	Code of practice for design, installation and maintenance of service lines upto and including 650 V
SP 72 : 2010	National Lighting Code

3 TERMINOLOGY

For the purpose of this Section, the definitions given in Part 1/Section 2 of this Code shall apply.

4 CLASSIFICATION

4.1 The electrical installations covered in this Section, are those in buildings intended for the following purposes:

Assembly/Recreational Buildings — These shall include any building where groups of people congregate or gather for amusement, recreation, social, religious, patriotic, civil and similar purposes, for example, theatres, motion-picture (cinema) houses, assembly halls, auditoria, exhibition halls, museums, restaurants, places of worship, dance halls, clubs, etc.

NOTE — Theatres are also classified further as permanent (air-conditioned and non-air-conditioned), temporary or traveling depending on the nature or construction of the premises. Temporary installations shall also conform to the additional provisions laid down in Part 5/Section 2 of this Code.

5 GENERAL CHARACTERISTICS OF INSTALLATIONS

5.0 General guidelines on the assessment of characteristics of installations in buildings are given in Part 1/ Section 8 of this Code. For the purpose of installations falling under the scope of this section, the characteristics defined below generally apply.

5.1 Environment

The following environmental factors shall apply to recreational and assembly buildings:

Environment (1)	*Characteristics* (2)	*Remarks* (3)
Presence of water	Probability of presence of water is negligible	—
Presence of foreign solid bodies	The quantity or nature of dust or foreign solid bodies is not significant	—
Presence of corrosive or polluting substances	The quantity and nature of corrosive or polluting substances is not significant	—
Mechanical stresses	Impact and vibration of low severity	—
Seismic effect and lighting	—	Depends on the location of the building

5.2 Utilization

The following aspects of utilization shall apply:

Utilization (1)	*Characteristics* (2)	*Remarks* (3)
Capability of persons	Uninstructed persons	Majority of the occupants
	Persons adequately advised or supervised by skilled persons	Electrical operating areas
Conditions of evacuation during emergency	High density occupation, easy conditions of evacuation	Small theatres and cinemas
	High density occupation difficult conditions of evacuation	Multiple cinema halls, cultural and theatrical buildings
Nature of processed of stored material	Existence of fire risk	In view of large quantum of furniture and drapings

6 SUPPLY CHARACTERISTICS AND PARAMETERS

6.0 Exchange of Information

6.0.1 Proper coordination shall be ensured between the architect, building contractor and the electrical engineer on the various aspects of the installation design in a building intended for recreational or assembly purposes. For large projects, the advice of the appropriate specialists shall be obtained, in particular on the following aspects:

a) Audio-visual systems,
b) Stage lighting and control, and
c) General auditorium lighting and other special service needs.

6.0.2 The installation work shall conform to the provisions of *Indian Electricity Rules* as well as other Rules applicable for assembly buildings formulated by the State Authorities.

6.1 Branch Circuits

6.1.0 The branch circuits shall in general cater to the following individual load groups:

a) Power installation:
   1) Stage machinery,
   2) Ventilation and air-conditioning installation,
   3) Lifts, and
   4) Additional power connections.
b) Lighting:
   1) In front of the theatre, such as general lighting of outdoor, foyer, corridors and stairs, and auditorium; and
   2) In the rear of the theatre for stage, work place dressing rooms, workshops and storehouses.
c) Emergency supply.

6.1.1 The electrical lighting of the main building shall have at least three separate and distinct main circuits as follows:

a) For the enclosures (cabin) and hence through a dimmer regulator to the central lighting of the auditorium;
b) For one-half of the auditorium, passage ways, stairways, exit and parts of the building open to the public; and
c) For the remaining half of the auditorium, passage ways, stairways, exit and parts of the building open to the public.

6.1.2 The control of the circuits in respect of the two halves of the auditorium referred to in **6.1.1** shall be remote from each other.

6.1.3 The cabin shall be provided with two separate circuits, one feeding the cabin equipments and the other lights and fans.

6.1.4 Wiring shall be of the conduit type. Ends of conduits shall enter and be mechanically secured to the switch, control gears, equipment terminal boxes, etc. Ends of conduits shall be provided with screwed bushes. Within the enclosure, all cables shall be enclosed in screwed metal conduits adequately earthed. PVC conduits may be used in the auditorium and other places.

6.1.5 Temporary wiring shall not be allowed in cabin, rewinding room, queue sheds and similar places.

6.1.6 The cabin equipment shall be accessible at all times. Nothing shall impede access to any part of the equipment or its controls.

6.1.7 Linked tumbler switches shall not be used for the control of circuits.

6.1.8 Branch and main distribution boards shall be mounted at suitable height not higher than 2 m from the floor level. A front clearance of 1 m should also be provided.

6.1.9 Wood work shall not be used for the mounting of or construction of the framework for iron-clad switch and distribution boards and controlgear.

6.1.10 All the lighting fittings shall be at a height of not less than 2.25 m.

6.1.11 The single pole switches for the individual lights and fans shall be mounted on sheet steel boards suitably earthed.

6.1.12 Suitable socket outlets with controls shall be provided on the side walls near the stage for tapping supply to screen motor; stage focusing lights, audio systems and portable lights.

6.1.13 In the queue sheds, bulk head fittings shall be used.

6.1.14 For outdoor lighting, water-tight fittings shall be used and fittings may be so mounted without spoiling the aesthetic view of the recreation buildings.

6.1.15 The installation in a traveling cinema should generally conform to the above requirements and the building should be sufficiently away from the nearest conductor of power lines (*see* **3.2** of Part 1/Section 7 of this Code).

6.1.16 The plug points shall be provided at a height of about 1.5 m from the floor, in assembly buildings.

6.1.17 In case of travelling cinemas, the wiring for the open yard lighting shall be done with weather-proof cables threaded through porcelain reel insulators suspended by earthed bearer wire at a height of not less than 5 m from ground level. The reel insulators shall be spaced 0.5 m from each other.

6.1.18 When a tapping is taken from the open yard wiring, it should be taken only at a point of support through porcelain connectors housed in a junction box, fixed to the supporting pole.

6.2 Feeders

6.2.1 Feeder circuits shall generally conform to the requirements laid down in Part 1/Section 11 of this Code.

6.2.2 Separate feeders shall be taken to air-conditioning units, lifts and the lighting and fan circuits.

6.3 Service Lines

Service lines shall conform to IS 8061.

6.4 Building Substation

6.4.0 The electrical power demand of an assembly building can vary from 30 kVA to more than 1 000 kVA according to the size of the building. Usually, supply at voltages above 1 kV is given for large theatres and auditoria. Building substations shall conform to the general requirements specified in Part 2 of this Code.

6.4.1 The following aspects shall be taken note of while deciding the location of substation:

a) As there will be concentration and movement of people, the substation should be located away from the area where people and vehicles move about, preferably at the rear of the building.
b) The substation should not be in the way of people and fire-fighting vehicles and personnel where they are likely to attend to an emergency.

6.5 System Protection

6.5.0 The rules for protection for safety laid down in Part 1/Section 7 of this Code shall apply. Reference may also be made to SP 7 on guidelines for fire protection of buildings. The general rules given below shall apply.

6.5.1 The type of occupancies covered in this Section fall under Group D (assembly buildings) from the point of view of fire safety classification. Such occupancies can be further classified into groups depending on the capacity of the theatre [auditorium to hold the congregation (*see* SP 7)]. Typical fire-fighting installation requirements are also covered therein. The following shall be provided besides fire-fighting equipment:

a) Building having a theatrical stage and fixed seats:
   1) Stage — Automatic sprinkler; and
   2) Auditoria, corridor, green rooms, canteen and storage Automatic fire-alarm system.
b) Buildings without a stage but no permanent seating arrangement—Automatic fire alarm system.
c) All other structures designed for assembly — Manually operated electrical fire-alarm system.

6.6 Building Services

6.6.1 *Lighting*

The general rules laid down in Part 1/Section 11 of this Code shall apply. The choice of lamps, lighting fitting and general lighting design together with power requirement shall be planned based on the recommended values of illumination and glare index given in Table 1 (*see* SP 72).

6.6.2 *Air-conditioning*

6.6.2.1 The general rules laid down in Part1/Section 11 of this Code shall apply.

6.6.2.2 In air-conditioned assembly buildings, inside temperature shall be 22 ± 2°C.

6.6.2.3 Provisions shall be made to record the temperature inside the auditorium.

Table 1 Recommended Values of Illumination and Glare Index
(*Clause* 6.6.1)

Sl No.	Part of Building	Illumination lux	Limiting Value of Glare Index
(1)	(2)	(3)	(4)
1.	*Assembly and concert:*		
	a) Foyers, auditoria	100-150	—
	b) Platforms	450	—
	c) Corridors	70	—
	d) Stairs	100	—
2.	*Cinemas:*		
	a) Foyers	150	—
	b) Auditoria	50	—
	c) Corridors	70	—
	d) Stairs	100	—
3.	*Museums:*		
	a) General	150	16
	b) Display	Special lighting	16
4.	*Art Galleries:*		
	a) General	100	10
	b) Paintings	200	10
5.	*Theatres:*		
	a) Foyers	150	—
	b) Auditoria	70	—
	c) Corridors	70	—
	d) Stairs	100	—

NOTE — The above is meant for general guidelines and does not include special lighting effects.

6.6.2.4 In the event of a breakdown of the air-conditioning plant, alternate arrangements should be available for ventilation and air circulation.

6.6.3 *Lifts and Escalators*

The general rules laid down in Part 1/Section 11 of this Code shall apply. However, the design of the lifts shall take into account the following recommendations:

a) *Occupant load*

This shall be as follows:

Occupancy	*Occupant Load, Gross Area* (m^2/*Person*)
Assembly halls with fixed or loose seats and dance floors	0.6
Without seating facilities including dining rooms	1.5

b) Passenger handling capacity and car speed — As given in Part 3/Section 2 of this Code.

7 TESTING OF INSTALLATIONS

The various tests on the installations shall be carried out as laid down in Part 1/Section 13 of this Code.

8 MISCELLANEOUS PROVISIONS

8.1 Emergency Supply

See also Part 2 of this Code.

8.1.1 In all recreational and assembly buildings, sufficient number of emergency lights in all the locations which includes all the emergency exit.

8.1.2 Battery powered (at least 2 h rating) emergency lights should be installed at critical and strategic locations to avoid catastrophic in case of total power failure. These will provide illumination by self contained battery source even on failure of a.c. mains. On resumption of a.c. power supply, they will switch back to mains automatically and simultaneous recharge the battery to the required level.

8.1.3 Depending on the total capacity required for standby supply for the occupancy, suitable standby generator set shall be installed. The location and installation of the standby DG set should be in accordance with the norms specified in Part 2 of this Code.

8.2 Stage Lighting

On the stage of a theatre, a great number of spotlights, border lights, projectors, etc, are required for illumination, including portable light sources. The various possibilities of switching each fittings shall be kept in view while designing the lighting circuits. For same lighting schemes, dimmer-control equipment may be required.

8.3 Group Control

The lighting in the auditorium shall be suitably combined into control groups to facilitate group switching. In the special case of stage lighting control, the lighting operator shall have a good view of the stage in order to be able to follow the performance. Therefore, the control-room shall be situated in a convenient position.

8.4 Audio-Visual System

Installation of amplifying and sound distribution systems shall conform to the guidelines contained in Part 1/Section 11 of this Code.

8.5 Luminous Sign

Photo luminescent safety signage should be provided at different strategic locations.

SECTION 4 MEDICAL ESTABLISHMENTS

0 FOREWORD

Hospitals in the country vary in size from simple premises used for medical purposes in villages to a well-equipped, multidisciplinary hospital in big cities. The lattser type will have several units functioning simultaneously with a variety of support services to cater to the needs of doctors and patients.

Safety requirements for electrical equipment used in medical practice are covered IS 13450 series. Additional safety provisions in the electrical installations of medically used rooms and medical establishments are covered in this Section of the Code. This Section 4 is based on the following considerations:

a) The patient may not be in a condition to react normally to the effects of hazardous events;
b) The electrical resistance of the skin, which is normally an important protection against harmful electric currents is bypassed in certain examinations or treatments;
c) Medical electrical equipment may often be used to support or substitute vital body functions, the breakdown of which may cause a dangerous situation;
d) Specific locations in medical establishments where flammable atmosphere exists, call for special treatment; and
e) Electric and magnetic interference may disturb certain medical examinations or treatments.

1 SCOPE

This Part 3/Section 4 of this Code applies to the electrical installations in medical establishments. This Section is also applicable to rooms for veterinary medicine and dental practice.

2 REFERENCES

This Part 3/Section 4 of the code should be read in conjunction with the following Indian Standards:

IS No.	*Title*
3646 (Part 2) : 1966	Code of practice for interior illumination : Part 2 Schedule for values of illumination and glare index
7689 : 1989	Guide for the control of undesirable static electricity
8061 : 1976	Code of practice for design, installation and maintenance of service lines upto and including 650 V
13450 (Part 1) : 1994 /IEC 60601-1 : 1988	Medical electrical equipment : Part 1 General requirements for safety
14665 (Part 1) : 2000	Electric traction lifts : Part 1 Guidelines for outline dimensions of passenger, goods, service and hospital lifts
SP 7 : 2005	National Building Code of India
SP 72 : 2010	National Lighting Code

3 TERMINOLOGY

In addition to the definitions contained in Part 1/ Section 2 of this Code the following shall apply.

3.1 Rooms

3.1.1 *Anaesthetic Room* — Medically used room in which general inhalation anesthetics are intended to be administered.

NOTE — Anaesthetic room comprises for instance the actual operating theatre, operating preparation room, operating plaster room and surgeries.

3.1.2 *Angiographic Examination Room* — Room intended for displaying arteries or veins, etc, with contrast media.

3.1.3 *Central Monitoring Room* — Room in which the output signals of several patient monitors are displayed, stored or computed.

NOTE — A central monitoring room is considered to be part of a Room Group, if a conductive connection (for example, by signal transmission lines) between the rooms of such a group exists.

3.1.4 *Central Sterilization Room* — Room, not spatially connected to a medically used room, in which medical equipment and utensils are sterilized.

3.1.5 *Delivery Room* — Room in which the actual birth takes place.

3.1.6 *Endoscopic Room* — Room intended for application of endoscopic methods for the examination of organs through natural or artificial orifices.

Examples of endoscopic methods are bronchoscopic, laryngoscopic, cystoscopic, gastroscopic and similar methods, if necessary, performed under anaesthesia.

3.1.7 *Heart Catheterization Room* — Room intended for the examination or treatment of the heart using catheters.

Examples of applied procedures are measurement of action potentials of the haemodynamics of the heart, drawing of blood samples, injection of contrast agents or application of pacemakers.

3.1.8 *Hemodialysis Room* — Room in a medical establishment intended to connect patients to medical electrical equipment in order to detoxicate their blood.

3.1.9 *Hydrotherapy Room* — Room in which patients are treated by hydrotherapeutic methods.

Examples of such methods are therapeutic treatments with water, brine, mud, slime, clay, steam, sand, water with gases, brine with gases, inhalation therapy, electrotherapy in water[1)], massage thermotherapy and thermotherapy in water[1)].

Swimming pools for general use and normal bathrooms are not considered as hydrotherapy rooms.

3.1.10 *Intensive Care Room* — Room in which bed patients are monitored independently of an operation by means of electromedical equipment. Body actions may be stimulated, if required.

3.1.11 *Intensive Examination Room* — Room in which patients are connected for the purpose of intensive examination, but not for the purpose of treatment, simultaneously to several electromedical measuring or monitoring devices.

3.1.12 *Intensive Monitoring Room* — Room in which operated patients are monitored, using electromedical equipment. Body actions (for example, heart circulation, respiration) may be stimulated, if required.

3.1.13 *Labour Room* — Room in which patients are prepared (waiting) for delivery.

3.1.14 *Medical Establishment* — Establishment for medical care (examination, treatment, monitoring, transport, nursing, etc) of human beings or animals.

3.1.15 *Medically Used Room* — Room intended to be used for medical, dental or veterinary examination, treatment or monitoring of persons or animals.

3.1.16 *Minor Surgical Theatre* — Room in which minor operations are performed on ambulant or non-ambulant patients, if necessary using anesthetics or analgesics.

3.1.17 *Operating Plaster Room* — Room in which plaster of Paris or similar dressings are applied while anaesthesia is maintained.

NOTE — Such a room belongs to the operating room group and is usually spatially connected to it.

3.1.18 *Operating Preparation Room* — Room in which patients are prepared for an operation, for example, by administering anaesthetics.

NOTE — Such a room belongs to the operating room group and is spatially connected to it.

3.1.19 *Operating Recovery Room* — Room in which the patient under observation recovers from the influence of anesthesia.

NOTE — Such a room is usually very close to the operating room group but not necessarily part of it.

3.1.20 *Operating Sterilization Room* — Room in which utensils required for an operation are sterilized.

NOTE — Such a room belongs to the operating room group and is spatially connected to it.

3.1.21 *Operating Theatre* — Room in which surgical operations are performed.

3.1.22 *Operating Wash Room* — Room in which medical staff at an operation can wash for disinfection purposes.

NOTE — Such a room belongs to the operating room group and is spatially connected to it.

3.1.23 *Physiotherapy Room* — Room in which patients are treated by physiotherapeutic methods.

3.1.24 *Radiological Diagnostic Room* — Room intended for the use of ionizing radiation for display of internal structures of the body by means of radiography or fluoroscopy or by the use of radio-active isotopes or for other diagnostic purposes.

3.1.25 *Radiological Therapy Room* — Room intended for the use of ionizing radiation to obtain therapeutic effects on the surface of the body or in internal organs by means of X-radiation, gamma radiation or corpuscular radiation or by the use of radio-active isotopes.

3.1.26 *Room Group* — Group of medically used rooms linked with each other in their function, by their designated medical purpose or by interconnected medical electrical equipment.

3.1.27 *Urology Room* — Room in which diagnostic or therapeutic procedures are performed on the urogenital tract using electromedical equipment, such as X-ray equipment, endoscopic equipment and high-frequency surgery equipment.

3.1.28 *Ward* — Medically used room or room group in which patients are accommodated for the duration of their stay in a hospital, or in any other medical establishment.

3.2 Zones of Risk (*see also* Annex A).

3.2.1 *Flammable Anaesthetic Atmosphere* — Mixture of a flammable anaesthetic vapour and/or a vapour of a flammable disinfection or cleaning agent with air in

[1)] With or without additives.

such a concentration that ignition may occur under specified conditions.

3.2.2 *Flammable Anaesthetic Mixture* — Mixture of a flammable anaesthetic vapour with oxygen or with nitrous oxide in such a concentration that ignition may occur under specified conditions.

3.2.3 *Zone G* — Volume in a medically used room in which continuously or temporarily small quantities of flammable anaesthetic mixtures may be produced, guided or used including the surroundings of a completely or partly enclosed equipment or equipment part up to a distance of 5 cm from parts of the equipment enclosure where leakage may occur because such parts are:

a) unprotected and liable to be broken,

c) subject to a high rate of deterioration, or

c) liable to inadvertent disconnection.

Where the leakage occurs into another enclosure which is not sufficiently (naturally or forcedly) ventilated and enrichment of the leaking mixture may occur, such an enclosure and possibly the surroundings of it (subject to possible leakage) up to a distance of 5 cm from said enclosure or part of it is regarded as a Zone G.

3.2.4 *Zone M* — Volume in a medically used room in which small quantities of flammable anaesthetic atmospheres of flammable anaesthetics with air may occur. A Zone M may be caused by leakage of a flammable anaesthetic mixture from a Zone G or by the application of flammable disinfection or cleaning agents. Where a Zone M is caused by leakage, it comprises the space surrounding the leakage area of a Zone G up to a distance of 25 cm from the leakage point.

3.3 Special Terms

3.3.1 *Equipotential Bonding* — Electrical connection intended to bring exposed conductive parts or extraneous conductive parts to the same or approximately the same potential.

3.3.2 *Essential Circuit* — Circuit for supply of equipment which is kept in operation during power failure.

NOTE — Provisions for supply of such circuit separately from the remainder of the electrical installation are present.

3.3.3 *Generator Set* — Self-contained energy convertor including all essential components to supply electrical power (for example, engine driven generator).

3.3.4 *Hazard Current* — Total current for a given set of connections in an isolated power system that would flow through a low impedance if it were connected between either — isolated conductor and earth.

The following hazard currents are recognized:

a) *Total hazard current* — Hazard current of an isolated system with all supplied equipment, including the line isolation monitor, connected.

b) *Fault hazard current* — Hazard current of an isolated system with all supplied equipment, except the line isolation monitor, connected.

c) *Monitor hazard current* — Hazard current of the line isolation monitor.

NOTE — This current is expressed in milliamperes (mA).

3.3.5 *Insulation Impedance Monitoring Device* — A device measuring the ac impedance at mains frequency from either of the conductors of an isolated circuit to earth and predicting the hazard current that will flow when an earth fault occurs and providing an alarm when a preset value of that current is exceeded.

3.3.6 *Insulation Monitoring Device* — Instrument indicating the occurrence of an insulation fault from a live part of an isolated electrical supply system to the protective conductor of the installation concerned.

3.3.7 *Insulation, Resistance Monitoring Device* — Instrument measuring the ohmic resistance between the monitored isolated circuit and earth providing an alarm when the value of this resistance becomes less than a given limit.

3.3.8 *Medical Isolating Transformer* — Electrical equipment used in medical practice intended to supply isolated power to medical electrical equipment in order to minimize the likelihood of discontinuity of supply in case of a failure to earth in the isolated power source or in equipment connected to it.

3.3.9 *Medical Safety Extra-Low Voltage (MSELV)* — Voltage not exceeding a nominal value of 25 V ac or up to and including 60 V dc or peak value at rated supply voltage on the transformer or converter between conductors is an earth-free circuit isolated from the supply mains by a medical safety extra-low voltage transformer or by a converter with separate windings.

3.3.10 *Operating Residual Current* — Value of a residual current causing a protective device to operate under specified conditions.

3.3.11 *Patient Environment* — Any area up to 1.5 m distance from the intended location of the patient in which intentional or unintentional contact between patient and equipment or some other person touching the equipment can occur (*see* Annex B).

3.3.12 *Touch Voltage* — Voltage appearing, during an insulation fault, between simultaneously accessible parts.

4 CLASSIFICATION

4.1 The electrical installations covered in this Section are those in buildings intended for the following purposes:

a) *Hospitals and sanatoria* — This includes any building or group of buildings, which is used for housing treating persons suffering from physical limitations because of health, age, injury or disease. This also includes infirmaries, sanatoria and nursing homes.

b) *Custodial institutions* — This includes any building or group of buildings which is used for the custody and care of persons, such as children (excluding schools), convalescents and the aged, for example, home for the aged and infirm, convalescent homes, orphanages, mental hospitals, etc.

5 GENERAL CHARACTERISTICS OF MEDICAL ESTABLISHMENTS

5.0 General guidelines on the assessment of characteristics of installations in buildings are given in Part 1/Section 8, of this Code. For the purpose of installations falling under the scope of this Section, the characteristics given below apply.

5.1 Environment

The following environmental factors shall apply to hospitals:

Environment (1)	*Characteristics* (2)	*Remarks* (3)
Presence of water	Probability of presence of water is negligible	
Presence of foreign solid bodies	The quantity or nature of dust or foreign solid bodies is not significant	—
Presence of corrosive or polluting substances	The quantity and nature of corrosive or polluting substances is not significant	Locations where some chemical products are handled (for example, laboratories in hospitals) will be categorized as in Part 1/Section 8
Mechanical stresses	Impact and vibration of low severity	—
Seismic effect and lighting	—	Depends on the location of the building

5.2 Utilization

The following aspects of utilization shall apply:

Utilization (1)	*Characteristics* (2)	*Remarks* (3)
Capability of persons	Children in locations intended for their occupation	Applies to child-care homes, orphanages, etc.
	Handicapped	Applies to hospitals in general, sanatoria, nursing homes, etc, where the occupants are not in command of all their physical and intellectual abilities
	Persons adequately advised or supervised by skilled persons	Applies to areas such as building substations, operations and maintenance staff
Contact of persons with earth potential	Persons do not in usual conditions make contact with extraneous conductive parts or stand on conducting surfaces	
Conditions of evacuation during emergency	Difficult conditions of evacuation	Applies in general to hospitals and similar buildings, irrespective of density of occupation
Nature of process fire or risk or stored materials	Fire or risk	Many locations in hospital buildings in general would fall under category BE 1 of no significant fire or explosion risk, specific locations like, operation theatre, casualty medicine store, X-Ray block fall under BE 2 and BE 3 (*see* Part 1/Section 8 of this Code)

6 SAFETY CONSIDERATIONS

6.0 General

6.0.1 In the context of this Section 'installation' means any combination of interconnected electrical equipment within a given space or location intended to supply power to electrical equipment used in medical practice.

6.0.2 As such, some parts of the installation may be present in the patient's environment, where potential differences, that could lead to excessive currents through the patient, must be avoided. For this purpose a combination of earthing of equipment and potential equalization in the installation seems to provide the best solution. A disadvantage of such a system is that in the case of an insulation fault in circuits directly connected to supply mains, the fault current may cause a considerable voltage drop over the protective earth conductor of the relevant circuit. Since a reduction of such a voltage drop by the application of increased cross-sectional areas of protective conductors is usually impractical, available solutions are the reduction of the duration of fault currents to earth by special devices or the application of a power supply which is isolated from earth.

6.0.3 Generally a power supply system including a separated protective conductor is required (TN-S-system).

In addition the following provisions may be required, depending upon the nature of the examinations or treatments performed:

a) Additional requirements concerning protective conductors and protective devices to restrict continuous voltage differences.

b) Restriction of voltage differences by supplementary equipotential bonding. During the application of equipment with direct contact to the patient, as least a potential equalized zone around the patient shall be provided with a patient centre bonding bar to which the protective and functional earth conductors of the equipment are connected. All accessible extraneous conductive parts in the zone shall be connected to this potential equalization bar.

c) Restriction of the potential equalization zone to the zone around one patient, meaning practically around one operation table or around one bed in an intensive care room.

d) If more than one patient is present in an area, connection of the various potential equalization centres to a central potential equalization busbar, which should preferably be connected to the protective earth system of the power supply for the given area.

   In its completed form the equipotential bonding network may consist partly of fixed and permanently installed bonding and partly of a number of separate bondings which are made when the equipment is set up near the patient. The necessary terminals for these bonding connections should be present on equipment and in the installation.

e) Restriction of the duration of transient voltage difference by the application of residual current operated protective devices (earth leakage circuit-breakers).

f) Continuity of power supply to certain equipment in the case of a first insulation fault to earth and restriction of transient voltage differences by application of isolating transformers.

g) Monitoring of a first insulation fault to earth in an IT-system (the secondary side of an isolating transformer) with sufficiently high impedance to earth.

h) Prevention of ignitions and fire in rooms where flammable anesthetics or flammable cleaning or disinfection agents are used by ventilation, anti-static precautions and careful layout of the installation.

j) Safety supply system for major parts of the hospital, usually a diesel-powered generator. Recommendations for essential circuits to be connected to it.

k) Special safety supply system for critical equipment as life-supporting equipment and operating room lamps.

   The power supply is taken over by these devices in a short time. The device may consist of rechargeable batteries possibly combined with converters or special generating sets.

m) Suppression of electromagnetic interference achieved by the layout of the building and wiring and provision of screening arrangements.

   Limits for magnetic fields of mains frequency are necessary for a number of sensitive measurements.

6.1 Safety Provisions

6.1.1 Safety measures are divided into a number of provisions as given in Table 1.

6.1.2 Provision P_0 shall be applicable to all buildings containing medically used rooms. Provision P_1 shall be applicable for all medically used rooms.

Other requirements of this Section, need not be complied with if:

Table 1 Safety Provisions
(*Clause* 6.1.1)

Sl No. (1)	Provisions (2)	Principal Requirements (3)	Installation Measures (4)
i)	P_0	Duration of touch voltages restricted to a safe limit	TN-S, TT or IT system
ii)	P_1	As P_0 but additionally: Touch voltages in patient environment restricted to a safe limit	Additional to P_0: Supply system with additional requirements for protective earthing, etc.
iii)	P_2	As P_1 but additionally: Resistance between extraneous conductive parts and the protective conductor but bar of the room not exceeding 0.1Ω.	Additional to P_1: Supplementary equipotential bonding
iv)	P_3	As P_1 or P_2 but additionally: Potential difference between exposed conductive parts, extraneous conductive parts and the protective conductor bus bar not exceeding 10 mV in normal condition (*see* Note)	As P_1 or P_2: Measurement necessary, corrective action possibly necessary
v)	P_4	As P_1 or P_2. Additional protection against electric shock by limitation of disconnecting time	Additional to P_1 or P_2: Residual current operated protective device
vi)	P_5	Continuity of the mains supply maintained in case of a first insulation fault to earth and currents to earth restricted	Additional to P_1, P_2 or P_3: Isolated supply system with isolation monitoring
vii)	P_6	Reduction of fault currents and touch voltages in case of a fault in the basic insulation	Additional P_1 or P_2: Medical isolating transformer supplying one individually piece of equipment
viii)	P_7	Prevention of dangerous touch voltages in normal condition and in single fault condition (*see* Note)	Additional to P_1 or P_2: Supply with medical safety, extra low voltage
ix)	*G E*	No interruption of the power supply of the essential circuits of the hospital for more than 15 s	Safety supply system
x)	E_1	No interruption of the power supply of life-supporting equipment for more than 15 s	Special safety supply system
xi)	E_2	No interruption of the power supply of the operating lamp for more than 0.5 s	Special safety supply system for operating lamp
xii)	*A*	Prevention of explosions, fire and electrostatic charges	Measures concerning explosion and fire hazards
xiii)	*I*	No exercise interference from electric and magnetic fields	Layout of building and installation, screening

NOTE — Normal condition means without any fault in the installation.

a) a room is not intended for the use of medical electrical equipment, or
b) patients do not come intentionally in contact with medical electrical equipment during diagnosis or treatment, or
c) only medical electrical equipment is used which is internally powered or of protection Class II.

The rooms mentioned under (a), (b) and (c) may be massage rooms, general wards, doctor's examining room (office, consulting room), where medical electrical equipment is not used.

6.1.3 Guidance on the application of the provisions are given in Table 2.

6.1.4 A typical example of an installation in a hospital is given in Annex C.

7 SUPPLY CHARACTERISTICS AND PARAMETERS

7.0 Exchange of Information

7.0.1 Proper coordination shall be ensured between the architect, building contractor and the electrical engineer or the various aspects of installation design. The necessary special features of installations shall be ascertained beforehand with reference to Table 2.

7.1 Circuit Installation Measures for Safety Provisions — *See* Table 1, col 3.

7.1.1 *Provision* P_0 *: General*

7.1.1.1 All buildings in the hospital area which contain medically used rooms shall have a TN-S, TT or IT power system. The conventional touch voltage limit (U_L) is fixed at 50 V ac.

NOTE — The use of TN-C-S system (in which the PEN-conductor may carry current in normal condition) can cause safety hazards for the patients and interfere with the function of medical electrical equipment, data processing equipment, signal transmission lines, etc.

7.1.2 *Provision* P_1*: Medical TN-S System*

7.1.2.1 The conventional touch voltage limit (U_L) is fixed at 25 V ac.

7.1.2.2 Protective conductors inside a medically used

Table 2 Examples of Application of Safety Provisions
(*Clause* 6.1.3)

Sl No.	Medically Used Room	Protective Measures							Safety Supply System			Explosions and Fire	Measures Against EM Fields
		P_0/P_1	P_2	P_3	P_4	P_5	P_6	P_7	GE	E_1	E_2	A	I
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
i)	Message room	M	O					O	X				
ii)	Operating wash room	M	X					O	X				
iii)	Ward general	M	O					O	X				
iv)	Delivery room	M	X		X	O		O	X	O	X	O	O
v)	ECG, EEG, EMG room	M	X		X			O	X				X
vi)	Endoscopic room	M	X		X			O	X		O		
vii)	Examination or treatment room	M	O		X	O		O	X		O		
viii)	Labour room	M	X		X	O		O	X				O
ix)	Operating sterilization room	M	O		X			O	X				
x)	Urology room (not being an operating theatre)	M	X		X			O	X		O		
xi)	Radiological diagnostic and therapy room, other than mentioned under Sl No. (xx) and (xxiv)	M	X		X			O	X				
xii)	Hydrotherapy room	M	X		X		O	O	X				
xiii)	Physiotherapy room	M	X		X	O		O	X				
xiv)	Anaesthetic room	M	X	X	X_1	X		O	X	X	X	O	O
xv)	Operating theatre	M	X	X	X_1	X		O	X	X	X	X	X
xvi)	Operating preparation room	M	X	X	X_1	X		O	X	X	X	X	X
xvii)	Operating plaster room	M	X		X_1	X		O	X	X	X	X	X
xviii)	Operating recovery room	M	X	X	X_1	X		O	X	X	X	X	X
xix)	Outpatient operating theatre	M	X		X_1	X		O	X	X	X	X	X
xx)	Heart catheterization room	M	X	X	X_1	X		O	X	X	X		X
xxi)	Intensive care room	M	X	O	X_1	X		O	X	X	X		X
xxii)	Intensive examination room	M	X	O	X_1	X		O	X	O	O		X
xxiii)	Intensive monitoring room	M	X	O	X_1	X		O	X	X	X		X
xiv)	Angiographic examination room	M	X	O	X_1	X		O	X	O	O		O
xxv)	Hemodialysis room	M	X	X	X_1	X			X				
xxvi)	Central monitoring room (*see* Note)	M	X	O	X_1	X		O	X				O

NOTE — Only if such a room is part of a medical room group and therefore installed in the same way as an intensive monitoring room. Central monitoring room having no conductive connection to the medically used room (for example, by use of isolating coupling devices for signal transmission) may be installed as non-medically used room (provision P_0 only).

Explanation:
M = Mandatory measure.
X = Recommended measure.
X_1 = As X, but only for equipment described in **7.1.6.7**.
O = Additional measure, may be considered desirable.

room shall be insulated: their insulation shall be coloured green-yellow (*see* Part 1/Section 4 of this Code).

7.1.2.3 Exposed conductive parts of equipment being part of the electrical installation used in the same room shall be connected to a common protective conductor.

7.1.2.4 A main equipotential bonding with a main earthing bar shall be provided near the main service entrance. Connections shall be made to the following parts by bonding conductors:

a) lightning-conductor;
b) earthing systems of the electric power distribution system;
c) the central heating system;
d) the conductive water supply line;
e) the conductive parts of the waste water line;

f) the conductive parts of the gas supply; and
g) the structural metal framework of the building, if applicable.

Main equipotential bonding conductors shall have cross-sectional areas not less than half the cross-sectional area of the largest protective conductor of the installation, subject to a minimum of 6 mm^2. The cross-sectional area need not, however, exceed 25 mm^2, if the bonding conductor is of copper or a cross-sectional area affording equivalent current-carrying capacity in other metals.

7.1.2.5 Each medically used room or room group shall have its own protective conductor bus bar, which should have adequate mechanical and electrical properties and resistance against corrosion.

This bus bar may be located in the relevant power distribution box. The leads connected to terminals of such a protective conductor bar shall be identified and shall be similarly designated on drawings of the installation system.

7.1.2.6 The impedance *(Z)* between the protective conductor bar and each connected protective conductor contact in wall sockets or terminals should not exceed 0.2 Ω, if the rated current of the overcurrent protective device is 16 A or less. In case of a rated current exceeding 16 A the impedance should be calculated using the formula:

$$Z = \frac{25}{6.I_r}\Omega \text{ in all cases } Z \text{ shall not exceed } 0.2\ \Omega.$$

where

I_r = rated current of overcurrent protective device in amperes (A).

NOTE — The measurement of the protective conductor impedance should be performed with an ac current not less than 10 A and not exceeding 25 A from a source of current with a no-load voltage not exceeding 6 V, for a period of at least 5 s.

7.1.2.7 The cross-sectional area of the protective conductor shall be not less than the appropriate value shown in Table 3.

Table 3 Cross-sectional Area of Conductors

Sl No.	Cross-sectional Area of Phase Conductor, *S*, mm^2	Minimum Cross-sectional Area of the Corresponding Protective Conductor, PE, mm^2
(1)	(2)	(3)
i)	$S \leq 16$	S
ii)	$16 < S \leq 35$	16
iii)	$S > 35$	$S/2$

NOTE — If the application of this table produces non-standard sizes, conductors having the nearest standard cross-sectional area are to be used.

The values given in Table 3 are valid only if the protective conductor is made of the same metal as the phase conductors. If this is not so, the cross-sectional area of the protective conductor is to be determined in a manner which produces a conductance equivalent to that which results from the application of Table 3.

The cross-sectional area of every protective conductor which does not form part of the supply cable or cable enclosure shall be, in any case, not less than:

a) 2.5 mm^2, if mechanical protection is provided, and
b) 4 mm^2, if mechanical protection is not provided.

7.1.2.8 It may be necessary to run the protective conductor separate from the phase conductors, in order to avoid measuring problems when recording bioelectric potentials.

7.1.3 *Provision P_2: Supplementary Equipotential Bonding*

7.1.3.1 In order to minimize the touch voltage, all extraneous conductive parts shall be connected to the system of protective conductors.

An equipotential conductor bar shall be provided. It should be located near the protective conductor bar (*see also* **7.1.2.5**). A combined protective conductor and equipotential bonding bar may be used, if all conductors are clearly marked according to **7.1.2.5** and **7.1.3.3** (e).

7.1.3.2 Connections shall be provided from the equipotential bonding bar to extraneous conductive parts, such as pipes for fresh water, heating, gases, vacuum and other parts with a conductive surface area larger than 0.02 m^2 or a linear dimension exceeding 20 cm, or smaller parts that may be grasped by hand.

Additionally the following requirements supply:

a) Such connections need not be made to:
   1) Extraneous conductive parts inside of walls (for example structural metal frame work of buildings) having no direct connection to any accessible conductive part inside the room, and
   2) conductive parts in a non-conductive enclosure.
b) In locations where the position of the patient can be predetermined this provision may be restricted to extraneous conductive parts within the patient environment (*see* Annex B)
c) In operating theatres, intensive care rooms, heart catheterization rooms and rooms

intended for the recording of bioelectrical action potentials all parts should be connected to the equipotential bonding bar *via* direct and separate conductors.

7.1.3.3 The following requirements shall be fulfilled:

a) The impedance between extraneous conductive parts and the equipotential bonding bar shall not exceed 0.1.

NOTE — The measurement of this impedance should be performed with a current not less than 10 A and not exceeding 25 A during not less than 5 s from a current source with a no-load potential not-exceeding 6 V ac.

b) All equipotential bonding conductors shall be insulated, the insulation being coloured green/ yellow.

NOTE — Insulation of the equipotential bonding conductors is necessary, to avoid loops by contact and to avoid picking up of stray currents.

c) Equipotential conductors between permanently installed extraneous conductive parts and the equipotential bonding bar shall have a cross-sectional area of not less than 4 mm^2 copper or copper equivalent.

d) The equipotential bonding bar, if any, should have adequate mechanical and electrical properties, and resistance against corrosion.

e) The conductors connected to the equipotential bonding bar shall be marked and shall be similarly designated on drawings of the installation system.

f) A separate protective conductor bar and an equipotential bonding bar in a medically used room or in a room group shall be inter-connected with a conductor having a cross-sectional area of not less than 16 mm^2 copper or its equivalent (*see also* **7.1.3.1**).

g) An adequate number of equipotential bonding terminals other than those for protective conductor contacts or pins of socket outlets should be provided in each room for the connection of an additional protective conductor of equipment or for reasons of functional earthing of equipment.

7.1.4 *Provision P_3: Restriction of Touch Voltage in Rooms Equipped for Direct Cardiac Application*

7.1.4.1 The continuous current through a resistance of 1 000 connected between the equipotential bonding bar and any exposed conductive part as well as any extraneous conductive part in the patient environment shall not exceed 10 μA in normal condition for frequencies from dc to 1 kHz.

For a description of patient environment, *see* Annex B.

Where the measuring device has an impedance and a frequency characteristics as given in Annex D, the current may also be indicated as a continuous voltage with a limit of 10 mV between the parts mentioned above.

a) During the test it is assumed that fixed and permanently installed medical electrical equipment is operating.

b) 'Normal conditions' means 'without any fault in the installation and in the medical electrical equipment'.

Compliance with this requirement may be achieved through one or more of the following methods:

a) Extraneous conductive parts may be:

   1) connected to the equipotential bonding bar by a conductor of a large cross-sectional area in order to reduce the voltage drop across such a conductor,

   2) insulated so that it is not possible to touch them unintentionally, and

   3) provided with isolating joints at those places where they enter and leave the room.

b) Exposed conductive parts of permanently installed equipment may be isolated from the conductive building construction.

7.1.5 *Provision P_4: Application of Residual-Current Protective Devices*

7.1.5.1 The use of a residual-current protective device is not recognized as a sole means of protection and does not obviate the need to apply the provisions P_1 and P_2.

7.1.5.2 Each room or each room group shall be provided with at least one residual-current protective device.

7.1.5.3 A residual-current protective device shall have a standard rated operating residual-current $I\Delta \leq 30$ mA.

7.1.5.4 A medical isolating transformer and the circuits supplied from it shall not be protected by a residual-current protective device.

7.1.5.5 Electrical equipment such as general lighting luminaries, installed more than 2.5 m above floor level need not be protected by a residual-current protective device.

7.1.5.6 Fixed and permanently installed electromedical equipment with a power consumption requiring an overcurrent protective device of more than 63 A rated value may be connected to the supply mains by use of a residual-current protective device with $I\Delta \leq 300$ mA.

7.1.6 *Provision P_5: Medical IT-System*

7.1.6.0 The use of a medical IT-system for the supply of medically used rooms for example operating theatres, may be desirable for different reasons:

a) A medical IT-system increases the reliability of power supply in areas where an interruption of power supply may cause a hazard to patient or user;

b) A medical IT-system reduces an earth fault current to a low value and thus also reduces the touch voltage across a protective conductor through which this earth fault current may flow;

c) A medical IT-system reduces leakage currents of equipment to a low value, where the medical IT-system is approximately symmetrical to earth;

   It is necessary to keep the impedance to earth of the medical IT-system as high as possible. This may be achieved by:

   1) restriction of the physical dimensions of the medical isolating transformer,

   2) restriction of the system supplied by this transformer.

   3) restriction of the number of medical electrical equipment connected to such a system, and

   4) high internal impedance to earth of the insulation monitoring device connected to such a circuit.

If the primary reason for the use of medical IT-system is the reliability of the power supply, it is not possible to define for such a system a hazard current and an insulation resistance monitoring device should be used.

If on the other hand the restriction of leakage current of equipment is the main reason for the use of the medical IT-system, an insulation impedance monitoring device should be used.

7.1.6.1 For each room or each room group at least one fixed and permanently installed medical isolating transformer shall be provided.

7.1.6.2 A medical isolating transformer shall be protected against short circuit and overload.

In case of a short circuit or a double earth fault in parts of opposite polarity of the medical IT-system the defective system shall be disconnected by the relevant overcurrent protective device.

If more than one item of equipment can be connected to the same secondary winding of the transformer, at least two separately protected circuits should be provided for reasons of continuity of supply.

7.1.6.3 Overcurrent protective devices shall be easily accessible and shall be marked to indicate the protected circuit.

7.1.6.4 An insulation monitoring device shall be provided to indicate a fault of the insulation to earth of a live part of the medical IT-system.

7.1.6.5 Fixed and permanently installed equipment with a rated power input of more than 5 kVA and all X-ray equipment (even with a rated power input of less than 5 kVA) shall be protected by provision P_4. Electrical equipment such as general lighting, more than 2.5 m above floor level, may be connected directly to the supply mains.

7.1.6.6 *General requirements for insulation monitoring devices*

A separate insulation resistance or impedance monitoring device shall be provided for each secondary system. It shall comply with the requirements given below:

a) It shall not be possible to render such a device inoperative by a switch. It shall indicate visibly and audibly if the resistance or impedance of the insulation falls below the value given in **7.1.6.7** and **7.1.6.8**.

   The arrangement may be provided with a stop button for the audible indication only.

b) A test button shall be provided to enable checking the response of the monitor to a fault condition as described in **7.1.6.4**.

c) The visible indication mentioned in (a) of the insulation monitoring device shall be visible in the monitored room or room group.

d) The insulation monitoring device should be connected symmetrically to the secondary circuit of the transformer.

7.1.6.7 *Insulation resistance monitoring device*

The ac resistance of an insulation resistance monitoring device shall be at least 100 k. The measuring voltage of the monitoring device shall exceed 25 V dc, and the measuring current (in case of a short circuit of an external conductor to earth) shall not exceed 1 mA. The alarm shall operate if the resistance between the monitored isolated circuit and earth is 50 k or less, setting to a higher value is recommended.

7.1.6.8 *Insulation impedance monitoring device*

An insulation impedance monitoring device shall give readings calibrated in total hazard current with the value of 2 mA near the centre of the meter scale.

The device shall not fail to alarm for total hazard currents in excess of 2 mA. In no case, however, shall the alarm be activated until the fault hazard current exceeds 0.7 mA.

During the checking of the response of the monitor to a fault condition the impedance between the medical IT-system and earth shall not decrease.

NOTE — The values of 2 mA or 0.7 mA are based on practical experience with 110 to 120 V power supplies. For a 220-240 V power supply it may be necessary to increase these values to 4 mA and 1.4 mA because of the higher leakage current of equipment.

7.1.7 *Provision P_6: Medical Individual Electrical Separation*

7.1.7.0 Individual electrical separation of a circuit is intended to prevent shock currents through contact with exposed conductive parts which may be energized by a fault in the basic insulation.

7.1.7.1 The source of supply shall be a medical isolating transformer.

7.1.7.2 Only one item of equipment shall be connected to one source of supply.

7.1.7.3 The voltage of the secondary circuit shall not exceed 250 V.

7.1.7.4 Live parts of the separated circuit shall not be connected at any point to any other circuit or to earth.

7.1.7.5 To avoid the risk of a fault to earth, particular attention shall be paid to the insulation of such circuits from earth, especially for flexible cables and cords.

7.1.7.6 Flexible cables and cords shall be visible throughout any part of their length where they are liable to mechanical damage.

7.1.7.7 All conductors shall be physically separated from those of other circuits.

7.1.8 *Provision P_7: Medical Safely Extra-Low Voltage (MSELV)*

7.1.8.1 Medical safety extra-low voltage shall not exceed 25 V ac or 60 V dc peak value.

7.1.8.2 A supply transformer for medical safety extra-low voltage shall comply with relevant Indian Standards.

7.1.8.3 A source of medical safety extra-low voltage other than a transformer shall have at least the same separation and insulation to other circuits and earth as required for the transformer under **7.1.8.2**.

7.1.8.4 Live pans at medical safety extra-low voltage shall not be connected to live parts or protective conductors forming part of other circuits or to earth.

7.1.8.5 Exposed conductive parts shall not intentionally be connected to:

a) earth, or
b) protective conductors or exposed conductive parts of another system, or
c) extraneous conductive parts except that, where electrical equipment is inherently required to be connected to extraneous conductive parts, it is ensured that those parts cannot attain a voltage exceeding medical safety extra-low voltage.

7.1.8.6 Live parts of circuits at medical safety extra-low voltage shall be electrically separated from other circuits. Arrangements shall ensure electrical separation not less than required between the input and output of a medical safety extra-low voltage transformer.

In particular, electrical separation not less than that provided between the input and output windings of a medical safety extra-low voltage transformer shall be provided between the live parts of electrical equipment such as relays, conductors, auxiliary switches and any part of a circuit with a higher voltage.

7.1.8.7 Medical safety extra-low voltage circuit conductors shall either be physically separated from those of any other circuit or where this is impracticable, one of the following arrangements is required:

a) Medical safety extra-low voltage circuit conductors shall be enclosed in a non-metallic sheath additional to their basic insulation.
b) Conductors of circuits at different voltages shall be separated by an earthed metallic screen or an earthed metallic sheath.
c) Where circuits at different voltages are contained in a multi-conductor cable or other grouping of conductors, medical safety extra-low voltage circuits shall be insulated, individually or collectively, for the highest voltage present.

NOTE — In the above arrangements, basic-insulation of any conductor should comply only with the requirements for the voltage of the circuit of which it is a part.

7.1.8.8 Plugs and socket-outlets shall comply with the following requirements:

a) Supply systems of different voltages or different kinds or nature shall not have interchangeable plugs and sockets, and
b) Socket-outlets shall not have a protective conductor contact.

7.2 Wiring

7.2.1 The general design of wiring shall conform to Part 1/Section 9 of this Code.

7.2.2 All panel boards and switchboards shall preferably be of dead front type, enclosed in metal cabinet. Where locked cabinets are provided, all locks should be keyed alike. Switchboard and panel boards shall be installed in non-hazardous locations.

7.2.3 Circuit-breakers are preferred to switchfuse units in power and lighting feeders.

7.2.4 Inside the wards only silent type wall mounted switches should be used to reduce noise. The lighting points shall be so grouped so that minimum lighting may be switched on during night time.

7.2.5 Separate circuits shall be provided for X-ray, electrotherapy, diathermy, electrocardiograph, etc. Advice of equipment manufacturers shall also be sought in their installation.

7.2.6 In corridors and spaces accessible to public provisions shall be made for lighted signs.

7.2.7 Special convenience outlets in corridors spaced about 12 m apart are desirable for portable treatment equipment and cleaning machines.

7.3 Feeders

The general provisions laid down in Part 1/Section 9 of this Code shall apply.

7.4 Service Lines

7.4.1 The general provisions laid down in IS 8061 shall apply.

7.4.2 The main supply conductors shall preferably be brought into the building underground to reduce the possibility of interruption of power supply.

7.5 Building Substation

7.5.0 *General*

The design of power supply for hospital and similar buildings shall take into account the concentration of power demand for the various electrical loads. If the load demand is high requiring supply at high voltage, accommodation of substation equipment will be required. Emergency and standby power-supply needs of hospital buildings shall also be taken into account in designing the building substation.

7.5.1 While calculating the power requirement, the diversity factor for different electrical appliances and installations shall be considered. For guidance, Table 4 gives reference values of power requirement and diversity factor for the different parts in a hospital installation.

7.5.2 The location and layout of building sub-station and emergency diesel generating set/s shall conform to the general rules laid down in Part 2 of this Code.

Table 4 Power Requirement
(*Clause* 7.5.1)

Sl No. (1)	Part of Electrical Installation (2)	Proportion of Total Power Requirement Percent (3)	Diversity Factor (4)
i)	Lighting	25	0.9
ii)	Air-conditioning	15	1.0
iii)	Kitchen	10	0.6
iv)	Sterilizer	10	0.6
v)	Laundry	5	0.6
vi)	Lifts	15	1.0
vii)	Electromedical installations and other loads	20	0.6

7.6 System Protection

7.6.0 *General*

The general rules for protection for safety laid down in Part 1 of this Code shall apply. Reference should be made to SP 7 for guidelines for fire-protection of buildings. The additional rules given below shall apply.

7.6.1 The type of buildings covered in this Section fall under Group C1 (hospitals and sanatoria), C2 (custodial institution), and C3 (panel institutions — for mental hospitals, and similar buildings) from the fire-safety classification point of view.

7.6.2 In hospitals and similar buildings, besides fire-fighting equipment manually operated electrical fire alarm system and automatic fire-alarm system shall be provided. Restricted paging system arrangement with sound alarm/indicators in the duty rooms/nurses rooms shall be made.

7.6.3 For guidelines on selection of fire detectors, *see* SP 7. The wiring for fire-fighting systems shall be segregated from other wiring to reduce risk of damage to them in the case of fire. For high-rise buildings, the fire-fighting pump motors are generally large and they draw heavy current. Sufficient care shall be taken to ensure that the supply to such motors is maintained properly.

7.7 Fire-protection

Where electrical equipment contains pipes or tubes of combustion supporting gases, such as oxygen or nitrous oxide, the following additional requirements apply:

a) Gas outlets shall be located at least 20 cm away from electrical components which, in normal use or in case of a fault, could generate sparks.
b) The gas-flow shall not be directed towards such electrical components.

c) Electrical wiring shall only be allowed to be run in a common enclosure, for example in a common conduit for channel, with tubes for combustion supporting gases, such as oxygen or nitrous oxide, if in the relevant circuit the product of the no-load voltage in volts (V) and the short-circuit current in amperes (A) does not exceed 10.

d) If the requirements in (c) cannot be. fulfilled gas-tight separation shall be provided between the electrical wiring and the tubes for gases.

The gas-tight separation shall be electrically conducting and shall be connected to the protective earth busbar.

e) Where electrical leads are close to a pipeline guiding ignitable gases or oxygen, a short-circuit of these leads or a short-circuit of one lead with a metal duct or pipeline shall not result in a temperature which may cause ignition.

8 ADDITIONAL REQUIREMENTS FOR HAZARDOUS LOCATIONS IN HOSPITALS

8.1 Provision A: Explosion and Fire Protection

8.1.1 *Explosion Protection: General*

a) When the administration of flammable anaesthetic atmospheres or flammable anesthetics or flammable cleaning and/or disinfection agents with air or oxygen and nitrous oxide is intended, special measures to avoid ignitions and fire are necessary. These measures include mainly the use of antistatic flooring.

b) Effective ventilation and the application of a suction system on anaesthesia equipment assists in reducing flammable concentrations of flammable anaesthetic mixtures in the patient environment, the anaesthetists working-place and the operating table. The effectiveness of a ventilation, system may be subjected to National Regulations.

c) Limits of zones of risk are given in Annex A.

Zones of risk exist only when flammable anesthetics or flammable cleaning and/or disinfection agents are used.

d) Requirements on construction, marking and documentation of medical electrical equipment of category AP or APG are given in IS 13450 (Part 1).

Allocation of equipment of the categories AP or AG to zones of risk in operating theatres or other anaesthetic rooms are under consideration.

e) Mains plug connections, switches, power distribution boxes and similar devices, which may cause ignition shall be kept outside zones of risk.

8.2 Antistatic Floor

8.2.1 Antistatic floors shall be used in rooms where zones of risk occur.

Where antistatic floors are used in conjunction with non-antistatic floors marking should be provided, which should be described in the application code.

8.2.2 The resistance of an antistatic floor shall not exceed 25 MΩ at any time during the lifetime of the floor when measured according to IS 7689.

NOTE — The fact that during the lifetime of the floor the resistance may changes should be taken into consideration. The resistance of terrazzo floors increases, while that of PVC floors decreases with time.

8.2.3 If floors of low resistance (< 50 k) are used. Provision P_4 and/or P_5 shall be used to effectively limit the effects of fault currents.

9 BUILDING SERVICES

9.1 Lighting

9.1.1 The general rules laid down in Part 1/Section 11 of this Code shall apply. The choice of lamps, lighting fittings and the general lighting design together with the power requirement shall be plane based on the recommended values of illumination and glare index given in Table 5 (*see also* SP 72).

9.2 Heating, Ventilation and Air-Conditioning

The provisions of Part 1/Section 11 of this Code shall apply. Provision shall be made to maintain positive air pressure and induct increased quantity of fresh air to avoid entry of gases from one room to another.

9.3 Lifts

9.3.1 The general rules laid down in Part 1/Section 11 of this Code shall apply. However, the design of lifts in hospitals and similar buildings shall be made taking into account the criteria given Table 5.

9.3.2 *Dimensions*

The outline dimensions of hospitals lifts shall conform to those laid down in Table 3 of IS 14665 (Part 1).

9.3.3 *Occupant Load*

For the types of buildings covered in this Section, the occupant load expressed as gross area in m^2 per person, shall be 15.

Table 5 Recommended Values of Illumination and Limiting Glare Index
(*Clauses* 9.1.1 *and* 9.3.1)

Sl No. (1)	Buildings (2)	Illumination (3)	Limiting Glare Index (4)
i)	*Hospitals*		
	a) Reception and waiting rooms	150	16
	b) Wards		
	1) General	100	13[1]
	2) Beds	150	
	c) Operating theatres/Dental surgeries		
	1) General	300	10
	2) Tables/chairs	(Special lighting)	—
	d) Laboratories	300	19
	e) Radiology department	100	—
	f) Casualty and outpatient department	150	16
	g) Stairs, corridors	100	—
	h) Dispensaries	300	19
ii)	*Doctor's Surgeries*		
	a) Consulting rooms	150	—
	b) Corridors	70	—
	c) Sight testing (acuity) wall charts and near vision types	450	—
iii)	*Laundries/Dry-cleaning Works*		
	a) Receiving, sorting, washing, drying	200	25
	b) Dry-cleaning, bulk machine work	200	25
	c) Ironing, pressing, mending, spotting, dispatch	300	25
iv)	*Offices*	(*see* Part 3/Section 2 of this Code)	
v)	*Kitchens*	200[2]	25

[1] Care shall be taken to screen all bright light and areas from view of patients in bed.
[2] Special local lighting required over kitchen equipment.

9.3.4 *Car Speed*

These shall be as follows:

Sl No. (1)	*Type of Lift* (2)	*No. of Floors Served* (3)	*Car Speed* (m/sec) (4)
i)	Hospital passenger lift	13-20 4-5	Above 1.5 0.5 to 0.75
ii)	Hospital bed lifts		
	a) Short travel lifts in small hospitals	—	0.25
	b) Normal	—	0.5
	c) Long travel lifts in general hospitals	—	0.6-1.5

9.3.5 *Position*

It is convenient to position the hospital passenger lifts near the staircases. Hospital bed lifts shall be situated conveniently near the ward and operating theatre entrances. There shall be sufficient space near the landing door for easy movement of stretcher/trolley.

10 TESTING OF INSTALLATION

10.1 The various tests on the installation shall be carried out as laid down in Part 1/Section 13 of this Code.

10.2 The initial testing of the installation shall also include:

a) Testing of the effectiveness of protective measures (provisions P_0 to P_1);
b) Testing of the resistance of protective conductors and of the equipotential bonding;
c) Testing of the insulation resistance between live conductors and earth in each separately fused circuit;
d) Testing of the resistance of antistatic floors;
e) Testing of the general safety supply system and
f) Testing of the special safety supply system.

11 STANDBY, SAFETY AND SPECIAL SAFETY SUPPLY SYSTEM

11.1 Provision GE : Standby and Safety Supply System

11.1.1 Electrical systems for medical establishments shall comprise essential circuits capable of supplying a limited amount of lighting and power service which is considered essential for safety, life support and basic hospital operation during the time the normal electrical service is interrupted (*see also* Annex E).

11.1.2 All medical establishments containing life-supporting equipment shall be provided with a safety supply system.

11.1.3 Essential circuits shall provide facilities for charging batteries of a special safety supply system.

11.1.4 Operation of a safety supply system shall not impair the function of protective measures.

11.1.5 All parts of essential circuits shall be marked.

11.1.6 An example of safety supply systems of a hospital is given in Annex F.

11.1.7 A safety supply system shall be capable of automatically taking over the load of essential circuits in the event of a failure of the normal power supply.

11.1.8 The taking-over procedure shall not start earlier than after a period of 2 s has elapsed during which the system voltage has dropped below 90 V of the nominal value and shall be completed within 15 s after the starting of the taking-over procedure.

Return to normal power supply should be delayed. For diesel-generators the delay should be at least 30 min.

11.1.9 To prevent simultaneous damage, the main feeders for the safety supply system shall be segregated from the normal system wherever possible.

11.2 Provisions E_1 and E_2: Special Safety Supply System

11.2.1 *Provision* E_1: *Special Safety Supply System, Medium Break*

11.2.1.1 A special safety supply system shall automatically take over the load within 15 s after a failure of the power supply at the medical establishment containing life-supporting equipment.

11.2.1.2 It shall be possible to resume operation of equipment for maintaining important body functions, in particular breathing equipment, or equipment for resuscitation, within 15 s and to maintain operation for a period of 3 h subsequently, for example, *via* a battery with inverter or *via* a motor driven generator.

11.2.1.3 Where the rating of the special safety supply system is sufficient the circuits of a medical IT-system according to **7.1.6** may be connected to it.

11.2.1.4 Where not all socket outlets in a medically used room are connected to the special safety supply system the connected socket outlets shall be marked clearly as such.

11.2.2 *Provision* E_2: *Special Safely Supply System, Short Break*

11.2.2.1 A special safety supply system shall automatically take over the load within 0.5 s after a failure of the power supply at the operating lamp.

11.2.2.2 Operation of at least one operating lamp shall be resumed after a switchover time not exceeding 0.5 s and operation shall be maintained for at least 3 h.

11.2.3 *Common Recommendations for the Provisions* E_1 *and* E_2

11.2.3.1 The rated power of the source of a special safety supply system shall not be less than required by the connected functions. At least the loads which require continuity of supply shall be connected to the special supply system.

11.2.3.2 Operation of a special safety supply system shall not impair the function of protective measures.

For diesel-generators the requirements of **11.1.8** shall apply.

11.2.3.3 Voltage deviations under normal conditions shall be less than 10 percent for periods of time exceeding 5s.

11.2.3.4 Frequency deviations shall be less than 1 percent for periods of time exceeding 5 s.

11.2.3.5 The special safety supply system source shall be located outside the medically used rooms, if possible close to the relevant distribution point, so that physical damage to the cables connecting the source to the distribution point is unlikely.

11.2.3.6 Operation of the special safety supply system shall be indicated by visual means in all rooms concerned.

NOTE — It is recommended to provide additionally a total load indicator in each room connected to the same special safety supply system.

11.2.3.7 Automatic means shall be provided to keep batteries optimally charged.

11.2.3.8 The charging device shall be designed so that, starting from the fully charged conditions, it is possible to discharge continuously during 3 h at nominal output, and subsequently to re-change during 6 h after which it shall be possible to discharge once more for 3 h under the conditions mentioned above.

11.2.3.9 It shall be possible to supply the charging circuit of a special safety supply system from the safety supply system, so that the special safety supply system batteries can be charged even during a failure of the normal power supply.

12 MEASURES AGAINST INTERFERENCE PROVISION I

12.1 Measures Against ac Interference

12.1.1 In rooms where measurements of bioelectric potentials are performed measures against interference in the room and in the surrounding area should be affected, if such interference may cause incorrect measurements. Such rooms are:

a) rooms intended for measurement of bio-electric potentials (EEG, ECG, etc);
b) intensive examination rooms;
c) intensive care and monitoring rooms;
d) catheterization rooms;
e) angiographic examination rooms; and
f) operating theatres.

12.2 Measures Against Interference Caused by Mains-Induced Electric Fields

12.2.1 The electrical wiring on both sides of or inside walls, floor and ceiling of the rooms concerned should be screened by means of metal shielding of cables or by metal conduits for cables and wiring.

If such metal shielding is applied it should be connected to protective earth at one point only.

12.2.2 Metal enclosures or pans of enclosures of fixed and permanently installed electrical equipment of Class II and III (such as of lighting fittings) should be connected to the equipotential bonding system.

12.2.3 Where adequate measures according to **11.1** cannot be applied and ECG and EEG monitoring is to be undertaken, it is recommended to shield the room or a part of the room against electric fields by installing a room screening within the wall structure.

12.3 Measures Against Interference Caused by Mains-Induced Magnetic Fields

12.3.1 It is recommended to provide sufficient distance between electrical components and equipment which may, cause magnetic interference and the place for the examination of patients. In practice the following values of magnetic field strength have been found to be sufficiently low to avoid magnetic interference:

a) $4 \times 10^7 T_{pp}$ for ECG recording, and
b) $2 \times 10^7 T_{pp}$ for EEG recording.

NOTE — Ballasts incorporated in fluorescent lamp fittings generate an alternating magnetic field; those on the ceiling of the room immediately below the examination room are the ones most likely to cause interference. In some cases it may be necessary to remove ballasts of a certain type from the lighting fitting and to mount them at sufficient distance.

12.3.2 Sufficient distance should be provided when installing units with strong stray magnetic fields such as transformers and motors. This applies also to the isolating transformer of provision P_5. The distance should be 3 m or more.

12.3.3 The rooms listed in **12.1** should not have large power cables passing through or adjacent to them. Suggested minimum distances are:

Conductor Cross-Sectional Area	*Distance, Min* m
10 to 70	3
95 to 185	6
240	≥ 9

NOTES

1 Cables, either single phase or three phase, will have a negligible external field if the load is correctly distributed between phase or between phase and neutral but in practice faults between neutral and earth or incorrectly distributed loads between lines and neutral, and leakage currents will cause alternating magnetic fields in the vicinity of power cables.

2 The values apply only to twisted cables. When bar systems or separated single cables are used, the distances may have to be substantially larger.

12.4 Measures Against Interference from Radio Frequency Electromagnetic Fields

12.4.0 Powerful radio frequency fields may cause interference in sensitive electromedical equipment.

12.4.1 Normally such fields exist only where short-wave diathermy or surgical diathermy equipment is used and close to transmitting aerials used for such purposes as staff location and ambulance communications. The simplest measure against such interference is to locate equipment which causes it well away from areas where sensitive equipment is used. Additional measures are the inclusion of radio frequency rejection circuits in sensitive equipment and the use of short-wave diathermy equipment with a low modulation factor.

If the measures described here are not sufficiently effective it may be necessary to use sensitive equipment with a screened room.

NOTE — The construction of such a screened room should be entrusted to a specialist. An attenuation of 40 dB over the frequency range 150 kHz to 30 MHz is considered to be adequate.

12.5 Electric Heating Cables

12.5.0 The following requirement applies to electric heating cables embedded in or attached to surfaces in buildings. It does not apply to removable appliances which may be mounted on the surface of walls.

12.5.1 Electric heating cables of any type should not be used in rooms where bioelectric potentials are recorded.

NOTE — Due to the construction of such heating cables it is very likely, that the electric and magnetic fields will interfere with the recording of bioelectric potentials. Appropriate measures according to **12.2** and **12.3** should be taken.

13 MISCELLANEOUS PROVISIONS

13.1 Call Systems

13.1.0 Electrical call and signal system when provided in hospitals should comply with the requirements given in **13.1.1** to **13.1.4.1** The following are the important call and signal system:

a) Nurses call,
b) Doctors' paging, and
c) In-and-out register.

NOTE — It is recommended that electrical call and signal system should be provided in all hospitals so that patients may receive prompt service and the doctors, nurses and attendants may work more efficiently.

13.1.1 *Nurses' Call System*

The nurses call system should be a wired electrical system whereby patients may signal for a nurse from the bed site. Two types of systems are recommended:

a) A simple one-way signal system which connects the bed side call stations with a signal at the nurses' station, utility room and floor pantry of the nursing unit. It simultaneously lights a dome light over the door of the room from which the call originated. The signal at the nurses' station may be in the form of an annunciator with a buzzer or a single light with a buzzer. Two or more lights in the ceiling of the corridor at the nurses' station to indicate the direction from which the call came are desirable for the latter arrangement.

b) A central control panel should be set up preferably on the ground floor incorporating a set of indicating panels according to the number of wards. Each indicating panel should have a number of small lamps according to the number of beds. At each bed there could be 4 push buttons. First for 'Calling Nurses', second for 'Nurse Present', third for 'Setting Combination' and fourth for 'Call for Doctor'. When any patient presses the push button the indication is at the central control room from where intimation to nurses can be sent. After reaching the bed site the nurse presses the 'Nurse Present' button which gives an indication to operator at the central control panel that the nurse is available near the particular bed. After attending the patient, the nurse presses the resetting button which puts the whole equipment to the original condition. If the patient needs further help of a doctor then the nurse again presses the fourth push button and the central control panel operator sends message to the doctor for that particular bed.

13.1.1.1 For emergency call of nurse by the patient when he/she is inside a bath or water-closet, suitable pull cord switches shall be provided inside bath and water-closet. These switches when operating will give an indication at the central control panel from where intimation to nurse can be sent.

13.1.1.2 Nurses call system may also be of the intercommunicating type with a microphone and loudspeaker at the bed connected to the nurses' station. The patient can signal for a nurse or speak to her and receive an answer. For maximum benefit and service, this system should include all the features described in **13.1.1** for the one-way signal system in addition to the inter-communicating features.

13.1.2 *Doctors Paging System*

This may consist of loudspeakers located throughout the hospital, clinics on which doctors' numbers can be sounded or the flasher type which indicates the doctors' numbers. The loudspeaker and other audible calls should not be used as they may disturb the patients and attendants. The flasher system consists of a keyboard and flasher at the telephone switchboard. The telephone operator may set the board to flash as many as three doctors' numbers automatically in rotation. The numbers appear on annunciators located in all sections of the corridors. The same number of numerals, at least three, should be used for each doctor so that a burnt out lamp may be located.

13.1.2.1 These paging systems could be used for calling interns, administrators, heads of departments and their assistants and engineers. These flashers may also be used for other general calls such as 'fire' with a red 'F' and buzzer. The flasher call system has its shortcomings as the individual may fail to see the numbers when flashed. For this reason the flasher system should be supplemented with loudspeakers at points where interns, heads of departments and doctors may congregate, that is, in doctors' lounge, staff dining room, laboratory and engineers' office and such other areas where the calls may not disturb the patients.

13.1.3 *VHF Paging System*

This system consists of a low powered transmitting station from which calls are broadcast throughout the hospital to miniature receiving sets which the doctors and others may carry in their pockets.

13.1.4 *In-and-Out Register*

The doctors' in-and-out register permits the doctor to register 'IN' and 'OUT' with the minimum of effort and delay. The register consists of a board, at one or more entrances, on which all staff doctor, upon entering or leaving, operates a switch opposite his name which indicates whether or not he is in the building. The switch controls a light at or back of the name on all boards connected in the system.

13.1.4.1 Except in very small hospitals, it is recommended to install register system with a board at two or more entrances and at the telephone switchboard. Such a system should include a recall feature which consists of a flasher unit, having a motor driven interrupter. This flasher unit, controlled at the telephone switchboard, will actuate a flashing light at the doctors' name on all register boards which indicates there is a massage for the doctors, and attracts the attention of doctor upon entering or leaving the building. Call back systems are used for nurses' and interns' bedrooms. With such system the nurses and interns can be awakened, called for duty, or called to the telephone by push-buttons in the office which operate buzzers in the rooms. The room called can answer by pushing a button which registers on an annunciator in the office. The main office buzzers may be connected through a selector switch so that serial rooms or sections may be called by one button.

13.2 Telephones

13.2.0 A centralized EPABX System with adequate number of P&T lines shall be installed for internal and external communication. Interconnecting telephones should be provided for each important department and at patients' bed. These shall be interconnected to permit internal communication without operator's assistance. Facility shall be provided for external communication with these departments through operator's assistance. Some of the most important departments shall have direct access facility for external communication. At all special and important beds, telephone jacks should be installed so that a telephone may be plugged in any time.

13.2.1 In case of operation theatre and rooms where surgical operations and dressing is done, concealed wiring should be provided to avoid risk of contamination. In other places, any type of general wiring may be acceptable.

13.2.2 The concealed wiring and switch-socket outlets in the operation theatres shall be kept at a minimum height of 1.5 m from the floor as anaesthetic gases are heavier than air and gravitate to the floor.

13.3 Clocks

Electric clock system when provided, should have clocks at nurses' stations, main lobby, telephone switchboard, kitchen, laundry, dining room and boiler room, as well as in the operating and delivery rooms. The clocks should be of the recessed type, preferably with a narrow frame. Clocks in operating and delivery rooms should have sweep second hands. The general guidance provided in Part 1/Section 11 of this Code shall apply.

13.4 Other Special Installations

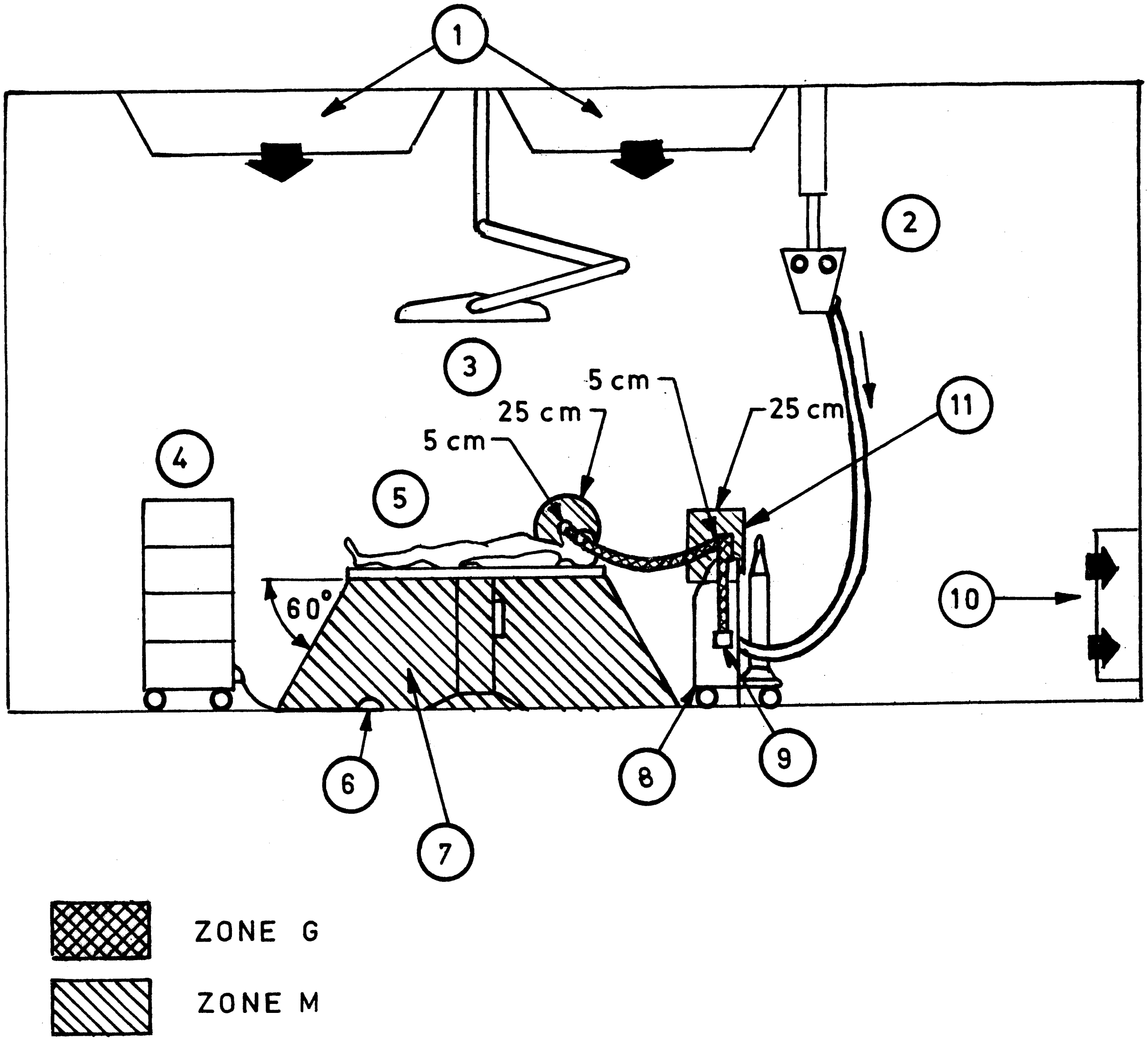
The list of other special circuits in installations in hospitals are given below:

a) Closed-circuit television in surgery department (for teaching purposes);
b) Television sets in wards;
c) Short-wave, ultraviolet rays or sterile ray lamps in ceilings of operating and delivery rooms around the operating light, to reduce the bacteria count; and
d) Luminous signs.

ANNEX A

(*Clauses* 3.2 *and* 8.1.1)

ZONES OF RISK IN THE OPERATING THEATRE WHEN USING FLAMMABLE ANAESTHETIC MIXTURES OF ANAESTHETIC GASES AND CLEANING AGENTS



Legend

1 = Ventilation system
2 = Ceiling outlet with sockets for electric power gases (for example, oxygen), vacuum and exhaust ventilation system for medical electrical equipment
3 = Operation lamp
4 = Equipment
5 = Operating table

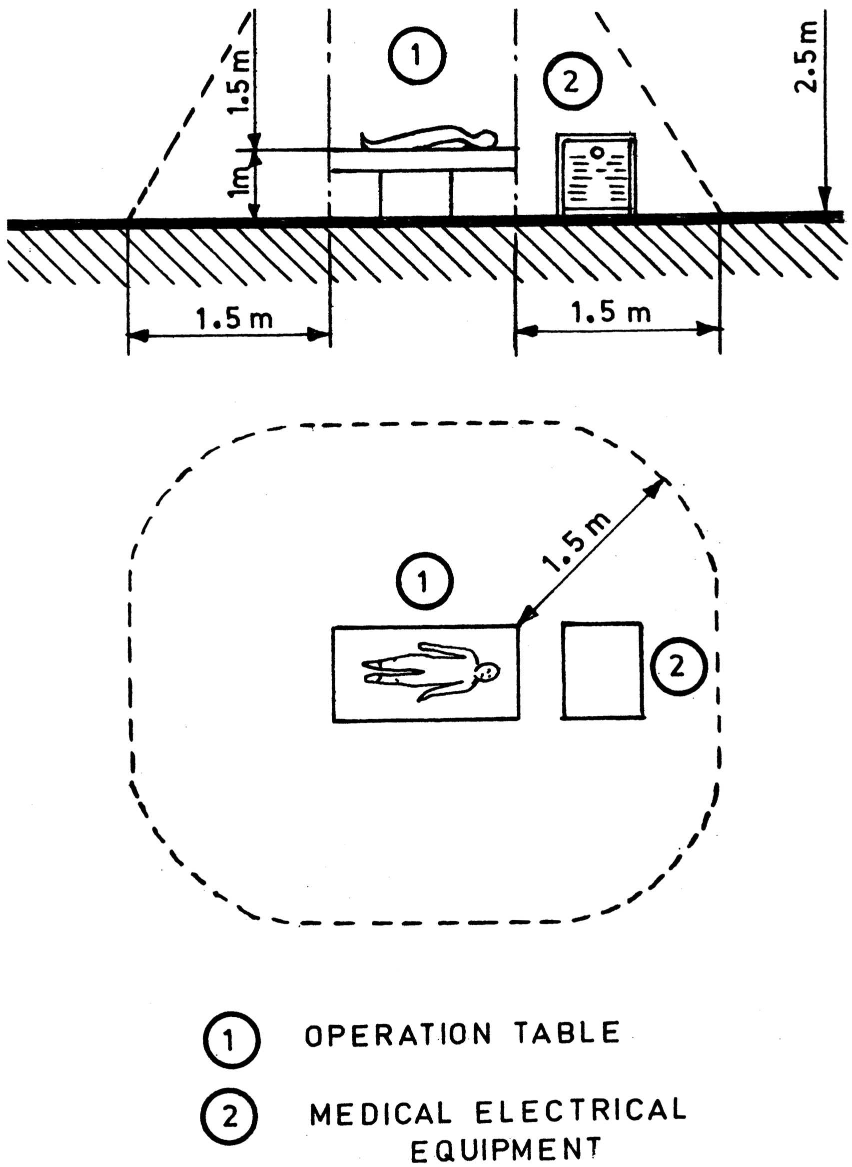
Legend

6 = Foot switch
7 = Additional zone M due to use of flammable disinfection and/or cleaning agents
8 = Anaesthesia apparatus
9 = Exhaust system for anaesthesia gases
10 = Exhaust ventilation system
11 = Parts unprotected and likely to the broken

ANNEX B

[*Clauses* 3.3.11, 7.1.3.2(b) *and* 7.1.4]

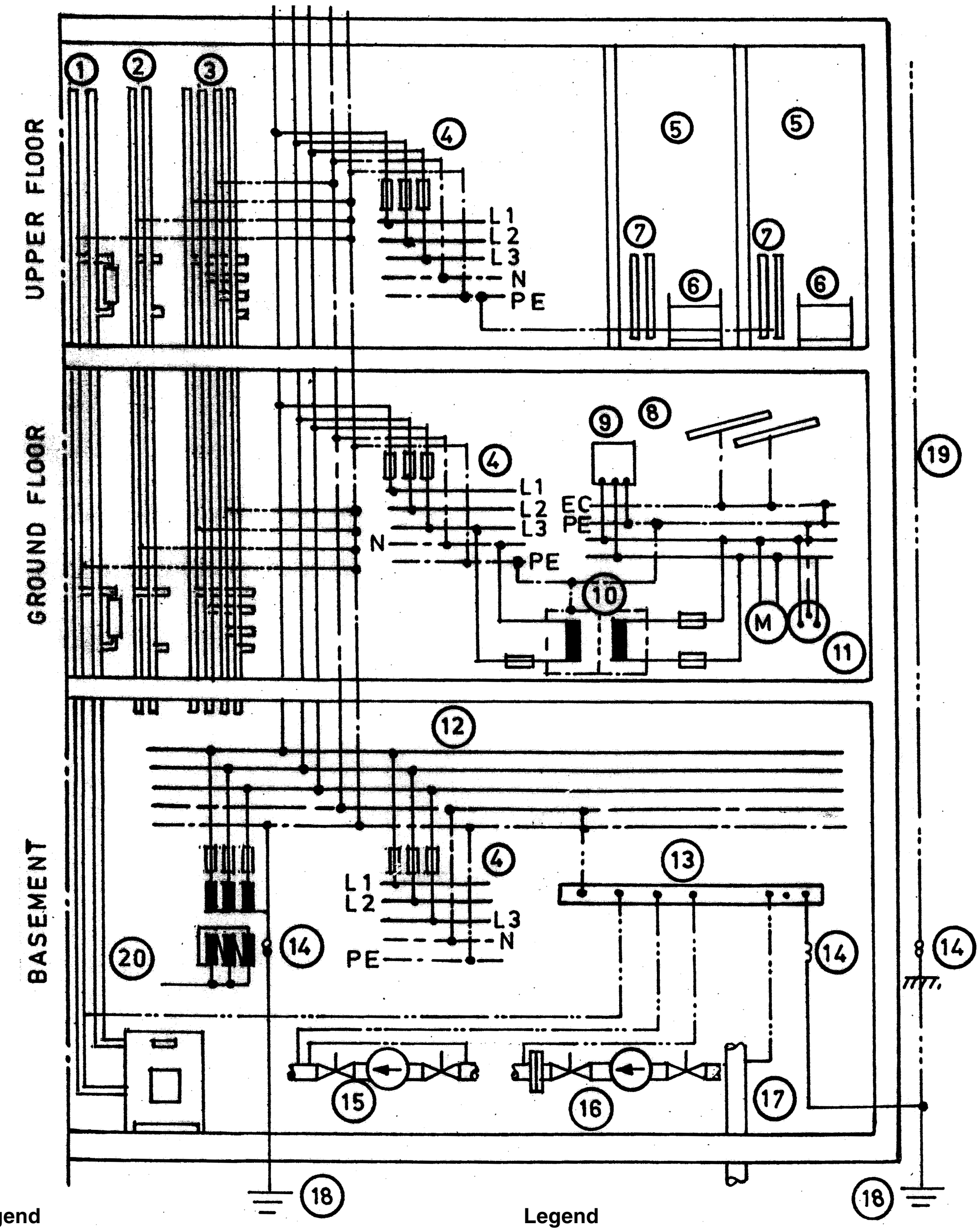
PATIENT ENVIRONMENT



ANNEX C

(*Clause* 6.1.4)

EXAMPLE OF AN ELECTRICAL INSTALLATION IN A MEDICAL ESTABLISHMENT



Legend

1 = Heating pipes
2 = Water supply
3 = Gas supply
4 = Distribution board
5 = General ward
6 = Hospital bed
7 = Heating and water pipes
8 = Medical IT-system for Operation Theatre
9 = Insulation monitoring device
10 = Medical isolating transformer
11 = Socket outlet
12 = Main distribution board.

Legend

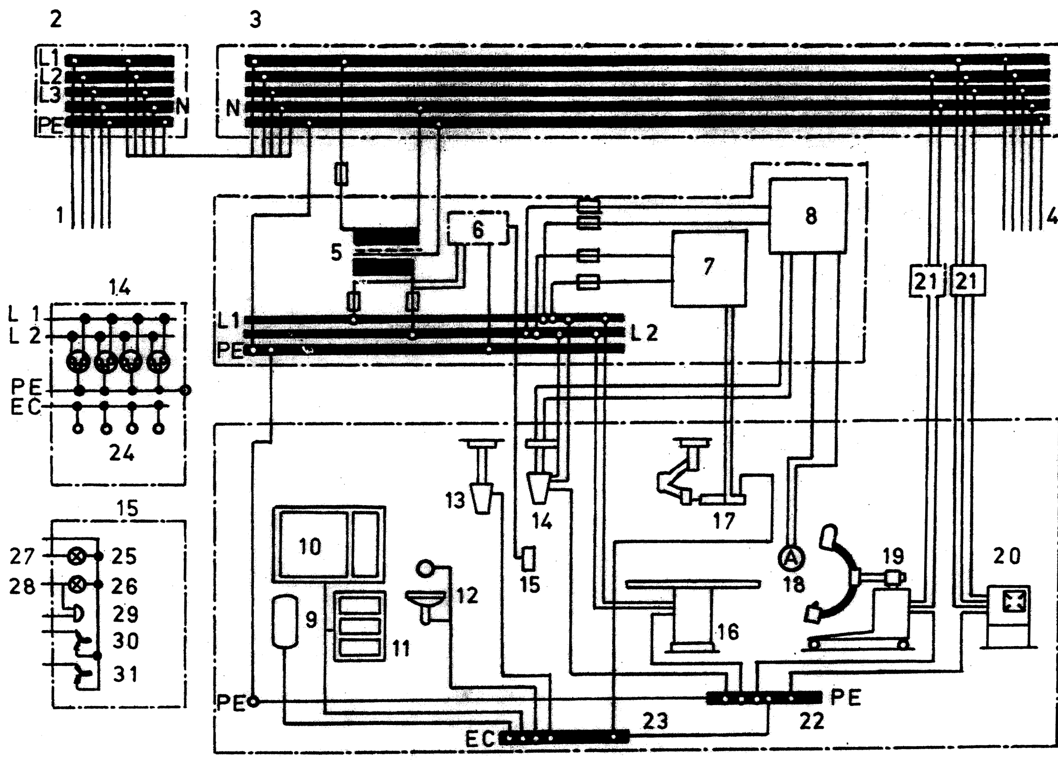
13 = Main earthing bar
14 = Joint
15 = Water meter
16 = Gas meter
17 = Waste water
18 = Earth electrode
19 = Lighting protective system
20 = From public electric power system

L_1, L_2, L_3 = phase conductors
N = neutral conductors
EC = bonding conductor
PE = protective conductor

ANNEX D

(*Clause* 7.1.4.1)

SCHEMATIC PRESENTATION OF PROTECTIVE CONDUCTORS AND EQUIPOTENTIAL BONDING IN OPERATING THEATRES



Legend

1 = Feeder from the main service entrance (main distribution board)
2 = Distribution of the floor
3 = Operating theatre distribution panel
4 = Safety supply system
5 = Medical isolating transformer
6 = Insulation monitoring device
7 = Special safety supply system, E_2
8 = Special safety supply system E_1
9 = Central heating
10 = Metal window-frame
11 = Metal cabinet for instruments
12 = Meal washing-basin and water supply
13 = Ceiling stand with outlets for gas supply
14 = Ceiling stand with mains socket outlets (with terminals for equipotential bonding, enclosure connected to the protective conductor bar)
15 = Alarm device for the insulation monitoring device (example)
16 = Operating table (electrically driven)

Legend

17 = Operating lamp
18 = Ampere meter for special safety supply system
19 = X-ray equipment
20 = Sterilizer
21 = Residual-current protective device
22 = Protective conductor bar
23 = Equipotential conductor bar
24 = Terminals for equipotential bonding
25 = Operation
26 = Warning
27 = Green
28 = Red
29 = Buzzer
30 = Stop button for buzzer
31 = Test button

PE = protective conductor
EC = equipotential bonding
L_1, L_2, L_3 = phase conductors
N = neutral conductor

ANNEX E

(*Clause* 11.1.1)

SAFETY SUPPLY SYSTEM

E-0 GENERAL

E-0.1 This Annex contains recommendations for the design of the safety supply system in medical establishments.

Priority is given to all aspects ensuring safe working conditions in medically used rooms.

Interruption of normal electrical service in medical establishments may cause hazardous situations. Therefore, it is necessary to provide for continuity of power supply for vital services at all times.

In some medically used rooms a special safety supply system should be provided additionally. It supplies life supporting equipment and the operating table lighting for 3 h only, that is, for a relatively short time if the mains supply or the safety supply system fails or the switch-over time cannot be tolerated.

The safety supply system is intended to supply electrical energy for a longer period of time to essential circuits of the medical establishment if the mains supply fails by external causes.

E-1 ESSENTIAL SERVICES — LIGHTING

E-1.1 Essential lighting requirements will vary considerably in different locations, depending on the importance and nature of the work. In some instances, for example, operating table lighting in operating suites, and the critical working areas in the delivery room and recovery rooms, the degree and quality of emergency lighting should be approximately equal to that of the normal lighting. Even in these areas, however, considerable reduction in the general lighting may be acceptable. Ample socket-outlets connected to essential circuits should be available to enable portable lighting fittings to be used for any tasks outside the critical working area-which require a higher standard of lighting.

E-1.2 No general recommendations can be made for the emergency lighting arrangements for stairs and corridors as needs will differ considerably according to the design and size of the hospital. As a general guide, safety lighting should be provided to enable essential movement of staff and patients to be carried out in reasonable safety. Safety lighting should also be provided in public waiting spaces, at entrances and exits, and in corridors used by members of the public, ambulance staff, etc. External emergency lighting will normally be restricted to the accident and emergency entrance areas.

E-1.3 Three grades of emergency lighting are suggested, namely:

a) Grade A lighting of intensity and quality equal or nearly equal to that provided under normal supply conditions;
b) Grade B reduced standard of lighting, for example, about half the normal standard, sufficient to enable essential activities to be properly carried out; and
c) Grade C safety lighting of a much reduced standard but sufficient to allow the free movement of persons, trolleys, etc.

Levels for Grades A, B and C are under consideration.

E-1.4 Table 6 is intended as a general guide. Emergency lighting may be needed in areas not mentioned in the table.

E-2 ESSENTIAL CIRCUITS — SOCKET-OUTLETS

E-2.1 Socket-outlets should be so distributed that in each area where essential equipment will be used, socket-outlets connected to at least two separate sub-circuits are available.

Table 7 is intended as a general guide.

E-2.2 Socket outlets in operating rooms for the connection of X-ray equipment for fluoroscopy should be supplied from an essential circuit.

E-2.3 Electrical services, including automatic controls, which are essential for the safe operation of sterilizing equipment in operating theatre and the central sterile supply department should be supplied from an essential circuit.

E-2.4 Blood banks and other clinical refrigerators are usually equipped with temperature retaining facilities which will satisfactorily safeguard against power failures of several hours' duration. Nevertheless, they shall be supplied from an essential circuit.

E-2.5 Motors of surgical suction plant should be connected to an essential circuit. It is desirable that the motors should be so arranged that once they are switched on they will restart automatically, following an interruption of supply.

Table 6 Emergency Lighting
(*Clause* E-1.4)

Sl No.	Department or Location	Area	Grade of Lighting
(1)	(2)	(3)	(4)
i)	*Major Operating Suites*		
	Operating theatre	Critical working area	Grade A
	Operating theatre	General working area	Grade B
	Anaesthetic rooms	General working area	Grade A
	Post operative	General working area	Grade A
	Intensive care room	Circulating areas	Grade C
ii)	*Delivery Suites*		
		Critical working area	Grade A
	Delivery rooms	Other nursing areas	Grade B
		Circulating areas	Grade C
iii)	*Accident and Emergency Departments*		
	Operating theatres	Critical working area	Grade A
	Intensive care rooms	Critical working area	Grade A
		General working area	Grade B
		Circulating areas	Grade C
iv)	*Out-Patient Department*		
	Operating theatres	Critical working area	Grade A
	Treatment rooms	General working areas	Grade B
	Consulting rooms	General working areas	Grade B
		Circulating areas	Grade C
	Pathological department	Essential working areas	Grade B
		Blood bank	Grade A
		Transfusion laboratory	Grade A
	Diagnostic X-ray department	General working area (where portable X-ray machines may be used)	Grade B
		Circulation areas	Grade C
	Radiotherapy department	Treatment areas	Grade A
		Public circulating areas	Grade C
	Pharmacy	Dispensing areas	Grade B
		Laboratory	Grade B
v)	*Ward Areas*		
	Intensive therapy units	Intensive nursing area	Grade A
		Other nursing areas	Grade B
		Nurses' station or duty room	Grade B
vi)	*Special Baby Care Units*		
	Nurseries	General working area	Grade B
	Psychiatric wards	General working area	Grade B
	Treatment rooms	General working area	Grade A
	Other nursing areas	General working area	Grade C (night-lighting)
vii)	*Central Sterile Supply Department*	General working area	Grade B
iii)	*Telephone Exchanges*	Essential working area	Grade B
ix)	*Operators Room*		Grade B
x)	*Lifts*		
	Lifts cars		Grade A
	Entrance and exit of elevators		Grade A
xi)	*General circulating Areas*		
	Public entrances and exits	—	Grade C
	Corridors and staircases forming recognized means of escape	—	Grade C
	Corridors and circulating spaces of deep planned designs	—	Grade C
ii)	*Assembly Areas*		
	Assembly rooms and associated exists	—	Grade C
	Public waiting space	—	Grade C
	Plant rooms housing essential plant	Working area	Grade B
	Kitchens	Essential working areas	Grade B

Table 7 Socket-Outlets in Essential Circuits
(*Clause* E-2.1)

Sl No.	Department	Number of Socket-Outlets Connected to Essential Circuits (*see* Note)
(1)	(2)	(3)
i)	Operating suits	All
ii)	Intensive care room and operating rooms in accident and emergency department	All
iii)	Delivery rooms	All
iv)	Post-anaesthetic recovery rooms	All
v)	Intensive therapy units	All
vi)	Radiological diagnostic room	All
vii)	Ward accommodation set aside for patents dependent on electrically driven equipment, for example, respirators, rocking beds, artificial kidney machines, etc.	All
viii)	Special baby care units	All
ix)	Pathology laboratories	2
x)	Wards where essential equipment such as suction apparatus will be used	2 sockets outlets for wards containing 1 to 4 beds and, *pro rata*, where the number of beds exceeds 4.

NOTE — It is reasonable to assume that only essential equipment will be used in these areas during periods of power failure. The recommendation that all socket are connected to the Essential Circuits provide the most convenient choice of sockets outlets at any time, and to simplify installation.

E-2.6 Safety supply systems for facilities for ventilation and air-conditioning purposes will usually apply only to plants which serve areas which are entirely dependent on mechanical ventilation and have no facilities for natural ventilation or where mechanical ventilation services are essential for clinical reasons. Where ventilation requirements are met by duplicate plants it will usually only be necessary for one of the plants to be supplied from the emergency source, thus ensuring air supplies of approximately 50 percent of the normal rate. Changeover switches, however, should be provided, to enable either of the plants to be connected to the emergency service.

E-2.7 Any mains-energized alarm and control circuits should be so arranged that they are automatically connected to the safety supply system in the event of a power failure.

E-2.8 In biochemical laboratories and in the pharmacy about 50 percent of the normal load should be supplied from essential circuits.

E-3 PARTS OF ESSENTIAL CIRCUITS

E-3.1 Deep-freeze refrigerators and food storage refrigerators will normally operate within a temperature range of –10 to –23°C and be fitted with a temperature alarm device to give a warning when the refrigerator temperature approaches the upper safety limit. It may be desirable for one deep-freeze refrigerator at each hospital to be supplied from the essential circuits where this can be conveniently arranged.

E-3.2 In milk kitchen, all refrigerators should be supplied from an essential circuit.

E-3.3 Where electrically operated pumps are used to maintain essential water supplies (including that for fire fighting purposes) it will be necessary to make suitable arrangements for the pumps to be connected to the safety supply system.

E-3.4 Telephone exchange equipment is usually energized from float charged batteries having sufficient capacity for at least 24 h normal working.

E-3.5 Where lifts are provided for the movement of patients it is desirable that one lift in each separate section of the hospital should be so arranged that it is normally connected to the essential circuits of the installation having automatic changeover facilities. These lifts will be regarded as emergency or fire lifts, and should be suitably indicated by markings at each landing.

Suitable manually-operated switching arrangements should be provided to enable the general safety supply system to be switched from the emergency lift to each of the other lifts in turn to eliminate the possibility of occupants being trapped in the lifts during power failures. Under normal supply conditions the emergency lifts only will be connected to the essential circuit of the installation.

E-3.6 Communication equipment should be connected to essential circuits.

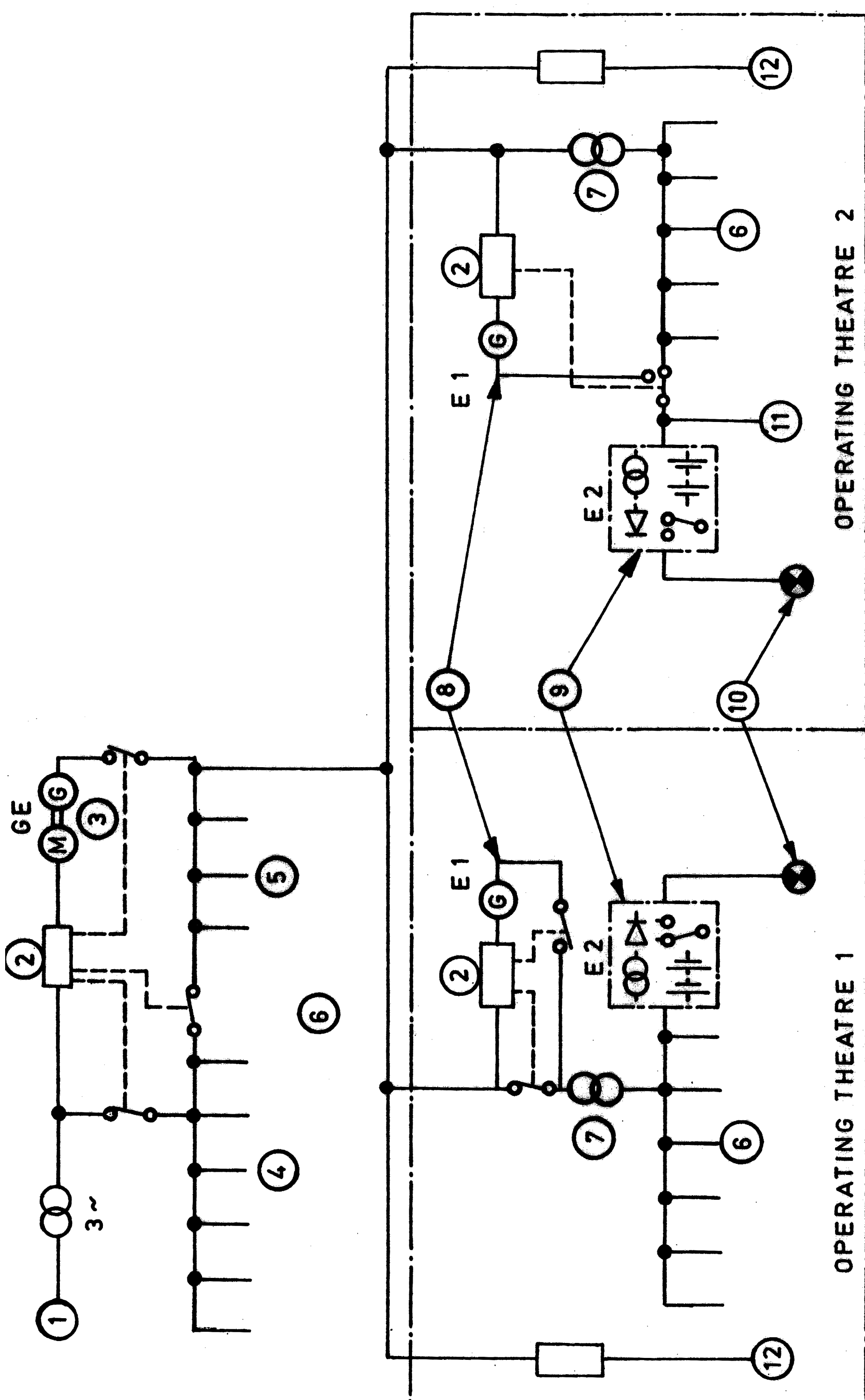
E-3.7 All boiler house supplies should be fed from essential circuits.

E-3.8 Emergency supplies for computers should be examined in each case.

ANNEX F

(*Clause* 10.1.6)

SAFETY SUPPLY SYSTEM OF A HOSPITAL (EXAMPLE)



Legend

1 = Mains
2 = Starting equipment
3 = Safety supply system
4 = Less essential circuit
5 = Essential circuit
6 = Supply circuit

Legend

7 = Mains transformer
8 = Special safety supply system (motor-generator or inverter with batteries switch-over time < 15 s)
9 = Special safety supply system supply for operating lamp (switch over time < 0.5)
10 = Operating lamp
11 = Supply circuits for life supporting equipment
12 = Equipment > 5 kVA, lighting, X-ray equipment.

SECTION 5 HOTELS

0 FOREWORD

Hotels lodging or rooming houses are of a wide variety, ranging from simple dormitory type accommodation for guests, where only a common bath is provided with no facility for dining/kitchen to the sophisticated star hotels. Increasing competition in the hotel industry as such, coupled with the demand by guests for a variety of comforts, calls for an electrical installation in a hotel with increased sophistication.

The electrical needs of a hotel depend on the type and extent of facilities being provided and the rating of the hotel. The system design would in general be identical with that of any other large building, the actual power requirement expressed in terms of per-unit area or per guest room.

Specific requirements for installations in swimming pool are covered in Annex A to this Section. These requirements also apply to swimming pools in other occupancies, say sports buildings. For editorial convenience, these specific requirements form part of this section of the Code.

1 SCOPE

This Section 5 of the Code covers requirements for electrical installations in buildings such as hotels and lodging houses.

2 REFERENCES

This Part 3/Section 5 of the Code should be read in conjunction with the following Indian Standards:

IS No.	*Title*
3646 (Part 2) : 1966	Code of practice for interior illumination: Part 2 Schedule for values of illumination and glare index
8061 : 1976	Code of practice for design, installation and maintenance of service lines upto and including 650 V
IS/IEC 60309-1 : 2002	Plugs, socket-outlets and couplers for industrial purposes: Part 1 General requirements (*first revision*)
IS/IEC 60309-2 : 2002	Plugs, socket-outlets and couplers for industrial purposes: Part 2 Dimensional interchangeability requirements for pin and contact tube accessories (*first revision*)
SP 7 : 2005	National Building Code of India
SP 72 : 2010	National Lighting Code

3 TERMINOLOGY

For the purpose of this Section, the definitions given in Part 1/Section 2 of the Code shall apply.

4 CLASSIFICATION

4.1 The electrical installations covered in this Section are those in buildings intended for the following purposes:

a) *Lodging or rooming houses* — These include any building or group of buildings in which separate sleeping accommodation for a total of not more than 15 persons on either transient or permanent basis with or without dining facilities, but without cooking facilities for individuals, is provided.

NOTE — The above is distinct from single or two family private dwellings which are covered in Part 3/Sec 1 of this Code.

b) *Hotels* — These include any building or group of buildings in which sleeping accommodation is provided with or without dining facilities for hire to more than 15 persons, who are primarily transient such as hotels, inns, clubs and motels.

NOTE — For the purpose of this Code, restaurants other than those forming part of a large hotel are treated as assembly buildings and are covered in Part 3/Sec 3 of this Code.

4.2 The electrical installations in hotels covered in this Section include the following services:

a) Supply intake,
b) Main distribution centre,
c) Ventilation and exhaust systems,
d) Kitchen,
e) Laundry,
f) Cold storage,
g) Health club,
h) Swimming pool and filtration plants,
j) Restaurants and bars,
k) Interior lighting,
m) Telephones,
n) Channelized music,
p) Service lifts and passenger lifts,
q) Offices,
r) Fire protection and alarm systems,
s) Banquet halls and conference facilities,
t) Gardens and parking lots and illumination systems therein,

u) Illuminated signs, display lights and decorative illuminations, and
v) Emergency system.

5 GENERAL CHARACTERISTICS OF INSTALLATIONS

General guidelines on the assessment of characteristics of installations in buildings are given in Part 1/Sec 8 of this Code. For the purposes of installations falling under the scope of this Section, the characteristics defined below generally apply (*see also* SP 7).

5.1 Environment

5.1.1 The following environmental factors apply to hotels:

Environment (1)	*Characteristics* (2)	*Remarks* (3)
Presence of water	Probability of presence of water is negligible	Majority of locations in hotels. Traces of water appearing for short periods are dried rapidly by good ventilation.
	Possibility of jets of water from any direction	Applies to gardens
	Possibility of permanent and total covering by water	Locations such as swimming pools
Presence of foreign solid bodies	The quantity or nature of dust or foreign solid bodies is not significant	
Presence of corrosive or polluting substances	The quantity and nature of corrosive or polluting substances is not significant	For hotels situated by the sea or industrial zones, other categorization applies (*see* Part 1/Section 8 of this Code)
Mechanical stresses	Impact and vibration of low severity	—
Seismic effect and lighting		Depends on the location of the building

5.2 Utilization

5.2.1 The following aspects of utilization shall apply:

Utilization (1)	*Characteristics* (2)	*Remarks* (3)
Capability of persons	Ordinary, uninstructed persons	A major proportion of occupants in Hotels
	Persons adequately advised or supervised by skilled persons	Applies to areas, such as building substation and for operating and maintenance staff
Contact of persons with earth potential	Persons in non-conducting situations	
Condition of evacuation during emergency	Low density occupation, easy conditions of evacuation	Applies to lodging houses
	High density occupation, difficult conditions of evacuation	Large hotels, high-rise buildings.
Nature of processed of stored material	No significant risks	
	Contamination risks due to presence of unprotected food stuffs	Applies to kitchens

6 SUPPLY CHARACTERISTICS AND PARAMETERS

6.0 Exchange of Information

6.0.1 Proper coordination shall be ensured between the architect, building contractor and the electrical engineer on the various aspects of installation design. In addition to the general aspects which require coordination and identified in other sections, information shall be obtained on the following services:

a) Whether central air-conditioning system is intended. If so, layout of air handling units, fan coil units, ducting, false ceiling and chilled water lines should be obtained.
b) Whether centrally controlled fire-fighting is intended. If so, layout of fire-fighting installation should be obtained.
c) Whether telephone and TV facilities are intended in each room. If so, layout of the

telephone installation and TV circuits should be obtained.

d) Whether centrally heated out water system is intended. If so, layout of hot water pipe-line be obtained.

6.1 Branch Circuits

6.1.1 The general provisions for the design of wiring of branch circuits shall conform to those laid down in Part 1/Section 9 of this Code. However, for special cases such as for communication networks, fire-alarm system, etc, as well as in areas such as kitchen, laundry, etc, the recommendation of the manufacturer shall apply.

6.1.2 The branch circuit calculations shall be done as laid down in Part 1/Section 1 of this Code. The specific demands of the lighting, appliance and motor loads, as well as special loads encountered in hotel building shall be taken into account.

6.1.3 In hotel buildings, the interior décor normally includes false ceiling, carpets and curtains. Any wiring laid above the false ceiling should be adequately protected, such as by drawing the wires in metallic conduits and not run in open. Wires shall not be laid under carpets. They shall be run at skirting level and encased for mechanical protection.

6.1.4 *Panel Boards and Switch-boards*

The provisions of Part 1/Section 9 of this Code shall apply.

6.1.5 *Socket-outlets and Plugs*

6.1.5.0 These should be provided in all places where plug-in service is likely to be required, to reduce the need for alterations and extensions of wiring after the hotel building is completed. Duplex or other suitable outlets should be provided as required in the offices and work places for fans, lamps and appliances. The socket-outlets shall preferably have covers. Corridors and staircases shall be provided with sufficient socket-outlets for floor cleaning appliances. These shall be connected in a circuit separate from the circuits for the guest rooms.

6.1.5.1 If provided, use of a central radio receiving system wired with multi-channels piped music system to each room is recommended so that the occupant may choose one of the broadcasts. For such reception, special aerials and related wiring are required. Aerial outlets at rooms are required for portable radios in areas and buildings where reception is poor but in general the aerial built in the set may be adequate.

6.1.5.2 Special convenience outlets in corridors at suitable locations are desirable for use of portable equipment such as floor cleaning appliances. They should be of the 3-pin type, suitably rated with one-pin earthed.

Heavy duty sockets should also be provided in pantries, kitchens, toilets and utility rooms for use of appliances.

Adequate plug-in sockets at proper locations should be provided in banquet halls and other meeting places for flood lights and other appliances.

6.2 Feeders

The general provisions laid down in Part 3/Section 9 of this Code shall apply.

6.3 Service Lines

The general provisions laid down in IS 8061 shall apply.

6.4 Building Substation

6.4.1 If the load demand is high which requires supply at voltage above 650 V a separate indoor accommodation, as near the main load centre of the hotel as possible shall be provided to accommodate switchgear equipment of supply undertaking and indoor/outdoor accommodation for the transformers. The main distribution equipment of the hotel shall preferably be located next to the substation. Separate feeders shall be provided for major loads like central air-conditioning, kitchen, laundry, swimming pool, lighting of main building and other essential loads.

6.4.2 The supply line should preferably be brought into the building underground to reduce the possibility of interruption of power supply. The accommodation for substation equipment as well as for main distribution panel shall be properly enclosed so as to prevent access to any unauthorized person. It shall be provided with proper ventilation and lighting arrangement.

6.4.3 The location and layout of building sub-station and emergency diesel generating set(s) shall be in conformance with Part 2 of this Code.

6.5 System Protection

6.5.1 *General*

The general rules for protection for safety laid down in Part 1/Section 7 of this Code shall apply. Reference should be made to SP 7 for guidelines for fire protection of buildings.

6.5.2 For lodging and rooming houses of 3 storey and above, with a floor area more than 200 m^2 with central corridor and rooms on either side, besides fire fighting equipment, manually operated electric fire-alarm system shall be provided. Both manually operated and automatic fire-alarm systems shall be provided in large hotels.

6.6 Building Services

6.6.1 *Lighting*

6.6.1.1 The general rule laid down in Part 1/Section 14 of this Code shall apply. The choice of lighting fittings and general lighting design together with power requirements shall be planned based on the recommended values of illumination and limiting values of glare index given in Table 1 [*see also* IS 3646 (Part 2) and SP 72].

Table 1 Recommended Values of Illumination and Glare Index for Hotels

Sl No. (1)	Building (2)	Illumination, lux (3)	Limiting Glare Index (4)
i)	Entrance halls, lobby	150	—
ii)	Reception and accounts	300	—
iii)	Dining rooms (tables)	100	—
iv)	Lounges	150	—
v)	Bedrooms:		
	a) General	100	—
	b) Dressing tables, bed heads, etc.	200	—
vi)	Writing tables	300	—
vii)	Corridors	70	—
viii)	Stairs	100	—
ix)	Laundries	200	25
x)	Kitchens	200	25
xi)	Goods/passenger lifts	70	—
xii)	Cloakrooms/toilets	100	—
xiii)	Bathrooms	100	—
xiv)	Shops/stores	150 - 300	22

NOTE — The lighting of some of these locations is determined primarily by aesthetic considerations and the above values should be taken as a guide only.

6.6.1.2 In guest bedrooms, it shall be possible to switch the general lighting not only from the entrance but also from the bedside (*see also* **8.4.2**)

6.6.1.3 In bathrooms, the lights should be mounted at head level on both sides of the mirror. Care shall be taken to ensure that there is no glare.

6.6.1.4 Lighting in banquet halls shall be given special consideration in view of its multipurpose utility such as fairs, dances, fashion shows, conferences, exhibition or concerts. Sufficient number of controlled socket-outlet circuits shall be combined in a switching station from which the entire hall shall be visible.

6.6.1.5 In designing outdoor lighting installations, care shall be taken to ensure that disturbing glare does not reach the rooms of the guests.

6.6.2 *Air-conditioning*

The provisions of Part 1/Section 14 of this Code shall apply.

6.6.3 *Lifts and Escalators*

6.6.3.0 The general rules laid down in Part 1/Section 14 of this Code shall apply. However, the design of lifts shall take into account the following recommendations.

6.6.3.1 *Occupant load*

For hotel buildings, an occupant load of 12.5 gross area, in m^2 per person is recommended.

6.6.3.2 *Passenger handling capacity*

The passenger handling capacity expressed in percent of the estimated population that has to be handled in the 5 min peak period shall be 5 percent for hotel buildings.

6.6.3.3 *Car speed* — This shall be as follows:

Occupancy (1)	*Floors Served* (2)	*Car Speed* m/s (3)
Passenger lifts for low and medium class lodging houses	—	0.5
Hotels	4-5	0.5-0.75

6.6.3.4 For hotel buildings, it is desirable to have at least a battery of two lifts at convenient points of a building. If this is not possible, it is advisable to have at least two lifts side by side at the main entrance, and one lift at different sections of the building for intercommunication.

7 TESTING OF INSTALLATION

The various tests on the installation shall be carried out as laid down in Part 1/Section 10 of this Code.

8 MISCELLANEOUS PROVISIONS

8.1 Call System

The general provisions for electrical bells and call system shall conform to those laid down in Part 1/ Section 14 of this Code. The call system should be a wired electrical system whereby customer may signal for attendance from his room. Two types of systems are recommended:

a) A simple one-watt signal system which connects the room side call stations with a signal at the attendant station. It simultaneously lights a dome light over the door of the room from which the call is originated. The signal at the attendant station may be in the form of an annunciator with a buzzer or a light with a buzzer.
b) A central control panel shall, be set up

preferably on the ground floor incorporating a set of indicating panels according to the number of wings. Each indicating panel should have a set of small lamps according to the number of rooms. After-attending the customer, the attendant presses the resetting button which puts the whole equipment to the original condition.

8.2 Telephones

A centralized EPABX System with sufficient P&T lines shall be installed for internal and external communications with the help of operator's assistance as well as directly through this system. These may be connected on a dial system which permits internal communication through the hotel switchboard without the assistance of the operator. At all the rooms, telephone jacks shall be installed so that a telephone may be plugged in any time at any convenient location. Parallel telephones may be provided in the bedrooms. Each room shall also be provided with jacks for Broad Band Multi Service facility/internet facility.

8.3 Clock Systems

The general provisions for clock systems shall conform to those laid down in Part 1/Sec 14. The following locations may be provided with clocks:

a) Guest rooms,
b) Main lobby,
c) Telephone switchboard,
d) Dining room,
e) Banquet halls,
f) Kitchen, and
g) Restaurant and bar rooms.

8.4 Emergency Supply

See also Part 2 of this Code.

8.4.1 In the event of a failure of supply, a large standby power supply usually a diesel driven generating set could be used to partly or entirely supply the loads in the hotel. Emergency lighting shall be confined to essential areas, and the standby power supply shall feed essential and safety installations in the hotel.

8.4.2 Part of the kitchen, storage and refrigeration rooms in the hotel shall also be supplied by the emergency supply. A part of the lighting in each room, corridor, staircases and other circulation areas shall be connected to emergency supply.

8.5 Other Special Installations

The list of such installations is given below:

a) TV sets at main assembly areas and in guest rooms,
b) Lighting in banquet halls,
c) Fire-fighting system,
d) Swimming pool (*see* Annex A),
e) Cold storage,
f) Sauna Heaters (*see* Annex B), and
g) Broad Band Multi Service facility/internet facility.

8.6 For particular requirements for locations containing a bathtub or shower basin, *see* Annex A of Part 3/ Section 1 of this Code.

8.7 Luminous Sign

Photo luminescent safety signage should be provided at different strategic locations.

ANNEX A

(*Clause* 8.5)

PARTICULAR REQUIREMENTS FOR SWIMMING POOL

A-1 SCOPE

This Annex applies to the basins of swimming pools and paddling pools and their surrounding zones where susceptibility to electric shock is likely to be increased by the reduction of body resistance and contact with earth potential.

A-2 CLASSIFICATION OF ZONES

A-2.1 Reference is drawn to Fig. 1 and Fig. 2.

Zone 0 — is the interior of the basin.

Zone 1 — is limited by a vertical plane 2 m from the rim of the basin by the floor or the surface expected to be occupied by persons and the horizontal plane 2.50 m above the floor of the surface.

Zone 2 — is limited by the vertical plane external to Zone 1 and a parallel plane 1.50 m from the former, by the floor or surface expected to be occupied by persons and the horizontal plane 2.50 m above the floor or surface.

NOTE — Where the pool contains diving boards, spring boards, starting blocks or a chute, Zone 1 comprises the zone limited by a vertical plane situated 1.50 m around the diving boards, spring boards and starting blocks, and by the horizontal plane 2.50 m above the highest surface expected to be occupied by the persons.

A-3 PROTECTION FOR SAFETY

A-3.1 Where safety extra-low voltage is used, whatever the nominal voltage, protection against direct contact shall be provided by barriers or enclosures affording at least a protection of IP2X, or insulation capable or withstanding a test voltage of 500 V for 1 min.

A-3.2 All extraneous conductive parts in Zones 0, 1 and 2 shall be bonded with protective conductors of all exposed conductive parts situated in these Zones.

A-4 SELECTION OF EQUIPMENT

A-4.1 Electrical equipment shall have at least the following degrees of protection:

a) *Zone* 0 : IP X 8
b) *Zone* 1 : IP X 4
c) *Zone* 2 : IP X 2 for inside swimming pools.
IP X 4 for outside swimming pools.

A-4.2 For Zone 1 and Zone 2, water jet is likely to be used for clearing purpose : IP X 5

This requirement does not apply to instantaneous water heaters complying with IS 302 (Part 2/Sec 35).

A-5 WIRING SYSTEMS

A-5.1 In Zone 0 and Zone 1, wiring systems shall be limited to those necessary to the supply of appliances situated in those zones.

A-5.2 Junction boxes are not permitted in Zone 0 and Zone 1. In Zone 2, they are permitted provided they have the necessary degree of protection as given in **A-4.1**.

A-5.3 In Zone 0 and Zone 1 no switchgear and accessory shall be installed. In Zone 2 socket-outlets are permitted only if they are either:

a) supplied individually by an isolating transformer, or
b) supplied by safety extra low voltage, or
c) protected by a residual current protective device.

A-5.4 If it is not possible to locate socket-outlets may be installed only if they are complying

a) Outside 1.25 m from the Zone 0 border, and
b) protected by residual current protection device.

A-5.5 The socket-outlets shall comply IS/IEC 60309 (Part 1) and IS/IEC 60309 (Part 2).

A-5.6 An electric heating unit embedded in the floor in Zones 1 and 2 shall incorporate a metallic sheath connected to the local supplementary equipotential bonding and shall be covered by the metallic grid required by **A-3.2**.

A-5.7 In Zone 2, only water heaters are permitted excepting that other equipment supplied by SELV (Safety Extra Low Voltage) at a nominal voltage not exceeding 12 V may be installed.

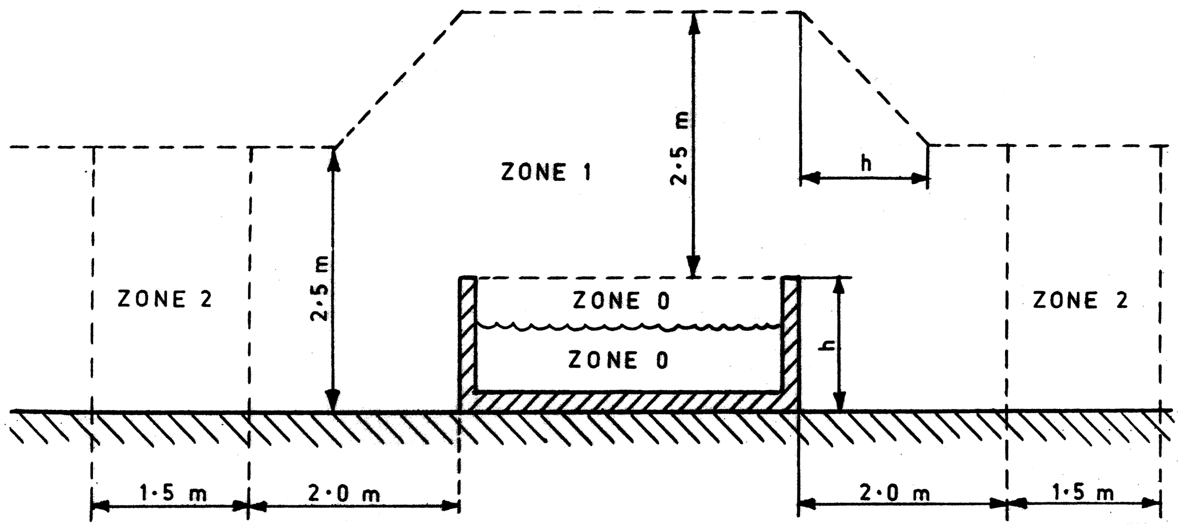


FIG. 1 ZONE DIMENSIONS FOR BASINS ABOVE GROUND

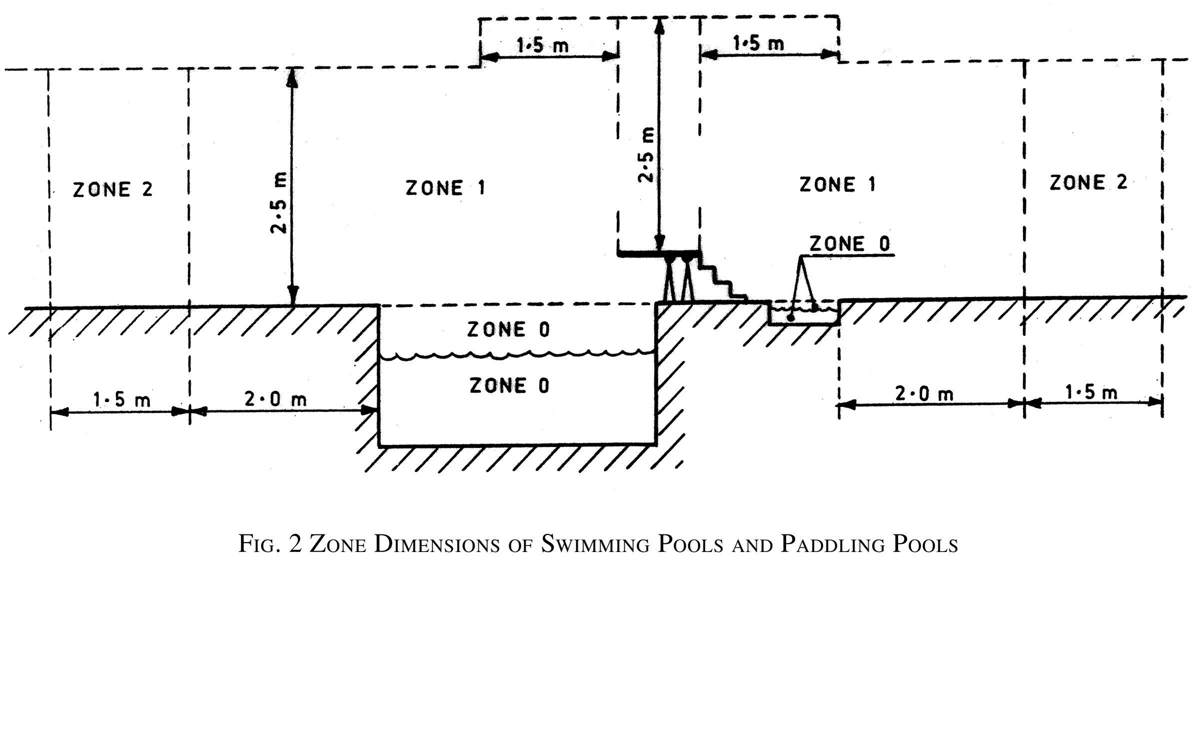


FIG. 2 ZONE DIMENSIONS OF SWIMMING POOLS AND PADDLING POOLS

ANNEX B
(*Clause* 8.5)

PARTICULAR REQUIREMENTS FOR LOCATIONS CONTAINING SAUNA HEATERS

1 SCOPE

The particular requirements of this Annex apply to locations in which hot air sauna heating equipment is installed.

B-2 CLASSIFICATION OF TEMPERATURE ZONES

B-2.1 The assessment of the general characteristics of the location shall take due consideration of the classification of the four temperature zones which are illustrated in Fig. 3.

B-3 PROTECTION FOR SAFETY

B-3.1 Where Safety Extra Low Voltage (SELV) is used, irrespective of the nominal voltage, protection against direct contact shall be provided by one or more of the following:

a) insulation capable of withstanding a test voltage of 500 V ac, rms for 1 min.
b) barriers or enclosures, affording at least degree of protection IP 24.

B-3.2 All extraneous conductive parts shall be bonded with protective conductors of all exposed conductive parts situated in these zones and earthed.

B-4 SELECTION OF EQUIPMENT

B-4.1 All equipment shall have at least the degree of protection IP 24.

B-4.2 Equipment should be selected in accordance with the temperature zones as depicted in Fig. 3 as per the following details:

a) Zone A: only the sauna heater complying with relevant safety standard and equipment

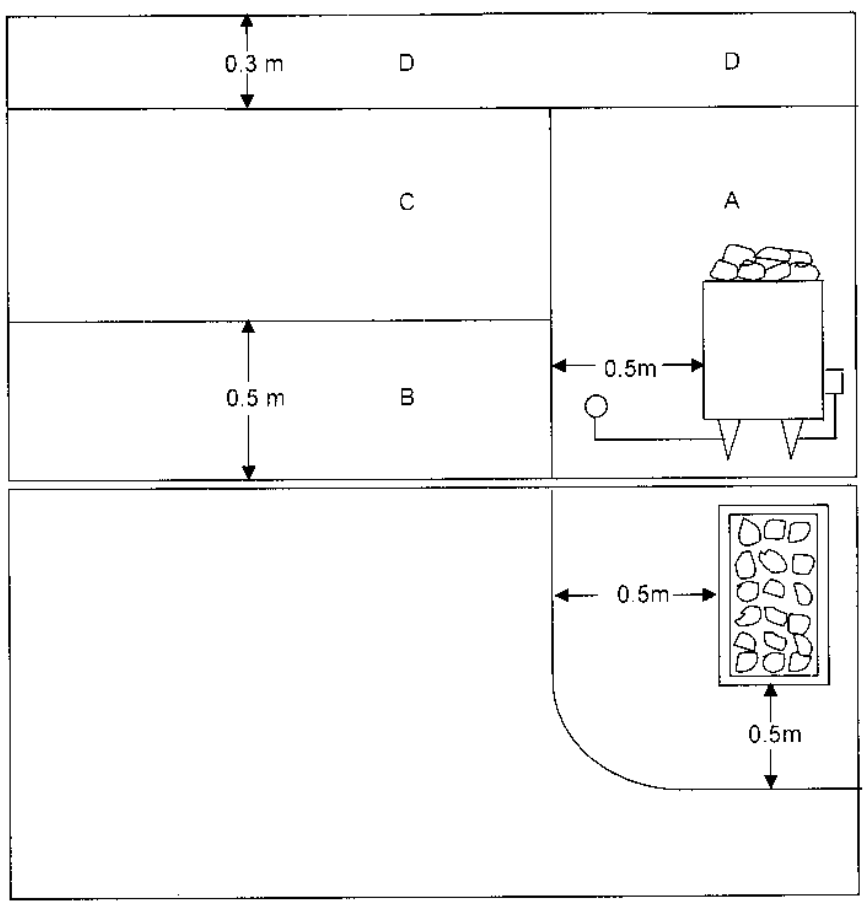


FIG. 3 CLASSIFICATION OF TEMPERATURE ZONES

directly associated with it shall be installed.

b) Zone B: there is no special requirement concerning heat resistance of equipment.

c) Zone C: equipment shall be suitable for an ambient temperature of 125°C.

d) Zone D: only luminaries and their associated wiring, and control devices for the sauna heater and their associated wiring shall be installed. The equipment shall be suitable for an ambient temperature of 125°C.

B-5 WIRING SYSTEMS

B-5.1 Flexible elastomer insulated and mechanically protected cords complying with appropriate standard, suitable for 150°C should be used.

B-5.2 Switchgear not built into sauna heater, other than a thermostat and a thermal cut-out shall be installed outside the hot air sauna.

B-5.3 Except as permitted in **B-4.2** and **B-5.2** accessories shall not be installed within the hot air sauna.

B-6 OTHER FIXED EQUIPMENT

B-6.1 Luminaries shall be so mounted as to prevent overheating.

SECTION 6 SPORTS BUILDINGS

0 FOREWORD

The design and erection of electrical installation in a sports building have to take into account a multitude of factors that are unique to the type of use to which it is put. In a way the electrical power needs and the external influences in a sports building are quite identical to those for theatres and other multipurpose buildings for cultural events excepting that for international events exacting standards of services and flexibility had to be provided in a multipurpose sports stadia.

Several stadia, especially those of the indoor type are meant for staging a variety of games which between themselves require varying standards of lighting levels. The design of illumination system in a sports building therefore requires consultations with a specialist and the guidelines provided in this Section are purely recommendatory in nature in this respect.

In indoor stadia where large number of people congregate it is essential to inbuild adequate fire precautions from the point of view of safety. Assessing the need for adequate strength of a standby supply for essential services requires special consideration.

It is to be noted that a sports stadia should preferably be designed for use for other purposes as well, such as the staging of cultural events and this aspect shall be borne in mind while designing the electrical needs of the complex so as to ensure optimum utilization of the facilities.

With the advent of sophisticated stadia in the country as well as keeping in view the accent on sports, this Section of this Code has been set aside to cover such of those specific requirements applicable to sports buildings from the electrical engineering point of view. Taking note of the fact that the type of buildings and their needs for the purposes of sports and games would be quite different between them, only broad guidelines are outlined in this Section. It is recommended that assistance of experts shall be sought in the design of the installation at the early stages itself.

1 SCOPE

This Part 3/Section 6 of the Code covers requirements for electrical installations in sports buildings and stadia, indoor and outdoor.

2 TERMINOLOGY

For the purpose of this Section, the definitions given in Part 1/Section 2 of this Code shall apply.

3 CLASSIFICATION OF SPORTS BUILDINGS

3.1 The buildings for the purposes of conducting sports and games are characterized by the criteria that large number of people congregate. Sports complexes not basically meant for exhibition purposes, and not likely to be utilized for other purposes, such as for staging special or cultural events, shall however conform to the special requirements of this Section. The type of building shall therefore be classified as follows:

a) *Based on type of building:*
   1) Indoor stadia.
   2) Outdoor stadia: Stadia meant for use in daylight. Stadia meant for use during night under artificial lighting.
b) *Based on type of game/sport:*
   1) Single game sports hall/stadia.
   2) Multigames hall/stadia.
c) *Based on utility:*
   1) Stadia meant for games only.
   2) Multipurpose stadia for other amusements as well.
d) *Based on audience-factor:*
   1) Stadia/halls meant for exhibition purposes — where groups of people congregate.
   2) Stadia/halls meant for training and passtime — where audience may not normally be present.

NOTE — Classification d (1) includes stadia meant for staging tournaments and events, and d (2) includes games halls in educational institutions and the like where normally no exhibition is intended.

3.1.1 Reference should be made to **5.5.1.2** for classification from lighting consideration.

3.2 The electrical installation needs in sports buildings would therefore be governed by the type of use indicated in **3.1**(a) to (d). A large sports complex may include the following sub-units:

a) Supply intake/voltage of supply;
b) Main substation and satellite substations, if any;
c) Central control room/switch rooms;
d) Electrification of restaurant, health clubs; hospitals, offices and other support structures;
e) Communication facilities (telephone, telex, telegraph, data processing TV, radio and press facilities);

f) Fire protection services;
g) External electrification of gardens and parking lots, service routes, lake fountains (if any);
h) Emergency electric supply system including uninterrupted power requirements;
j) Audio systems, public address/security;
k) De-watering arrangements, sewage disposal, water supply systems;
m) Gas/oil arrangements for sports flame if required; and
n) Miscellaneous requirements for power-socket, microphone outlets, score-boards, etc.

4 GENERAL CHARACTERISTICS OF SPORTS BUILDINGS

General guidelines on the assessment of characteristics of installations in buildings are given in Part 1/Section 8 of this Code. For the purposes of installations falling under the scope of this Section, the characteristics given below shall apply.

4.1 Environment

4.1.1 The following environmental factors apply to sports buildings:

Environment (1)	*Characteristics* (2)	*Remarks* (3)
Presence of water	Submersion, possibility of permanent and total covering by water	Locations such as swimming pools where electrical equipment is permanently and totally covered with water under pressure greater than 0.1 bar.
Presence of foreign solid bodies	The quantity or nature of dust or foreign solid bodies is not significant	Indoor stadia.
	Presence of dust in significant quantify	Outdoor stadia.
Presence of corrosive or polluting substances	Negligible	Covers majority of cases. Stadia and games complexes situated by the sea or industrial zones require special consideration.
Lighting	Negligible	Covers category d(2) (*see* **3.1**) type of installations.
	Indirect exposure to lighting, where hazard from supply arrangements exists	Installations supplied by overhead lines.
	Direct exposure or hazard from exposure of equipment is present	Lighting towers in outdoor stadia.

4.2 Utilization

The following aspects utilization shall apply:

Utilization (1)	*Characteristics* (2)	*Remarks* (3)
Capability of persons	Uninstructed persons	In sports stadia the sportsmen and spectators fall under this category. However, electrical operating areas are accessible to instructed persons only.
Conditions of evacuation in an emergency	Low density occupation, easy conditions of evacuation	Training halls and the like where people do not congregate.
	High density occupation, difficult conditions of evacuation	Large multipurpose stadia for exhibition purposes.
Nature of processed of stored material	Existence of fire-risks.	Due to furniture and false floor for playing area

5 SUPPLY CHARACTERISTICS AND PARAMETERS

5.0 Exchange of Information

5.0.1 Proper coordination shall be ensured between the architect building contractor and the electrical engineer on the various aspects of the installation design. In addition to the general aspects which require coordination and identified in other sections, the following data shall specifically be obtained:

a) The total electrical power needs of the stadium including the standby power arrangements, which will decide the voltage of supply, number of substations and their preferred locations, capacity of diesel engine generating sets for standby supply, transformers, switchgear, voltage stabilizers, uninterrupted power supply requirements, etc;

b) In case of indoor stadia, whether air-conditioning is required and if so, the capacity and locations of main plants, air-handling units, pumps, ducting, layout, route of chilled water lines, etc. In case of outdoor stadium, the covered portions like offices, restaurants, are to be air-conditioned or not and their details as above;

c) Details of fire fighting system/fire alarm system envisaged;

d) Details of water supply arrangements, storm water drainage, sewage disposals and pump capacities, locations, etc;

e) Locations of substations, switchrooms, distribution boards, etc;

f) Requirements of audio-communication system for the stadium which includes public address system, car calling system, ambulance call, fire service call, intercom stations, wireless paging system, inter-stadia communication facilities, computer-aided results information, etc;

g) Details of score-boards — that is whether and their power etc, centralized manual or automatic, etc, needs, voltage stability, clock system, etc;

h) Special requirements of press, TV, Radio, telecommunication, games federations, etc;

j) Requirements of lighting, the location of lighting luminaries, type of light source, level of illumination required for various stages like training, TV (black and white or colour) coverage, etc;

k) Requirements for power outlets, speaker outlets, microphone outlets, etc., in playing arena and field; and

m) Other miscellaneous items like electrification of ancillary buildings in the sports complex, restaurants, gas/oil requirements for flame and their controls, fountain lighting system, car park, path way and external electrification.

5.0.2 The following drawings are recommended to be prepared before commencing the installations work:

a) Single line diagram for electrical distribution;

b) Complete layout drawings indicating type and mounting of luminaries and conduit/cable installations for various services. This shall be prepared in coordination with civil and structural engineers;

c) Wiring diagrams showing switching sequence of luminaries, firealarm system, public announcement systems, etc;

d) In case of air-conditioning, layout of plants, chilled water piping routes, ducts/grill layout, etc;

e) Layout of public address system envisaged; and

f) Site plan indicating the location of pump houses for storm water drains, water supply, sewage and fire fighting systems, with the proposed source and route of power supply.

5.1 Branch Circuits

5.1.1 The general rules as laid down for other large assembly buildings (*see* Part 3/Section 3) and as laid down in Part 1 of this Code shall apply.

5.1.2 Wiring installations for general purpose lighting and ventilation needs of the sports buildings shall conform to the requirements laid down in Part 1/Sec 1 of this Code. It is preferable to avoid temporary wiring in electrical central control room.

Whenever floodlight luminaries of more than 1 000 W are installed, it is preferable to have individual branch, circuits to each of the luminaries after considering the economic aspects.

Junction boxes shall be installed near the luminaries from which connection to the light source may be taken by flexible conduits. This will help maintenance work to be carried out without disturbing the positioning of the lighting fittings.

5.1.3 *Panel Boards and Switchboards*

The provision of Part 1/Section 9 of this Code shall apply. In large stadia, the areas covered by the services shall be segregated into zones and the sub-distribution and distribution boards shall be so arranged and marked keeping in view their accessibility in times of need.

5.1.4 *Socket-outlets and Plugs*

For small stadia/halls, the provisions of Part 3/Section 3 of this Code shall apply. The need for special convenience outlets shall be considered for services enumerated in **3.2**(e). Utility socket outlets shall be provided at a height of about 0.3 m from the floor except in field/arena. These shall be of weather-proof type.

5.2 Feeders

5.2.1 The utility shall be consulted as to the type of service available, whether primary or secondary, single-phase or three-phase star or delta.

5.2.2 Outdoor floodlighting installations can be made with either overhead or underground distribution feeders. From the point of view of appearance and minimum interference, the underground system is more desirable where large playing areas are involved.

5.2.3 The underground system shall either be cables directly buried or cables in conduits.

5.3 Building Substation

5.3.1 The electrical needs of sports stadia may vary from 30 kVA to 1 000 kVA, according to the size of the installation. Usually HV supply is used for large multipurpose stadia where power demand is in excess of 500 kVA. The design of location of substation and the diesel generating set, if provided, shall conform to the requirements specified in Part 2 of this Code.

5.3.2 The main substation for a sports building shall preferably be located in such a place that does not interfere with the movement of people congregating. All electrical operating areas, and control rooms shall preferably be segregated from public routes for the sporting events.

5.3.3 Some installations may justify a separate transformer on each pole of the floodlighting tower with primary wiring to each tower. In smaller installations, it may be more economical to reduce the number of transformers by serving several locations from a single transformer through secondary wiring.

5.3.4 For buildings staging national and international sports events, it shall be provided with duplicate power supply so that in the event of failure of one power supply, other one can be able to cater the total load intended to serve. The changeover should be automatic.

5.3.5 Emergency power supply by DG set/s shall be provided at strategic locations to keep the general lighting and ventilation of the sport buildings in case of normal ac power failure. The changeover should be automatic.

5.4 System Protection

5.4.0 The general rules for the protection of safety laid down in Part 1/Section 7 of this Code shall apply.

5.4.1 Sports buildings are classified as 'assembly buildings' (Group D) from fire-safety point of view. Besides fire fighting equipment fire-detection and extinguishing system shall be provided as recommended below (*see also* SP 7):

Description (1)	*Fire Detection System* (2)
Big halls for over 5 000 persons	Automatic sprinkler and alarm system
Small halls, health clubs, arena, gymnasiums, etc, indoor with or without fixed seats corridors for about 1 000 persons	Automatic sprinkler Automatic fire alarm system
Same as above, occupancy for less than 1 000 persons	Same as above
Small indoor games halls for less than 300 persons	Automatic fire alarm system
Grandstands, stadia for outdoor gathering	Manually operated fire alarm systems, in offices and automatic fire alarm system in stadia, machine room, control room, etc

5.5 Building Services

5.5.1 *Lighting*

5.5.1.0 The general rules laid down in Part 1/Section 11 of this Code shall apply (*see also* SP 72).

5.5.1.1 *Special design features*

Design of sports lighting, especially in large stadia require considerations of not only the objects to be seen, the background brightness, etc, but the observer's location in the grandstand as well. The following shall be taken into account:

a) Observers have no fixed visual axis or field of view. During the shifting of sight, even the ceiling and luminaries are likely to come into the line of vision.
b) While the game is in play, the objects of regard are not fixed, and mostly moving in a three-dimensional space.
c) It is important for observers to be able to estimate accurately the object velocity and trajectory.

5.5.1.2 For the purposes of artificial lighting design, it is recommended to divide the location of sport play into general areas for more than one sport and areas for particular sport.

General areas include field houses, gymnasiums, community centre halls and other multipurpose areas. For the purposes of lighting design, the nature of sports shall be divided as follows:

a) Aerial sports (sports which are aerial in part or whole) — Badminton, basketball, handball, squash, tennis and volleyball.

b) Low level (games which are close to the ground level) — Archery, billiards, bowling, fencing, hockey, swimming and boxing.

5.5.1.3 *Levels of illumination*

For some representative types of sport, the recommended values of illumination are as given in Table 1.

Table 1 Recommended Values of Illumination

Sl No.	Sport	Illumination, lux
(1)	(2)	(3)
i)	Archery	
	Target	540
	Shooting line	220
	Badminton	320
	Basketball	540
	Billiards (on table)	540
	Boxing and wrestling	540
ii)	Football (*see* Notes 1 and 2)	
	Class I	1 100
	II	540
	III	320
	IV	220
iii)	Gymnasiums	
	Matches	540
	General exercising	320
	Hockey (field)	220
iv)	Racing	
	Bicycle	320
	Horse	220
v)	Rifle (outdoor)	
	Targets	540 (vertical)
	Firing point	110
	Range	54
vi)	Swimming	
	a) Indoor Exhibition	540
	Underwater[1)]	100 W/m^2 of surface area
	b) Outdoor Exhibition	220
	Underwater	60 percent of indoor
	Tennis (laws) Indoor	540
	Outdoor	320
	Table tennis	540
	Volleyball	220

NOTES

1 It is generally conceded that the distance between the spectators and the play is primary consideration for football, as well as the potential seating capacity of the stand. The following classification is therefore described.

Class I — 30 000 spectators, over 30 m minimum distance.

Class II — 10 000-30 000 spectators, over 15-30 m minimum distance.

Class III — 5 000-10 000 spectators, over 10-15 m minimum distance.

Class IV — 5 000 spectators, over 10 m minimum distance.

2 For football, uniform illumination shall be provided at ground level as well as vertically for 15 m above ground.

[1)] Levels recommended are for incandescent lamps. For discharge lamps W/m^2 would be reduced depending upon the efficiency of light source. In order that the installed flux.

5.5.1.4 *Selection of light sources*

For sports lighting, the following light sources are advantageous together with the considerations indicated against each:

a) *Incandescent lamps (including tungsten halogen)* — Where necessary, over-voltage operation can be used to advantage especially as in sports installations, the lighting systems are used for less than 500 h a year.

b) *Fluorescent lamps* — Advantageous where mounting heights are low and short projection distances are acceptable, for example tennis, bowling, trampoline and a variety of indoor sports.

c) *High intensity discharge lamps* — These are characterized by long life and high human efficiency. However, the inherent time delay for full glow when first energized or when there is power interruption may necessitate use of incandescent lighting system to provide emergency standby illumination in spectator areas.

For sports events, where colour rendition is important, use of fluorescent mercury lamps is recommended.

5.5.1.5 *Miscellaneous considerations for lighting*

a) While selecting and installing high intensity discharge or fluorescent lamps in multipurpose stadia, it is necessary to connect lamps on alternate phases of supply to avoid flicker on rapidly moving objects. Where a quite surrounding is required in order to avoid ballast hum, remote mounting of ballasts shall be considered.

b) Efforts shall be required to coordinate the lighting design for sports events with the illumination requirements for TV or film coverage. A horizontal illumination in excess of 300 lux is considered adequate for operation of black and white TV and film recording. Colour recording calls for more stringent requirements. Colour filming may also need lamps having correlated colour temperature of between 3 000 K to 7 000 K.

For film/TV coverage, data on the following shall be necessary:

1) Camera sensitivity,
2) Exposure time, and
3) Effective aperture.

c) *Group switching* — Group switching of luminaries is recommended to have maximum energy saving, after considering the following factors as well:

1) Separate switching for lighting outside the stadia,
2) Requirement of lighting for training purpose,
3) Requirement of lighting for tournaments with film and TV coverage, and
4) Separate switching for playing arenas.

5.5.2 *Air-conditioning*

5.5.2.1 The requirements for air-conditioning and ventilation as laid down in Part 1/Sec 14 of this Code shall apply.

5.5.3 *Lifts and Escalators*

The general rules laid down in Part 1/Section 14 of this Code shall apply.

6 TESTING OF INSTALLATIONS

The various tests on the installation shall be carried out as laid down in Part 1/Section 10 of this Code.

7 MISCELLANEOUS PROVISIONS

7.1 Electrical Audio Systems

The general provisions for the installation of public address systems shall be as laid down in Part 1/ Section 11 of this Code.

In large grandstand stadia, the effect of time delay for the sound from the loudspeakers to reach different sections of the audience would be significant. This shall be avoided in taking proper precautions in the design of electrical audio systems.

7.2 Control Room

The various communication needs of large stadia is normally met with by electronic equipment centrally controlled, requiring specific power supply, and other installation conditions. This would call for special wiring systems with synchronizing systems. The technical requirements for these systems concerning voltage and frequency stability are very high. These shall be considered before designing the electrical services of the same.

7.3 Electrical/Electronic Score Board

The power requirements for such equipment would depend on the type of equipment to be installed. Guidelines of the manufacturer shall be adhered to.

7.4 Clock System

Reference shall be made to the provisions in Part 1/ Section 11 of this Code.

SECTION 7 SPECIFIC REQUIREMENTS FOR ELECTRICAL INSTALLATIONS IN MULTISTORIED BUILDINGS

0 FOREWORD

The design and construction of electrical installations in multistoried buildings call for special attention to details pertaining to fire-safety of the occupancy. While on the one hand, the civil design aspects are more stringent for high-rise buildings than for buildings of low heights, the electrical design engineer, on his part had to ensure that the fire hazards from the use of electric power is kept to the lowest possible limit.

In drafting the requirements of electrical installations in various occupancies it was felt that a separate compendium giving the specific requirements applicable to multistoried buildings should be brought out. For editorial convenience, such details have been stated in this Section where the major non-industrial occupancies have been covered.

In applying the provisions of this Section, note shall also be taken of the nature of occupancy of the high-rise buildings and a judicious choice of alternative features shall be made.

1 SCOPE

1.1 This Part 3/ Section 7 is intended to cover specific requirements for electrical installations in multistoried buildings.

1.2 The requirements specified here are in addition to those specified in respective sections of the Code, and are specifically applicable for buildings more than 15 m in height.

2 REFERENCES

This Part 3/Section 7 of the Code should be read in conjunction with the following Indian Standards:

IS No.	*Title*
SP 7 : 2005	National Building Code of India
2309 : 1989	Code of practice for the protection of buildings and allied structures against lightning
10028 (Part 2) : 1981	Code of practice for selection, installation and maintenance of transformers: Part 2 Installation

3 TERMINOLOGY

For the purposes of this Section, the definitions given in Part 1/Section 2 of the Code shall apply.

4 SPECIAL CONSIDERATIONS

Special considerations shall have to be given in respect of the following requirements for the electrical installations in multistoried buildings:

a) Internal wiring for lighting, ventilation, call bell system, outlets for appliances, power and control wiring for special equipments like lifts, pumps, blowers, etc;
b) Distribution of electric power;
c) Generators for standby electric supply;
d) Telephone wiring;
e) Fire safety;
f) Lightning protection;
g) Common antenna system;
h) Clock system;
j) Building Management System (BMS);
k) EPABX with P&T lines; and
m) Broad Band Multi Service facility.

5 EXCHANGE OF INFORMATION

5.1 The detailed requirements of the owner shall be assessed at the planning stage.

5.2 It is necessary that right at the planning stages, the requirements of space for accommodating the distribution equipment for the various electrical services and openings required in slabs for vertical risers for such services are assessed and incorporated in drawings in due coordination with the architect and structural designer. Care shall be taken to provide adequate and where necessary, independent spaces for the equipment for electrical services for different functions.

5.3 Multistoried buildings are usually in framed design. Coordination with the architect is required in evolving suitable layout of lights, fans and other outlets and the position for their switch controls to take care of functional utility and flexibility.

5.4 While designing the electrical services, due consideration should be given for conservation of energy.

5.5 The voltage of supply and location of energy meters (especially in multistoried buildings meant for residential purposes) shall be agreed to between the utility and the owner of the building. Spaces for accommodating the distribution and metering equipment of utility should be accordingly provided for by coordinating with the architect and licensee.

5.6 The telephone authorities shall be consulted for the requirements of space for accommodating the distribution equipment, battery, etc, for the telephone services.

5.7 The local fire brigade authorities shall be consulted in the matter of system layout for fire detection and alarm systems to comply with local bye-laws. The locations of control panel and indication panel shall be decided in consultation with the owner.

5.8 Runs of roof conductors and down conductors for lightning protection shall be coordinated with the architects of the building. The requirements as laid down in Part 1/Section 15 of this Code shall be complied with.

6 ASSESSMENT OF CHARACTERISTICS OF MULTISTORIED BUILDINGS

6.0 The general characteristics of buildings depending on the type of occupancy are assessed based on me guidelines given in relevant sections of this Code, together with those given in Part 1/Section 8.

6.1 For the purposes of multistoried buildings in addition to other external influences depending on the type of occupancy, the electrical installation engineer shall specifically take note of characteristics BD2, BD4 and CB2 given in Table 1 of Part 1/Section 8 of this Code.

7 DISTRIBUTION OF ELECTRIC POWER

7.0 Load Assessment and Equipment Selection

7.0.1 The electrical load shall be assessed considering the following:

a) Lighting and power loads;
b) Special loads of equipments as in laboratories, hospitals, data processing areas, etc;
c) Air-conditioning/evaporative cooling/heating services;
d) Water supply pumps;
e) Fire fighting pumps;
f) Electric lifts; and
g) Outdoor and security lighting.

The anticipated increase in load shall also be given due consideration.

7.0.2 Suitable demand factors and diversity factors shall be applied depending on the operational and functional requirements. The distribution equipments shall be selected by adopting standard ratings. Adequate spare capacity should be provided for every component in the distribution system.

7.0.3 The fault level at the point of commencement of supply should be obtained from the licencee and fault levels at salient points in the distribution system assessed. Distribution system component should be selected to satisfy the same.

7.1 Building Substation

7.1.1 The provisions contained in Part 2 of this Code shall apply.

7.1.2 A substation or a switch-station with apparatus having, more than 2 000 litre of oil shall not ordinarily be located in the basement where proper oil drainage arrangements cannot be provided. If transformers are housed in the building below the ground level, they shall necessarily be in the first basement in a separate fire-resisting room of 4-h rating. The room shall necessarily be at the periphery of the basement. The entrance to the room shall be provided with a fire-resisting door of 2-h fire rating. A curb (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. Direct access to the transformer room shall be provided, preferably from outside. The switchgears shall be housed in a room separated from the transformer bays by a fire-resisting wall with fire resistance of not less than 4 h.

7.1.3 The transformer, if housed in basement, shall be protected by an automatic high velocity water spray system. The transformer may be exempted from such protection if their individual oil capacity is less than 5 000 litres.

7.1.4 In case the transformers are housed in the basements, totally segregated from other areas of the basements by 4-h fire-resisting wall/walls with an access directly from outside, they may be protected by carbon dioxide or BCF (bromochloro difluro methane) or BTM (bromotrifluro methane) fixed installation system.

7.1.5 When housed at ground floor level, it/they shall be cut off from the other portion of premises by fire-resisting walls of 4-h fire resistance.

7.1.6 Oil-filled transformers shall not be housed on any floor above the ground floor.

7.1.7 Soak pit of approved design shall be provided where the aggregate oil capacity of the apparatus does not exceed 2 000 litres. Where the oil capacity exceeds 2 000 litre, a tank of RCC construction of capacity capable of accommodating entire oil of the transformers shall be provided at a lower level to collect the oil from the catch-pit in case of emergency. The pipe connecting the catch-pit to the tank shall be of non-combustible construction and shall be provided with a flame-arrester [*see* IS 10028 (Part 2)].

7.1.8 Only dry type of transformers should be used for installation inside the residential/commercial buildings.

7.2 Distribution System

7.2.0 Capacity and number of system components and the electrical distribution layout should be decided considering the likely future requirements, security, grade of service desired and economics. The choice between cables and metal rising mains for distribution of power should be done depending on the load and the number of floors to be fed.

7.2.1 In multistoried buildings where large number of people gather (for example office buildings), there shall be at least two rising mains located in separate shafts. Each floor shall have a changeover switch for connection to either of the two mains.

7.2.2 When cables are used for distribution to different floors, it may be desirable that cables feeding adjacent floors are interconnected for use when distribution cables in either of the floors fail.

7.2.3 It is essential to provide independent feeders for installations such as fire lift, fire alarm, fire pumps, etc.

7.2.4 In the case of residential buildings, submain wiring to the flats/apartments shall be independent for each flat/apartment.

7.2.5 Twin earthing leads of adequate size shall be provided along the vertical runs of rising mains.

7.3 Siting of Distribution Equipment

7.3.1 The following aspects shall be considered in deciding the location of electric substation for multistoried buildings:

a) Easy access for purpose of movement of equipment in and out of the substation including fire fighting vehicles;
b) Ventilation;
c) Avoidance of flooding by rain water;
d) Feasibility of provision of cable ducts (keeping in view the bending radius of the cable), oil soak pits (for large transformers) and entry of utility's cable(s);
e) Transformer hum (and noise and vibration from diesel generating sets where provided as part of the substation);
f) Where a separate building for substation is not possible, the same should preferably be at ground floor level of the multistoried building itself. In the case of a complex with a number of buildings, the substation should be located, as far as possible, near the load centre; and
g) In the cases of certain high rise buildings, provision of substation at intermediate floors may be necessary for case of distribution. In such cases, non-inflammable cooling medium shall be used for substation equipment from the point of view of fire safety.

7.3.2 The vertical distribution mains should be located considering the following aspects:

a) Proximity to load centre;
b) Avoiding excess lengths of wiring for final circuits and points;
c) Avoiding crossing of expansion joint, if any, by horizontal runs of wiring;
d) Avoiding proximity to water bound, areas like toilets, water coolers, sanitary/air-conditioning shafts, etc;
e) Easy maintainability from common areas like lobbies, corridors, etc; and
f) Feasibility to provide distribution switch-boards in individual floors vertically one over the other.

7.4 Wiring Installation

7.4.1 The electrical wiring shall be carried out in conformity with Part 1/Section 9 of this Code.

7.4.2 Aluminium conductor may be used for wiring cables, but copper conductor may be preferred for fire-alarm, telephones, control circuits, etc.

7.4.3 Where excessively long lengths of wiring runs are inevitable to suit the building layout, the conductor sizes shall be suitably designed to keep the voltage drop within limits (*see* Part 1/Section 9 of this Code).

7.4.4 The type and capacity of control switches shall be selected to suit the loading, such as room air-conditioners, water coolers, group control of fluorescent lights, etc.

7.4.5 All switchgear equipment used for main-distribution in multistoried buildings shall be metal enclosed. Woodwork shall not be used for the construction of switchboards.

7.4.6 The electric distribution cables/wiring shall be laid in a separate duct. The duct shall be sealed at every alternative floor with non-combustible materials having the same fire resistance as that of the duct. Low and medium voltage wiring running in shaft and in false ceiling shall run in separate conduits.

7.4.7 Water mains, telephone lines, intercom lines, gas pipes or any other service line shall not be laid in the duct for electric cables.

7.4.8 Separate circuits for water pumps, lifts, staircases and corridor lighting and blowers for pressurizing system shall be provided directly from the main switchgear panel and these circuits shall be laid in separate conduit pipes, so that fire in one circuit will not affect the others. Master switches controlling essential service circuits shall be clearly labelled.

7.4.9 The inspection panel doors and any other opening in the shaft shall be provided with airtight fire doors having the fire resistance of not less than 1 h.

7.4.10 Medium and low voltage wiring running in shafts, and within false ceiling shall run in metal conduit. Any 230 V wiring for lighting or other services, above false ceiling, shall have 660 V grade insulation. The false ceiling, including all fixtures used for its suspension, shall be of non-combustible material.

7.4.11 An independent and well-ventilated service room shall be provided on the ground floor with direct access from outside or from the corridor for the purpose of termination of electric supply from the licensees, service and alternative supply cables. The doors provided for the service room shall have fire resistance of not less than 2 h.

7.4.12 If the utility agree to provide meters on upper floors, the utility's cables shall be segregated from consumers' cable by providing a partition in the duct. Meter rooms on upper floors shall not open into staircase enclosures and shall be ventilated directly to open air outside.

7.4.13 The staircase and corridor lighting shall be on separate circuits and shall be independently connected so as it could be operated by one switch installation on the ground floor easily accessible to fire fighting staff at any time irrespective of the position of the individual control of the light points, if any. It should be of MCB type of switch so as to avoid replacement of fuse in case of crisis.

7.4.14 Staircase and corridor lighting shall also be connected to alternative supply as defined in **8.1** for buildings exceeding 24 m in height. For assembly institutional buildings of height less than 24 m, the alternative source of supply may be provided by battery continuously trickle charged from the electric mains.

7.4.15 Suitable arrangements shall be made by installing double throw switches to ensure that the lighting installed in the staircase and the corridor does not get connected to two sources of supply simultaneously. Double throw switch shall be installed in the service room for terminating the standby supply.

7.4.16 Emergency lights shall be provided in the staircase/corridor.

8 PROVISION OF STAND-BY GENERATING SET

8.1 A centralized EPABX System with P&T lines shall be installed for internal connection as well as for external communication with essential services. The following loads shall be fed from the stand-by generating set, to enable continuity of supply in the event of failure of mains:

a) Lighting in common areas, namely corridors, staircases, lift lobbies, entrance hall, common toilets, etc;
b) Fire lift;
c) Fire fighting pump, smoke extraction and damper systems;
d) Fire alarm control panel;
e) Security lighting;
f) Obstruction light(s);
g) Water supply pump; and
h) Any other functional and critical loads.

8.2 The norms specified in Part 2 of this Code is applicable for locating DG sets.

9 TELEPHONE WIRING SYSTEM

9.1 On the basis of assessment of demand of direct telephones and EPABX lines, the conduit runs for telephone wiring should be designed in consultation with telephone department. Where telephone wiring is intended to be taken on any other method, this should be coordinated with the architect and the telephone department.

9.2 Lighting, ventilation and flooring in battery rooms should be designed in accordance with the guidelines in Part 2 of this Code.

9.3 Suitable provisions should be made for cable entry and spaces for distribution components.

9.4 Where the layout of intercom telephones is known in advance, provisions for wiring for the same may also be made.

10 FIRE SAFETY

10.1 Consideration in respect of the following provisions is necessary from fire safety point of view:

a) Fire detectors and alarm system;
b) Fire fighting arrangements;
c) Fire lift;
d) First-aid and fire fighting appliances;
e) Construction of lift shafts, cable and rising main shafts, lobbies, substation, etc, from fire safety considerations; and
f) Provision for pressurization of stairwells, lift shafts, lobbies, etc.

10.2 Provisions contained in Part 1/Section 11 of this Code and SP 7 shall be applicable in respect of the above aspects. Any regulations of fire safety by local municipal/fire authorities shall also be complied with.

10.3 The following specific guidelines shall be kept in view.

10.3.1 All buildings with heights of more than 15 m shall be equipped with manually operated electrical fire alarm (MOEFA) system and automatic fire alarm system. However, apartment and office buildings between 15 m and 24 m in height may be exempted from the installation of automatic fire alarm system provided the local fire brigade is suitably equipped for dealing with fire above 15 m height and in the opinion of the Authority, such building does not constitute hazard to the safety of the adjacent property or the occupants of the building itself.

10.3.1.1 Manually operated electrical fire alarm system shall be installed in a building with one or more call boxes located at each floor. The call boxes shall conform to the following:

a) The location of call boxes shall be decided after taking into consideration the floor plan with a view to ensuring that one or the other call box shall be readily accessible to all occupants of the floor without having to travel more than 22.5 m.
b) The call boxes shall be of the 'break-glass' type where the call is transmitted automatically to the control room without any other action on the part of the person operating the call box. The mechanism of operation of the call boxes shall preferably be without any moving parts. However, where any moving part is incorporated in the design of the call box, it shall be of an approved type, so that there shall be no malfunctioning of the call box.
c) All call boxes shall be wired in a closed circuit to a control panel in the control room in accordance with good practice so located that the floor number/zone where the call box is actuated is clearly indicated on the control panel. The circuit shall also include one or more batteries with a capacity of 48 hours normal working at full load. The battery shall be arranged to be continuously trickle charged from the electric mains. The circuit may be connected to alternative source of electric supply.
d) The call boxes shall be arranged to sound one or more sounders so as to ensure that all appropriate occupants of the desired floor(s) shall be warned whenever any call box is actuated.
e) The call boxes shall be so installed that they do not obstruct the exit-ways and yet their location can easily be noticed from either direction. The base of the call box shall be at a height of 1 m from the floor level.

10.3.1.2 The installation of call boxes in hostels and such other places where these are likely to be misused, shall as far as possible be avoided. Location of call boxes in dwelling units shall preferably be inside the building.

NOTES

1 Several types of fire detectors are available in the market, but the application of each type is limited and has to be carefully considered in relation to the type of risk and the structural features of the building where they are to be installed. For guidelines for selection of fire detection reference may be made to relevant Indian Standard.

2 No automatic detector shall be required in any room or portion of building which is equipped with an approved installation of automatic sprinklers.

11 LIGHTNING PROTECTION

Provisions of lightning protection of multistoried buildings shall be made in conformity with Part 1/ Section 15 of this Code and IS 2309.

NATIONAL ELECTRICAL CODE

PART 4

PART 4 ELECTRICAL INSTALLATIONS IN INDUSTRIAL BUILDINGS

0 FOREWORD

Electrical networks in industrial buildings serve the purpose of distributing the required power to the consuming points where it is used for a multitude of purposes in the industry. The design of electrical installation in industrial premises is therefore more complicated than those in non-industrial buildings.

Industrial installation has to take care of load requirements and supply limitations in a simple and economic manner, ensuring at the same time full protection to human life and loss of property by fire. The network layout should also facilitate easy maintenance and fault localization. Keeping in view the tariff structures as also the economic necessity of conserving power to the maximum extent, power factor compensation assumes special importance.

A particular feature of electrical installations in industrial buildings is the reliability of supply to essential operations for which standby and emergency supply sources/networks had to be designed. The needs of such systems would depend on the type and nature of the industrial works.

Locations in industrial buildings which are by their nature hazardous, require special treatment in respect of design of electrical installations therein. Such special rules for hazardous areas are covered in Part 7 of the Code and these shall be complied with in addition to the general rules specified in this Part (*see also* Part 7 of this Code).

In clause **4** of this Part, an attempt has been made to classify industrial installations depending on the specified criteria therein. Such a classification, it is hoped would help identify the specific nature of each industry and the locations therein, assisting the design engineer in the choice of equipment and methods.

1 SCOPE

1.1 This Part 4 of the Code covers the guidelines for design and construction of electrical installations in industrial buildings.

1.2 This Part 4 does not cover specific areas in industrial sites, such as office buildings, workers rest rooms, medical facilities, canteen annexe, etc, for which requirements stipulated in the relevant sections of Part 3 of the Code apply.

1.3 This Part 4 also does not cover locations in industrial sites that are by nature hazardous for which the provisions of Part 7 of the Code apply.

2 REFERENCES

This Part 4 should be read in conjunction with the Indian Standards listed at Annex A.

3 TERMINOLOGY

For the purpose of this Part 4, the definitions given in Part 1/Section 2 of the Code and the following shall apply:

3.1 Pollution — Any condition of foreign matter, solid, liquid or gaseous (ionized gases), that may affect dielectric strength or surface resistivity

3.2 Pollution Degree (of Environmental Conditions) — Conventional number based on the amount of conductive or hygroscopic dust, ionized gas or salt and on the relative humidity and its frequency of occurrence, resulting in hygroscopic absorption or condensation of moisture leading to reduction in dielectric strength and/or surface resistivity.

4 CLASSIFICATION OF INDUSTRIAL BUILDINGS

Industrial buildings by definition include any building or part of building or structure, in which products or materials of all kinds and properties are stored, fabricated, assembled, manufactured or processes, for example, assembly plants, laboratories, dry cleaning plants, pumping stations, refineries, dairies, saw mills, chemical plants, workshops, distilleries, steel plants, etc.

Industrial installations are of various types and in a single industrial site, electrical loads of varying requirements are to be met. For the purpose of this Part, industries are classified based on three criteria as given in **4.1** to **4.3**.

4.1 Classification Based on Fire Safety

4.1.1 Industrial buildings are classified into Group G from the fire safety point of view in SP 7. Buildings under Group G are further subdivided as follows:

a) *Subdivision G-1 — Buildings used for low hazard industries* — Includes any building in which the contents are of such low combustibility and the industrial processes or operations conducted therein are of such a nature that there are no possibilities for any self-propagating fire to occur and the only consequent danger to life and property may arise from panic, fumes or smoke, or fire from some external source.

b) *Subdivision G-2 — Buildings used for moderate hazard industries* — Includes any building in which the contents or industrial processes of operations conducted therein are liable to give rise to a fire which will burn with moderate rapidity and give off a considerable volume of smoke but from which neither toxic fumes nor explosions are to be feared in the event of fire.

c) *Subdivision G-3 — Buildings used for high hazard industries* — Includes any building in which the contents or industrial processes or operations conducted therein are liable to give rise to a fire which will burn with extreme rapidity or from which poisonous fumes or explosions are to be feared in the event of fire.

NOTE — SP 7 includes Group J buildings for such location where storage, handling, manufacture or processing of highly combustible or explosive materials or products are being carried out. Such installations including such high hazard locations in Group G classification shall comply with the special rules of Part 7 of the Code.

4.1.2 Typical list of industries for different class of fire hazard are given in Annex B.

4.2 Classification Based on Power Consumption

4.2.1 Industrial buildings are also classified depending on the quantum of electric power requirements for its services as given in Table 1.

4.2.2 Loads within the industrial site could be divided depending on their nature and size. For guidance, the classification given in Table 2 shall be referred to.

4.3 Classification Based on Pollution

For the propose of evaluating creepage distances and clearances, the following four degrees of pollution in the micro-environment are established:

a) *Pollution degree 1* — No pollution or only dry, non-conductive pollution occurs. The pollution has no influence.

b) *Pollution degree 2* — Only non-conductive pollution occurs except that occasionally a temporary conductivity caused by condensation is to be expected.

Table 1 Classification Based on Power Consumption
(*Clause* 4.2.1)

Sl No.	Description[1)]	Average Power Requirement	Examples
(1)	(2)	(3)	(4)
i)	Light industries	Up to 50 kVA	Hosiery, tailoring and jewellery
ii)	Average industries	Above 50 kVA up to 2 000 kVA	Machinery, engine fitting, motor cars, aircraft, light pressings, furniture, pottery, glass, tobacco, electrical manufacturing and textile (*see* Note)
iii)	Heavy industries	Above 2 000 kVA	Heavy electrical equipment, rolling mills, structural steel works, tube making, foundries, locomotives, ship-building and repairing, chemical factories, factories for metal extraction from ores, etc.

NOTE — Average factory installations are set apart from heavy industries in that the former has no conditions requiring specialized or exceptional treatment.

[1)] Terminology based on IS 732. Where different degrees of hazard occupancy exist in different parts of building, the most hazardous of those shall govern the classification for the purpose.

Table 2 Load Groups in Industrial Buildings
(*Clause* 4.2.2)

Sl. No.	Groups	Type to Load	Examples	Corrected Power Factor
(1)	(2)	(3)	(4)	(5)
i)	1	Small and large loads fairly evenly distributed over the whole area and loaded constantly during the working day (precision mechanical engineering)	Repair shop, automatic lathe, workshop, spinning mill, weaving mill	>0.85
ii)	2	Loads fairly evenly distributed over the whole area, but varying loads and with peak load at different times (for example metal working industry)	Tool making	do
			Press shop	do
			Machine shop	do
			Welding shop	do
iii)	3	Loads having very high power requirement in conjunction with smaller loads of negligible size compared to the total load (for example, raw material, industry)	Heat treatment shop, steel works, rolling mills	do

c) *Pollution degree 3* — Conductive pollution occurs or dry non-conductive pollution occurs which becomes conductive due to condensation — which is to be expected.

d) *Pollution degree 4* — Continuous conductivity occurs due to conductive dust, rain or other wet conditions.

NOTES

1 Clearances and creepage distances according to the different pollution degrees are given in Tables 13 and 15 of IS/IEC 60947-1. Unless otherwise stated by the relevant product standard, equipment for industrial applications is generally for use in pollution degree 3 environment. However, other pollution degrees may be considered to apply depending upon particular applications or the micro-environment.

2 The pollution degree of the micro-environment for the equipment may be influenced by installation in an enclosure. Means may be provided to reduce pollution at the insulation under consideration by effective use of enclosures, encapsulation or hermetic sealing. Such means to reduce pollution may not be effective when the equipment is subject to condensation or if, in normal operation, it generates pollutants itself.

3 Pollution will become conductive in the presence of humidity. Pollution caused by contaminated water, soot, metal or carbon dust is inherently conductive. Small clearances can be bridged completely by solid particles, dust and water and therefore minimum clearances are specified where pollution may be present in the micro—environment.

5 GENERAL CHARACTERISTICS OF INDUSTRIAL BUILDINGS

General guidelines on the assessment of characteristics of installations in buildings are given in Part 1 of the Code. For the purposes of installations falling under the scope of this Part 4, the characteristics given below shall apply.

5.1 Environment

5.1.1 The following environmental factors shall apply to industrial installations:

Environment (1)	*Characteristics* (2)	*Remarks* (3)
Presence of water	Presence of water negligible, or possibilities of free falling drops or sprays	Depends on the location. For further details *see* Part 1/Sec 8 of the Code
Presence of foreign solid bodies	These conditions include possibilities of presence of foreign solid bodies of various sizes likely to affect electrical equipment (such as tools, wires, dust, etc.)	Depends on the location. For further details *see* Part 1/Sec 8 of the Code
Presence of corrosive	Atmospheric where the presence of	Industrial installations,

Environment (1)	*Characteristics* (2)	*Remarks* (3)
polluting substances	corrosive or polluting substances is significant	situated by the sea, chemical works, cement works where the pollution arises due to abrasive, insulating or conducting ducts
	Intermittent or accidental subjection to corrosive or polluting chemical substances being used or produced	Factory laboratories boiler rooms, etc.
	Continuous pollution	Chemical works
Mechanical stresses	Impact and vibration of low severity	Household and similar conditions
	Impact/vibration of high severity	Industrial installations subject to severe conditions
Seismic effect and lighting	—	Depends on the location of the buildings

5.2 Utilization — The following aspects utilization shall apply:

Utilization (1)	*Characteristics* (2)	*Remarks* (3)
Capability of persons	Instructed persons, adequately advised or supervised by skilled persons (operating and maintenance staff)	Majority of persons utilizing the industrial installations are in this category. However specific zones or operations involving uninstructed persons shall also be kept in view
	Persons with technical knowledge and sufficient experience (engineers and technicians)	Closed operating areas
Contact of persons with earth potential	Persons are frequently in touch with extraneous conductive parts or stand on conducting surfaces	Locations with extraneous conducting parts, either numerous or large area
	Persons are in permanent contact with metallic surroundings and for whom the possibility of interrupting contact is limited	Metallic surrounding such as boilers and tanks
Conditions of evacuation	Low density occupation, easy conditions of evacuation	This category applies to buildings of normal or low height
Nature of processed or stored material	Existence of fire-risks, where there is manufacture, processing or storage of flammable materials, including presence of dust	Wood-working shop, paper factories, textile mills, etc
	Processing or storage of low-flash-point materials including presence of explosive dust	Oil refineries, hydrocarbon stores

5.3 Compatibility

In industrial installations, an assessment shall also be made of any characteristics of equipment likely to have harmful effects upon other equipment or other services (*see* Part 1/Section 8 of the Code).

5.4 Maintainability

Assessment shall also be made of the frequency and quality of maintenance of the installation (*see* Part 1/Section 8 of the Code).

6 SUPPLY CHARACTERISTICS AND PARAMETERS

6.0 General

6.0.1 The arrangement of the electrical system in industrial plants and the selection of electrical equipment depends largely on the type of manufacturing process, the reliability of supply and adequate reserve of electrical capacity are the most important factors to avoid interruption of supply.

6.0.2 All electrical installation shall be suitable for the voltage and frequency of supply available.

6.0.3 For large loads, the relative advantage of high voltage three-phase supply should be considered. Though the use of high voltage supply entails the provision of space and the capital cost of providing a suitable transformer substation on 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.

6.0.4 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, furnaces, etc, should be evaluated. The relative economy attainable by use of medium or high voltage distribution and high voltage plant is a matter for expert judgement and individual assessment in the light of experience by a professionally qualified electrical engineer.

6.1 Industrial Substations

6.1.0 The general requirements for substation installations given in Part 2 of the Code shall apply in addition to those given below.

6.1.1 If the load demand is high, which requires supply at voltages above 650 V, a separate substation should be set up. For an outdoor substation general guidelines as given in Part 2 of the Code shall apply. For bringing the supply into the factory building, a separate indoor accommodation, as close as possible to the main load centre, should be provided to house the switchgear equipment.

6.1.2 The supply conductors should preferably be brought into the building underground to reduce the possibility of interruption of power supply. The accommodation for substation equipment as well as for main distribution panel shall be properly chosen so as to prevent access by any unauthorized person. It shall be provided with proper ventilation and lighting.

6.1.3 In cases where the load currents are very high, and the transformers are located just outside the building, a bus-trunking arrangement may be desirable. These trunkings should, however, be straight, as far as possible, and also as short as possible on economic grounds.

6.1.4 *Location of Transformers and Switchgear*

Oil filled transformers are preferably located outdoors while the associated switchgear is located in a room of the building next to the transformer. In certain cases, however, it may be considered desirable to locate the transformer inside the room.

For reasons of safety, however, it may be considered desirable to locate the transformer also inside the room. The transformer could be connected to the switchgear by cables for small loads, however it may often be found desirable to avoid cable joints and connect the transformer directly to the switchgear placed on either side of the transformer. For oil-filled transformer, special means should be available for remote operation of the main switches/circuit-breakers in an emergency created by explosion/fire in the transformers.

6.1.5 In order to ensure the reliability and safety of industrial sub-station, it is desirable to have circuit breakers as the main switching elements on both sides of the transformers. However, a high voltage sizes, switches and fuses may also be used for this purpose upto the limit specified under Rule 50, sub-rule 1 of *Indian Electricity Rules*, 1956.

6.1.6 For small substations up to 1 600 kVA capacity, it is also possible to locate the substation at the load centre, without a separate room. This yields considerable economies in cost. In such cases, the transformer shall be of dry type.

6.1.7 *Isolation of Switchgear*

For installations where the system voltage exceeds 650 V, the typical circuits and the recommended location of isolating switches in such circuits are illustrated in IS 732. Reference should be made to the same for guidance regarding isolation depending on the type of supply system.

6.2 Distribution of Power

6.2.1 From the main receiving station, power is taken to the loads, either directly as in the case of small factories, or through further load centre substations as would be the case with bigger installations.

Distribution is done on HV through circuit breaker/ load break switches depending on quantum of load to be transferred, distance to be covered, and on similar factors. MV/LV distribution is possible through one of the following:

a) Wall-mounted distribution boards,
b) Floor mounted distribution boards,
c) Local fuse distribution boards, and
d) Overhead bus bar system with tap-off holes.

6.2.2 In every layout, however, specific care shall be taken for:

a) Human safety,
b) Fire/explosion hazards,
c) Accessibility for repair/checking,
d) Easy identification, and
e) Fault localization.

6.2.3 *Switchgear*

6.2.3.0 All switchgear equipment used in industrial installations shall be metal enclosed. Woodwork shall not be used for mounting off switchboards.

6.2.3.1 MV switchgear isolation and protection of outgoing circuits forming main distribution system may be effected by means of circuit-breakers, or switchfuse units mounted on the main switchboards. The choice between alternative types of equipment may be influenced by the following considerations:

a) In certain installations where supply is from remote transformer substations, it may be necessary to protect main circuits with circuit-breakers operated by earth leakage trips, 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 by metal-clad circuit-breakers or contactors of air-break or oil-immersed type fitted with suitable instantaneous and time delay over current devices together with earth leakage and back-up protection where necessary.
c) In installations other than those referred to in (a) and (b) or where overloading of circuits may be considered unlikely to occur, HRC type fuses will normally afford adequate protection for main circuits. Where means for isolating main circuits is required, fuse switch or switch fuse units shall be used or fuses with switches forming part of the mean switchboard shall be used.

6.2.3.2 It may be necessary to provide for connection of capacitors for power-factor correction; and when capacitors are to be installed advice of capacitor and switchgear manufacturers shall be sought.

6.2.3.3 Adequate passageways shall be allowed so that access to all switchboards for operation and maintenance is available. Sufficient additional space shall be provided for anticipated future extensions.

6.2.3.4 Switchboards should, preferably, be located in separate rooms to ensure:

a) adequate protection against weather elements like heat, dust, corrosion, etc; and
b) protection against entry of factory material like cotton, wood dust, water during cleaning, etc.

Where necessary the control rooms should be designed to avoid wide fluctuations in ambient temperature, and against entry of excessive dust or corrosive gases.

6.2.3.5 Certain applications may necessitate location of the switchboards on the factory floor itself, without separate rooms. In such cases, the switchboards shall be specifically designed and protected against hazards mentioned above.

6.3 Main Distribution

6.3.1 For power distribution from a substation or main switchboard to a number of separate buildings, use shall preferably be made of;

a) metal-sheathed, bedded and armoured cable, served, installed overhead/underground, or
b) mineral-insulated metal-sheathed cable, served with PVC, laid overhead/direct in the ground, or
c) PVC-insulated, armoured and PVC-sheathed cable installed overhead/underground, or
d) XLPE insulated, armoured and PVC-sheathed cable installed overhead/underground.

6.3.1.1 Cables shall not be laid in the same trench or alongside a water main.

6.3.1.2 Cable trenches shall be made with sufficient additional space to provide for anticipated future extensions.

6.3.2 Cables at difference voltage levels should be laid with separation at least 250 mm and clearly identified. Cables at voltages above 1 000 V should be laid at the lowest level in trenches, and at the highest level on walls, keeping in view the requirements of human safety. The cable routes where buried should be properly identified by route markers, as a precaution against accidents. The marker should necessarily indicate the voltage level. Cables laid underground or at low working levels, should either be with armouring, or should be adequately protected against mechanical damage, for example, by the use of conduits.

6.4 Sub-circuits

6.4.0 The sub-circuit wiring shall conform in general to the requirements given in IS 732.

6.4.1 In 3-phase distribution systems, a neutral conductor may preferably be provided in all sub-main circuits even when there is no immediate requirement for the supply of single-phase circuits. Control devices are often designed for connection between one phase and neutral and considerable extra cost may be involved, if a four-wire sub-main has to be installed in place of a three-wire sub-main previously installed.

6.4.2 In workshops and factories where alterations and additions are frequent, it may be economical and convenient to install wiring in ducts or trunking. Alternatively, cables may be conveniently run on perforated metal cable trays. In this case earth continuity conductor shall be bonded to each section of ducts or trunking to provide permanency of the electrical continuity of the joints of the ducts.

6.4.3 In machine shops and factories where alterations in layout may repeatedly occur, consideration shall be given to the replacement of local distribution boards by overhead bus-bar or cable systems, to which subcircuit are connected through fused plugs in tapping boxes wherever required.

6.4.4 In industrial installations, the branch distribution boards shall be totally segregated for single phase wiring.

6.4.5 Where more than one distribution system is necessary, the socket outlets shall be so selected as to obviate inadvertent wrong connections.

6.4.6 In industrial premises, 3-phase and neutral socket outlets shall be provided with earth terminal either of pin type or scrapping type in addition to the main pins required for the purpose.

In industrial installations, socket outlets of rating 30 A and above shall be provided with interlocked type switch. These shall be of metal clad type.

6.4.7 Where non-luminous heating appliance is to be used, pilot lamps shall be arranged to indicate when the circuit is live.

6.4.8 Final sub-circuits for lighting shall be so arranged that all the lighting points for a given area are fed from more than one final sub-circuit.

6.4.9 Individual sub-mains shall be installed to supply passenger and goods lifts from the main or sub-main switchgear, and the lift manufacturer shall be consulted as to the appropriate rating of cables to be employed.

The supply to small hoists and service lifts shall not be taken from a distribution board controlling final sub-circuits for lighting, unless the maximum current, including the starting and accelerating current, of the motor is less than 20 percent of the total rating of all the ways of the distribution boards. Where the supply is taken from such a distribution board, the motor circuit shall be clearly labelled.

6.5 Selection of Wiring Systems

The selection of a wiring system to be adopted in a factory depends upon the factors enumerated in Part 1/ Section 9 of the Code.

The wiring system available for general use are listed in Annex C. Selection from a group of alternative systems shall be made in accordance with Annex C, keeping in view the particular circumstances of each circuit having regard to,

a) location, structural conditions, liability to mechanical damage and the possibility of corrosion;
b) protection against corrosion, nature of the corrosive elements being taken into account in conjunction with the protective coverings available;
c) occupancy of the building; and
d) presence of dust, fluff, moisture and temperature conditions.

6.6 Earthing in Industrial Premises

6.6.0 In factories and workshops all metal conduits, trunking, cable sheaths, switchgear, distribution fuse boards, starters, motors and all other parts made of metal shall be bonded together and connected to an efficient earth system. The electricity regulations made under the *Factories Act* require that adequate precautions shall be taken to prevent non-current-carrying metal work of the installation from becoming electrically charged.

In larger installations, having one or more substations, it is recommended to parallel all earth-continuity system.

6.6.1 *Earth Electrodes*

Any of the earth electrodes as mentioned in Part 1 of the Code except cable sheath, may be used in industrial premises.

6.6.2 *Earth-continuity Conductor*

6.6.2.1 *Earth-continuity conductors and earth wires not contained in the cables*

The size of the earth-continuity conductors should be correlated with the size of the current carrying conductors, that is, the sizes of earth-continuity conductors should not be less than half of the largest current-carrying conductor, provided the minimum size of earth-continuity conductors is not less than 1.5 mm^2

for copper and 2.5 mm^2 for aluminium and need not be greater than 70 mm^2 for copper and 120 mm^2 for aluminium. As regards the sizes of galvanized iron and steel earth-continuity conductors, they may be equal to the size of the current carrying conductors with which they are used. The size of earth-continuity conductors to be used along with aluminium current-carrying conductors should be calculated on the basis of equivalent size of the copper current-carrying conductors.

6.6.2.2 *Earth-continuity conductors and earth wires contained in the cables*

For flexible cables, the size of the earth-continuity conductors should be equal to the size of the current-carrying conductors and for metal sheathed, PVC and tough rubber sheathed cables the sizes of the earth-continuity conductors shall be in accordance with relevant Indian Standard.

6.6.2.3 Conduits may be used as earth-continuity conductors provided they are permanently and securely connected to the earth system. However, where by nature of the process, metal conduits cannot be used as earth-continuity conductor on account of corrosion, etc, the tough rubber or PVC sheathed cables may be used in which case they shall incorporate an earth-continuity conductor.

6.6.2.4 Flexible conduits shall not be used as earth-continuity conductors. A separate earth wire shall be provided either inside or outside the flexible conduits which shall be connected by means of earth clips to the earth system at one end and to the equipment at the other end.

6.6.2.5 *Earth leakage protection*

Use of earth leakage protection shall be made where greater sensitivity than provided by overcurrent protection is necessary. With a good earth electrode, overload protective devices may be used as earth leakage protective device.

In addition to the advantage of sensitivity gained by such methods, the circuits may be relieved of the thermal and mechanical socks associated with the clearance of heavy faults.

Some degree of discrimination may, in certain cases, be introduced with advantage by providing the delay in the operation of an earth-leakage trip, so that earth faults on smaller subsidiary circuits protected by fuses have time to clear and prevent the opening of the circuit-breaker, controlling a larger part of the installation.

6.6.3 *Earthing of Portable Appliances and Tools*

6.6.3.1 Good electrical continuity between the body of a portable appliance and the earth-continuity conductor shall always be maintained.

6.6.3.2 It shall be ascertained that the fixed wiring at the appliance inlet terminals has been done correctly and in accordance with relevant Indian Standard.

6.6.3.3 A single pole switch shall not be connected in the earth conductor.

6.6.3.4 No twisted or taped joints shall be used in earth wires.

6.6.3.5 Additional security may be obtained by arranging the earth-continuity conductor in the flexible cable between the socket outlet and the portable appliance in the form of a loop through which a light circulating current provided by a small low-voltage transformer is passed when the appliance is in use. Any discontinuity in this loop will interrupt the circulating current and can thus be caused to operate a relay and disconnect the supply from the portable appliance.

6.6.4 *Earthing of Electrically Driven Machine Tools*

In all types of machine tools connected to medium voltage, the body of all motors and bed plate of the machine shall be earthed at two places by means of a strip or conductors of adequate cross-sectional area. The strip or conductor shall be securely fastened to the bed plate by means of bolts.

6.6.5 *Earthing of Electric Arc Welding Equipment*

6.6.5.1 All components of electric arc welding equipment shall be effectively bonded and connected to earth. The transformers and separate regulators forming multioperator sets and capacitors for power factor correction, if used, shall be included in the bonding.

6.6.5.2 All terminals on the output side of a motor generator set shall be insulated from the car case and control panel, as the generator is not connected electrically to a motor and therefore the welding circuit is electrically separate from the supply circuit including the earth.

6.6.5.3 In case of transformer sets, which for welding purpose are double wound, an 'earth and work' terminal shall be provided. In single phase sets this terminal shall be connected to one end of the secondary winding and in case of three-phase sets this shall be connected to the neutral point of the secondary winding.

6.6.6 *Earthing of Industrial Electronic Apparatus*

6.6.6.0 The earthing of these apparatus shall follow normal practice but attention shall be paid to the points discussed below.

6.6.6.1 Any industrial electronic apparatus which derives its supply from two-pin plugs incorporates small capacitors connected between the supply and the metal case of the instrument to cut down interference. This capacitor shall be securely earthed.

6.6.6.2 When an oscilloscope is being used to examine the wave-form of a high frequency source, the oscilloscope shall be earthed by a conductor entirely separate from that used by the source of high frequency power. However, when an oscilloscope is being used on a circuit where the negative is above earth potential and also connected to its metallic case, the earthing of the oscilloscope is not possible. Precautions shall be taken that in such a case the oscilloscope is suitably protected from other apparatus.

6.6.6.3 High frequency induction heating apparatus shall be earthed by means of separate earth wire by as direct a route as possible.

6.6.6.4 Dielectric loss heating equipment work at frequencies between 10 MHz to 60 MHz according to its use. These should not be directly earthed. At 30 MHz, for example, a quarter wavelength is nearly 250 cm and an earth wire of this length or odd multiples of it is capable of being at earth potential at one end but several hundred volts at the other end. This is due to the presence of standing waves on the earth conductors which besides being dangerous can result in energy being radiated to the detriment of communication services. In such a case it is recommended to mount the equipment on a large sheet of copper or copper gauze, the earth conductor being connected to it at several points.

6.6.6.5 In case where direct earthing may prove harmful rather than provide safety, for example, high frequency and mains frequency coreless induction furnaces, special precautions are necessary. The metal of the furnace charge is earthed by electrodes connected at the bottom of the charge, and the furnace coils are connected to the mains supply but are unearthed. A relay is connected by a detection circuit which itself is earthed to the coils. The object is to prevent dangerous break-through of hot metal through the furnace lining, the earth detection circuit giving a continuous review of the conditions for the furnace lining. When leakage current attains a certain set maximum it becomes necessary to take the furance out of service and to re-line.

7 EMERGENCY/STANDBY POWER SUPPLIES

7.1 The provisions of Part 2 of the Code shall apply.

8 SYSTEM PROTECTION

8.1 Protection of Circuits

8.1.1 Appropriate protection shall be provided at switchboards and distribution boards for all circuits and sub-circuits against overcurrent and earth faults, and the protective apparatus shall be capable of interrupting any 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 where necessary.

8.1.2 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.

8.1.3 Where HRC type fuses are used for backup 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 therefrom, in the event of short circuits exceeding the breaking capacity of the circuit-breakers, the HRC fuses shall operate earlier than the circuit-breakers; but for smaller overloads within the breaking capacity of the circuit-breakers, the circuit-breakers shall operate earlier than the HRC fuse.

8.1.4 If rewirable type fuses are used to protect sub-circuits derived form 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 a sub-circuit, although discrimination may be achieved in respect of overload currents. The use of rewirable fuses is restricted to the circuits with short-circuit level of 4 kA; for higher level either cartridge or HRC fuses shall be used.

8.1.5 Provision shall also be made for control of general lighting and other emergency services through separate main circuits and distribution boards from the power circuits.

8.1.6 If necessary, independent source of supply for emergency service in particular installations may be provided.

8.1.7 Search suppressors shall be provided at the incomers of the sub distribution boards as considered necessary.

8.1.8 Wherever necessary to control the harmonics within permissible limits, passive/active filters may be used.

8.2 Fire-safety Requirements

8.2.1 Besides fire fighting equipment, the fire detection and extinguishing systems, as recommended in Part 4 of SP 7 shall be followed.

8.2.2 Reference is also drawn to IS 1646 regarding rules and regulations relating to electrical installations from the point of fire safety. Annex D covers specific requirements for fire safety for representative industries.

9 BUILDING SERVICES

9.1 Lighting

9.1.0 Industrial lighting encompasses seeing tasks, operating conditions and economy. With each of the various visual task conditions, lighting should be suitable for adequate visibility. Physical hazards exist in many manufacturing processes, therefore, lighting contribute to the utmost as a safety factor in preventing accidents. The speed of many manufacturing operations might also be hampered due to poor lighting. The general considerations for design of lighting in industrial areas are enumerated in IS 6665 (*see also* SP 72).

9.1.1 *Equipment for Lighting*

The choice of light sources and luminaries shall be governed by the guidelines given in IS 6665. The recommended values of illumination and limiting values of glare index are given in Annex E for guidance.

9.2 Air-conditioning, Heating and Ventilation

9.2.1 The electrical installation meant for the services such as air-conditioning heating and ventilation in industrial buildings shall conform to the requirements given in Part 1/Sec 11 of the Code. The specific needs of individual locations requiring these services in each factory shall be ascertained in consultation with the concerned personnel before designing the electrical system. Reference should be made to the guidelines given in SP 7.

9.3 Lifts

9.3.1 The general rules laid down in Part 1/Section 11 of the Code shall apply regarding lift installations. However, the design of lifts in industrial buildings shall take into account the following requirements:

a) *Occupant load* — The occupant load expressed in terms of gross area in m^2/person shall be 10 for industrial buildings.

b) *Car-speed for goods lifts* — These shall be as follows:

   1) Normal load carrying lifts — 2-2.5 m/s

   2) Lifts serving many floors — 1 m/s

9.3.2 The location of lifts in factories, warehouses and similar buildings should be planned to suit the progressive movement of goods through the buildings having regard to the nature of processes carried out, position of loading platform, railway slidings, etc. The placing of a lift in a fume or dust laden atmosphere, or where it may be exposed to extreme temperatures shall be avoided. Where it is impossible to avoid extreme environmental conditions. The selection of electrical equipment shall be such that they are suitable to meet the conditions involved.

10 MISCELLANEOUS/SPECIAL PROVISIONS

10.1 Control of Static Electricity

See IS 7689 regarding recommendations for controlling static electricity generated incidentally by processes in industries which may pose a hazard or inconvenience. Specific control methods are also given for some industries therein.

10.2 Safety in Electro-Heat Installations

Industrial process include in many instances, electro-heat installations such as;

a) Arc furnaces;
b) Induction furnaces;
c) Appliances for direct and indirect resistance heating;
d) Medium and high frequency induction heating, radio frequency heating and dielectric heating appliances;
e) Infra-red radiatum heating appliances; and
f) Microwave heating.

For safety requirements in such electro-heat installations reference shall be made to IS 9080 (Parts 2 and 4) and IS/IEC 60519 (Parts 1, 3, 5 and 9).

10.3 POWER FACTOR COMPENSATION

10.3.1 The provisions of Part 1/Section 17 of the Code shall apply. For specific guidance for installations covered by this Part (*see* Annex F).

ANNEX A
(*Clause* 2)

IS No.	*Title*
732 : 1989	Code of practice for electrical wiring installations
1646 : 1997	Code of practice for fire safety of buildings (general): Electrical installations
2726 : 1988	Code of practice for fire safety of industrial buildings: Cotton ginning and pressing (including cotton seed delintering) factories
3058 : 1990	Code of practice for fire safety of industrial buildings: Viscose rayon yarn and/or staple fibre plants
3079 : 1990	Code of practice for fire safety of industrial buildings: Cotton textile mills
3594 : 1991	Code of practice for fire safety of industrial buildings: General storage and warehousing including cold storage
3595 : 2002	Code of practice for fire safety of industrial buildings : Coal pulverizers and associated equipments
3836 : 2000	Fire safety of industrial buildings — Jute mills — Code of practice
4226 : 1988	Code of practice for fire safety of industrial building: Aluminium/ Magnesium powder factories
4886 : 1991	Code of practice for fire safety of industrial buildings: Tea factories
6329 : 2000	Code of practice for fire safety of industrial buildings — Saw mills and wood works
6665 : 1972	Code of practice for industrial lighting
7689 : 1989	Guide for the control of undesirable static electricity
9109 : 2000	Fire safety of industrial buildings — Pradio frequency paint and varnish factories — Code of practice
9080 (Part 2/ Sec 2) : 1980	Safety requirements in electro-heat installations: Part 2 Particular requirements for resistance heating equipment, Section 2 Protection in indirect resistance heating installations
9080 (Part 2/ Sec 4) : 1981	Safety requirements in electro-heat installations: Part 2 Particular requirements for resistance heating equipment, Section 4 Protection in installations used for drying varnishes and other similar products
IS/IEC 60519-1 : 1984	Safety in electroheat installation: Part 1 General requirements
IS/IEC 60519-3 : 1988	Safety in electroheat installations: Part 3 Particular requirements for induction and conduction heating and induction melting installations
IS/IEC 60519-5 : 1980	Safety in electroheat installation: Part 5 Specification for safety in plasma installation
IS/IEC 60519-9 : 1987	Safety in electroheat installations: Part 9 Particular requirements for high-frequency dielectric heating installations
IS/IEC 60947-1 : 2004	Specification for low-voltage switchgear and controlgear: Part 1 General rules
SP 7 : 2005	National Building Code of India
SP 72 : 2010	National Lighting Code

ANNEX B

(*Clause* 4.1.2)

EXAMPLES OF INDUSTRIES BASED ON FIRE-SAFETY

B-l The following is a representative list of industries classified according to the degree of fire hazard enumerated in **4.1.1**:

a) *Low Hazard Industries*

Abrasive manufacturing premises
Aerated water factories
Agarbatti manufacturing premises
Aluminium copper and zinc factories
Asbestos steam packing and lagging manufacturers
Battery manufacturers
Bone mills
Breweries
Canning factories
Carbon dioxide plants
Cardamom factories
Cement factories
Cement and/or asbestos or concrete products manufacturing premises
Ceramic and crockery factories
Clay works
Clock and watch manufacturing premises
Confectionery manufacturers
Electric generating houses
Electric lamps and fluorescent tube manufacturers
Electronic goods manufacturing premises
Electroplating workshops
Engineering workshops
Fruit products and condiment factories
Gold thread factories/gilding factories
Glass factories
Gum and glue factories
Ice candy and ice cream manufacturing premises
Ice factories
Ink factories (excluding printing inks)
Milk pasteurising plants and dairy farms
Mica products manufacturing premises
Potteries/tiles and brick works
Rice mills
Refractories works and firebrick kilns
Salt crushing factories and refineries
Silicate (other than sodium silicate) factories
Soap and detergent factories
Sugar candy manufacturers
Sugar factories
Tanneries
Tea colouring factories
Umbrella factories
Vermicelli factories
Wire drawing works

b) *Moderate Hazard*

Aeronaut/betelnut factories
Atta and cereal grinding premises
Bakeries and/or biscuit factories
Beedi factories
Book binders and paper cutting premises
Book sellers and stationers' shops
Boot and shoe factories and other leather goods factories
Boat builders and ship repairing docks
Button factories
Candle works
Canvas sheet manufacturers
Cardboard box manufacturers
Carbon paper manufacturing premises
Carpet and durries factories
Carpenter's workshops
Camphor boiling premises
Cashew nut factories (using open fire)
Cloth processing works
Coffee curing premises
Coffee roasting and grinding works
Colour/dyes mixing and/or blending factories
Coir factories
Cork factories
Cork stopper and other cork products manufacturing premises
Collieries
Chemical manufacturers
Cotton mills
Dyeing and dry cleaning works
Electric wire and cable manufacturing premises
Enamel factories
Essential oil distillation plants
Flour mills
Garment makers

Ghee manufacturing premises
Ginning and pressing factories
Grains and/or seeds disintegrating factories
Grease manufacturing works
Gunning and pressing factories
Hat and topee factories
Hosiery factories
Incandescent gas mantle manufacturers
Jute mills and jute presses
Mineral oil blending and processing works
Mutton tallow manufacturers
Manure and/or fertilizer works (blending, mixing and granulating only)
Mattresses and pillow making premises
Oxygen plants
Paper mills
Pencil factories
Plastic goods manufacturers
Printing press premises
Pulverizing and crushing mills (hazardous materials)
Rice mills
Rope factories
Rubber goods manufacturers
Shellac factories
Spray painting works
Starch factories
Synthetic fibre manufacturing premises
Tea factories
Thermal power stations
Tobacco (chewing), zarda, kimam and pan masala making premises
Tobacco grinding and crushing and snuff manufacturing premises
Tobacco curing and redrying factories
Tobacco pressing works
Upholsterers
Weaving factories
Woollen mills
Wool cleaning/pressing factories
Yarn gassing plants.

c) *High Hazard*

Acetylene plants
Alcohol distillers
Aluminium and magnesium powder plants Bituminished paper/hessian cloth manufacturing premises
Bobbin factories
Cinematograph film production studies
Calcium carbide plants
Cotton waste factories
Coal/coke/charcoal ball and briquettes factories
Celluloid goods manufacturers
Cigarette filter manufacturers
Cotton seed cleaning or deliniting premises
Duplicating and stencil paper manufacturers
Fertilizer plants
Explosive manufacturers
Fireworks factories
Foam plastics and foam rubber goods manufacturers
Grass, hay, fodder and *bhoosa* (chaff) pressing factories
Match factories
Oil mills
Oil extraction plants
Oil and leather cloth factories
Paint (including nitrocellulose paints) and varnish factories
Petrochemical plants
Plywood factories
Printing ink manufacturers
Resin and lamp black manufacturers
Rubber substitute manufacturers
Surgical cotton manufacturers
Tar distilleries
Tar felt manufacturing premises
Tarpauplin and canvas proofing factories
Timber and woodworkers' premises
Tin printers (where more than 50 percent of floor area is occupied as engineering workshop this may be taken as moderate hazard risk)
Terpentino distilleries
Tyre retreading and resoling factories
Woodmeal manufacturers

ANNEX C

(*Clause* 6.5)

SELECTION OF WIRING SYSTEMS

C-1 WIRING SYSTEMS FOR GENERAL APPLICATION

a) Bare solid or tubular conductors supported on insulators in metal or incombustible structural ducts or chases (main connections).

b) Tough rubber-sheathed or PVC-sheathed cables protected as necessary against mechanical damage, say, buried in plaster or installed in concrete ducts.

   NOTE — Polythene-insulated PVC-sheathed cable provides an alternative having the advantage of high insulation-resistance.

c) Elastomer-insulated braided and compounded or PVC-insulated cable installed in heavy-gauge screwed conduit.

   NOTE — The use of galvanized conduit and PVC-insulated cable is to be preferred where the situation may be damp or long life is required.

d) Elastomer-insulated braided and compounded or PVC-insulated cable installed in light-gauge steel conduit with lug grip.

e) Elastomer-insulated braided and compounded or PVC-insulated cable installed in PVC or other insulated conduit and provided with a bare copper or copper-alloy earth-continuity conductor as necessary.

f) Grid suspension wiring system comprising elastomer-insulated or PVC insulated cables laid around a galvanized steel catenary wire, braided overall or otherwise protected to withstand corrosive conditions where necessary.

g) Elastomer-insulated braided and compounded or PVC-insulated cable installed in metal trunking or ducts.

   NOTE — Incombustible insulated trunking and ducts provide an alternative and where these are used a bare copper or copper-alloy earth-continuity conductor may be required.

h) Elastomer-insulated braided and compounded or PVC-insulated cable installed on cleats, with appropriate protection where cable passes through floors or walls.

j) Elastomer-insulated lead-alloy-sheathed cables incorporating an earth continuity conductor, or elastomer-insulated aluminium-sheathed cable, protected as necessary against mechanical damage and corrosion.

   NOTE — Where a lead-sheathed cable has plumbed joints a separate earth-continuity conductor may not be required.

k) Mineral-insulated metal-sheathed cable with or without protective sheathing with suitable watertight glands.

C-2 ADDITIONAL WIRING SYSTEMS PARTICULARLY SUITABLE FOR USE IN FACTORIES AND THE LIKE

n) PVC-insulated and steel tape or wire armoured and PVC-sheathed cable buried directly in the ground or used in special conditions.

p) PVC-insulated steel tape or wire armoured and PVC-sheathed cable with cleat or hook suspensions.

q) PVC-insulated and PVC-sheathed cable, installed in underground earthenware ducts or metal pipes.

r) PVC-insulated and PVC-sheathed cable, mounted on porcelain or hardwood cleats or in trenches or ducts, and so installed as to be protected against mechanical damage.

s) Tough rubber-sheathed or PVC-sheathed cable mounted on insulating non-hygroscopic cleats affixed to treated, teak battens by screws of corrosion-resisting material, such as Monel metal or phosphor-bronze.

t) Elastomer-insulated braided and compounded or PVC-insulated cable installed in galvanized solid-drawn screwed conduit with flameproof couplings and inspection fittings.

u) Varnished-cambric insulated, lead-alloy or aluminium-sheathed cable.

v) Elastomer-insulated, tough rubber-sheathed cable, steel wire armoured.

   NOTE — Varnished cambric insulated cables without metal sheath should be used only for short connections on switchboards and the like in dry situations.

w) Cross-linked polyethylene insulated thermoplastic sheathed, armoured cable.

C-3 SELECTION OF WIRING SYSTEMS FOR FACTORIES

C-3.1 Wiring systems suitable for installations in different categories of factories are given in Table 3.

C-4 SPECIAL RESTRICTIONS

C-4.1 Even though guidance may be taken from the selection chart (*see* Table 3) for wiring systems, the following restrictions to their use apply:

Wiring System (*see* **C-1**, **C-2**) (1)	*Restrictions* (2)
b) and g)	If the ducts are in the form of under floor trenches then the following provisions should be observed: 1) Cables shall preferably be so mounted on suitably earth cracks or other supports and has to be at least 75 mm above the bottom. 2) Top of trenches shall be covered with chequered plates or concrete slabs, 3) In case of long trenches, it is recommended that trenches of more than 1 000 cm^2 cross-sectional area be divided by incombustible barriers at intervals not exceeding 45 m. The barriers shall be at least 50 mm in thickness and of the same height as of cable trench. The cables shall be carried through holes in the barriers, which shall be made good thereof to prevent the passage of fire beyond the barriers, 4) The combined cross-sectional area of all conductors or cables shall not as far as possible exceed 40 percent of the internal cross-sectional area of the trench, and 5) The cable trenches shall be kept free from accumulation of water, dusts and waste materials.
c)	Trunking or ducting systems for cables above ground shall not be used where: 1) they are exposed to physical damage, 2) they are exposed to corrosive vapours. 3) the atmosphere is likely to contain flammable gases or vapours, 4) the wet processes are carried out, or 5) in concealed spaces. Ordinary steel conduits shall not be permitted in areas where flammable vapour may be present, unless it is of type conforming with wiring system (t) and shall not be permitted in locations: 1) where wiring height is less than 2.5 m above working floor level, unless protected against mechanical damage,
	2) they are exposed to corrosive vapours. 3) where atmosphere is likely to contain flammable gases or vapours, 4) where wet processes are carried out, or 5) in concealed spaces. Ordinary steel conduits shall not be permitted in areas where flammable vapour may be present, unless it is of type conforming with wiring system (t) and shall not be permitted in locations: 1) where wiring height is less than 2.5 m above working floor level, unless protected against mechanical damage, 2) where ambient temperature is likely to be above 55°C at sometime or other during the year, 3) in concealed spaces of combustible construction, 4) where atmosphere is likely to contain flammable gases or vapours, or 5) where conductor operates at voltage above 650 V.
d)	It shall be permitted only where voltage is below 650 V and in locations where the atmosphere is unlikely to contain any flammable vapours or gases.
e)	Same as in case of wiring system (d). This system shall not be permitted in locations: 1) where exposed to severe physical damage, 2) where exposed to corrosive vapours, 3) where wet processes are carried out, or 4) in concealed places.
h) and s)	These systems should only be permitted for voltage below 250 V and that too only if use of such system is essential.
j)	Same as in case of wiring system (d).
m), n), p) and v)	Armoured cables shall not be permitted in following locations unless the cable is of PVC-sheathed type, and shall not be permitted in locations exposed to corrosive fumes or vapour; and battery rooms.

Table 3 Selection Chart for Wiring Systems for Installations in Factories
(*Clauses* C-3.1 *and* C-4.1)

Sl No.	Section of Installation	Category of Factory								
		Average Factory		Heavy Industry		Light Industry		Chemical Industry		Factories Involving Fire Risk
		1st Choice	2nd Choice	1st Choice	2nd Choice	1st Choice	2nd Choice	1st Choice	2nd Choice	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
									w	
i)	Main distribution at medium or low voltage	a	c	a	c	c	p	s	n	k
										w
		k	g	k	g	g	v		p	n
		w		w						
		n	r	n	r	k			q	p
						w				
						n				
		p	v	p	v	r			r	q
		q		q						t
									w	
ii)	Sub-main distribution to local distribution boards	a	g	a	g	c	h	f	b	k
									w	w
		c		c	v	f		s	q	t
		f		f		g			r	
		k		k		k				
		w		w		w				
		p		p		p				
		v		r		v				
iii)	Sub-circuit wiring	c		b	c	g	b	c		k
		f		h	f		h	f		t
		g		j	k		j	s		
		k		v						
		v								

NOTE — For description of a, b, c……. w, *see* **C-1** and **C-2**.

ANNEX D
(*Clause* 8.2.2)

REQUIREMENTS FOR FIRE SAFETY IN SPECIFIC INDUSTRIES

Type of Industry (1)	*Ref. IS* (2)	*Motors* (3)	*Other Equipment* (4)	*Fittings* (5)	*Miscellaneous* (6)
Jute spinning and weaving, jute rope, carpet making factories	3836	All motors shall be totally enclosed type and in wet locations shall be drip-proof	All equipment shall be metal clad, dust-tight	Lighting fittings shall be dust-tight	Supply shall be at < 250 V in jute godowns
Cotton ginning cotton seed delintering and pressing factories	2726		All equipment shall be metal clad, dust-tight		
Plants making viscose rayon yarn or staple fibre or both	3058		All equipment in the Xanthation disulphide plant shall comply with Part 8 of the Code	Vapour-proof lighting fittings in areas where corrosive gases are evolved	All current carrying parts, contacts liable for corrosion shall be cadmium plated

Type of Industry (1)	*Ref. IS* (2)	*Motors* (3)	*Other Equipment* (4)	*Fittings* (5)	*Miscellaneous* (6)
Textile mills using cotton, cotton waste regenerated cellulose, man-made fibres or any grouping of these	3079	Totally enclosed type, the cooling air for variable speed motor taken from outside the building	Metal clad and dust-tight. Equipment shall be flameproof in gas singeing rooms. Stop motion devices provided on frames shall be dust-tight	Dust-tight lighting fittings at willowing, lap breaking, waste opening, mixing, blow and raising rooms	Machines for singeing yarn shall be protected to ensure that heating elements are not switched on while yarn is stationary
Places where paints and varnishes are stored or processed	9109	—	—	Wiring in steel conduits. Lighting fittings of enclosed type	Provisions shall be made for switching off the whole factory at more than one control point
Factories where powders of aluminium, magnesium and their alloys are processed or used	4226	Motors shall be flameproof dust-protected (*see* Part 7 of the Code)	All equipment of the enclosed type	Wiring in steel conduits. Enclosed lighting fittings	Provisions shall be made for switching off the whole factory at more than one control point
Coal pulverizing mills, as also equipment therein for power generation cole or briquette making	3595	Totally enclosed, flameproof, dust-proof (*see* Part 7 of the Code)		Lighting fittings shall be dust-tight. Only conduits; armoured or mineral insulated type of wiring	Use of flexible cables to be kept to the minimum
Tea factories	4886	Where practicable, totally enclosed type	—	—	Fan motors of dryers and withering troughs and other control equipment shall be dust proof tape
Godowns, ware-houses, outdoor storage sites forming part of industrial complexes or others; cold storage buildings	3594	Driving motors for overhead cranes totally enclosed	All switchgear equipment metal enclosed. For mains operated electrical stackers, switch and socket shall be water-tight. Flexible connection to the stacker through rubber compound sheathed trailing cable with hard cord braiding	Screwed steel conduits mineral insulated, copper or aluminium sheathed cable. Lighting fittings to be positioned not below 45 cm below roof. A clearance of not less than 75 cm to be provided from highest stacking level. Flexible lighting pendants or portable lamps not allowed	All control equipment switches, etc., outside godown where fibrous goods, flammable liquids, nitro-cellulose, fire works or explosives are stored
Saw mills, furniture factories, coach and body build works, up-holsteries and other wood working shops. Plywood hard-wood, wood wool, insulation boards, wood flour, etc	6329	Motors shall be totally enclosed or pipe ventilated	All equipment shall be dust-tight and where spray painting is done shall comply with Part 7 of the Code		Electrical heaters shall be metal cases, totally enclosed, immersion type or totally enclosed low temperature type with external surface below 92°C

ANNEX E

(*Clause* 9.1.1)

RECOMMENDED VALUES OF ILLUMINATION AND LIMITING VALUES OF GLARE INDEX — INDUSTRIAL BUILDINGS

Sl No. (1)	*Industrial Buildings and Processes* (2)	*Average Illumination, lux* (3)	*Limiting Glare Index* (4)
i)	General factor areas:		
	a) Canteens	150	—
	b) Cloakrooms	100	—
	c) Entrances, corridors, stairs	100	—
ii)	Factory outdoor areas:		
	Stockyards, main entrances, exit roads, car parks, internal factory roads	20	—
iii)	Aircraft factories and maintenance hangers:		
	a) Stock parts productions	450	25
	b) Drilling, riveting, screw fastening, sheet aluminium layout and template work, wing sections, cowling welding, sub-assembly, final assembly, inspection	300	25
	c) Maintenance and repairs (Hangers)	300	25
iv)	Assembly shops:		
	a) Rough work, for example, frame assembly, assembly of heavy machinery	150	28
	b) Medium work, for example, machined parts, engine assembly, vehicle body assembly	300	25
	c) Fine work, for example, radio and telephone equipment, typewriter and office machinery assembly	700	22
	d) Very fine work, for example, assembly of very small precision mechanisms, instruments	1 500[1)]	19
v)	Bakeries:		
	a) Mixing and make-up rooms, oven rooms, wrapping rooms	150	25
	b) Decorating and icing	200	25
vi)	Boiler houses (industrial):		
	a) Coal and ash handling	100	—
	b) Boiler rooms:		
	1) Boiler fronts and operating areas	100[2)]	—
	2) Other areas	20 to 25	—
	c) Outdoor plants:		
	1) Catwalks	20	—
	2) Platforms	50	—
vii)	Bookbinding:		
	a) Pasting, punching and stitching	200	25
	b) Binding and folding; miscellaneous machines	300	22
	c) Finishing, blocking and in laying	300	22
viii)	Boot and shoe factories:		
	a) Sorting and grading	1 000[3)]	19
	b) Clicking and closing, preparatory operations	700	22
	c) Cutting table and presses, stitching	1 000	22
	d) Bottom stock preparation, lasting and bottoming, finishing	700	22

Sl No.	*Industrial Buildings and Processes*	*Average Illumination, lux*	*Limiting Glare Index*
(1)	(2)	(3)	(4)
	e) Shoe rooms	700	22
ix)	Breweries and distilleries:		
	a) General working areas	150	25
	b) Brewhouse, bottling and canning plants	200	25
	c) Bottle inspection	Special lighting	—
x)	Canning and preserving factories:		
	a) Inspection of beans, rice, barley, etc	450	22
	b) Preparation: kettle areas, mechanical cleaning, dicing, trimming	300	25
	c) Canned and bottled goods: retorts	200	25
	d) High speed labelling lines	300	25
	e) Can inspection	450	—
xi)	Carpet factories:		
	a) Winding, beaming	200	25
	b) Designing, Jacquard and cutting, setting pattern, tufting, topping, cutting, hemming, fringing	450	22
	c) Weaving, mending, inspection	450	22
xii)	Ceramics — *See* pottery and clay products		
xiii)	Chemical works:		
	a) Hand furnaces, boiling tanks, stationery driers, stationery or gravity crystalizers, mechanical driers, evaporators, filtration plants, mechanical crystallising bleaching, extractors, percolators, nitrators. electrolytic cells	150	28
	b) Controls, gauges, values, etc	100	—
	c) Control rooms:		
	1) Vertical control panels	200-300	19
	2) Control desks	300	19
xiv)	Chocolate and confectionery factories:		
	a) Mixing, blending, boiling	150	28
	b) Chocolate husking, winnowing, fat extraction, crushing and refining, feeding, bean cleaning, sorting, milling, cream making	200	25
	c) Hand decorating, inspection, wrapping, packing	300	22
xv)	Clothing factories:		
	a) Matching-up	450[3)]	19
	b) Cutting sewing:		
	1) Light	300	22
	2) Medium	450	22
	3) Dark	700	22
	4) Pressing	300	22
	c) Inspection:		
	1) Light	450	19
	2) Medium	1 000	19
	3) Dark	1 500	19
	d) Hand tailoring:		
	1) Light	450	19
	2) Medium	1 000	19
	3) Dark	1 500	19

Sl No. (1)	*Industrial Buildings and Processes* (2)	*Average Illumination, lux* (3)	*Limiting Glare Index* (4)
xvi)	Collieries (surface buildings):		
	a) Coal preparation plant:		
	1) Working areas	150	—
	2) Other areas	100	—
	3) Picking belts	300	—
	4) Winding houses	150	—
	b) Lamp rooms:		
	1) Main areas	100	—
	2) Repair sections	150	—
	3) Weigh cabine	150	—
	c) Fan houses	100	—
xvii)	Dairies:		
	a) General working areas	200[2)]	25
	b) Bottle inspection	Special lighting	—
	c) Bottle filling	450	25
xviii)	Die sinking:		
	a) General	300	—
	b) Fine	1 000	19
xix)	Dye works:		
	a) Reception, 'grey' perching	700	—
	b) Wet processes	150[2)]	28
	c) Dry processes	200[2)]	28
	d) Dyers' offices	700[3)]	19
	e) Final perching	2 000[3)]	—
xx)	Electricity generating stations: Indoor locations		
	a) Turbine halls	200	25
	b) Auxiliary equipment; battery rooms, blowers auxiliary generators, switchgear and transformer chambers	100	—
	c) Boiler houses (including operating floors) platforms, coal conveyors, pulverizers, feeders, precipitators, soot and slag blowers	70-100	—
	d) Boiler house and turbine house	100	—
	e) Basements	70	—
	f) Conveyor houses, conveyor gantries, junction towers	70-100	—
	g) Control rooms:		
	1) Vertical control panels	200-300	19
	2) Control desks	300	19
	3) Rear of control panels	150	19
	4) Switch houses	150	25
	h) Nuclear reactors and steam, raising plants:		
	1) Reactor areas, boilers, galleries	150	25
	2) Gas circulator days	150	25
	3) Reactor charge/discharge face	200	25
xxi)	Electricity generating stations: Outdoor locations		
	a) Coal unloading areas	20	—
	b) Coal storage areas	20	—

Sl No.	*Industrial Buildings and Processes*	*Average Illumination, lux*	*Limiting Glare Index*
(1)	(2)	(3)	(4)
	c) Conveyors	50	—
	d) Fuel oil delivery headers	50	—
	e) Oil storage tanks	50	—
	f) Catwalks	50	—
	g) Platforms, boiler and turbine decks	50	—
	h) Transformers and outdoor switchgear	100	—
xxii)	Engraving:		
	a) Hand	1 000	19
	b) Machine (*see* Die sinking)	—	—
xxiii)	Farm buildings (dairies)		
	a) Boiler houses	50	—
	b) Milk rooms	150	25
	c) Washing and sterilizing rooms	150	25
	d) Stables	50	—
	e) Milking parlours	150	25
xxiv)	Flour mills:		
	a) Roller, purifier, sifting and packing floors	150	25
	b) Wetting tables	300	25
xxv)	Forges: General	150	28
xxvi)	Foundries:		
	a) Charging floors, tumbling cleaning, pouring, shaking out, rough moulding and rough core making	150	25
	b) Fine moulding and core making, inspection	300	25
xxvii)	Garages:		
	a) Parking areas (interior)	70	28
	b) Washing and polishing, greasing, general servicing, pits	150	28
	c) Repairs	300	25
xxviii)	Gas works:		
	a) Retort houses, oil gas plants, water gas plants, purifiers, coke screening and coke handling plants (indoor)	30-50[4)]	28
	b) Governor, meter, compressor, booster and exhauster houses	100	25
	c) Open type plants:		—
	1) Catwalks	20[4)]	—
	2) Platforms	50[4)]	—
xxix)	Gauge and tool rooms: General	700[5)]	19
xxx)	Glass works and processes:		
	a) Furnace rooms, bending, annealing lehrs	100	28
	b) Mixing rooms, forming (blowing, drawing, pressing, rolling)	150	28
	c) Cutting to size, grinding, polishing, toughening	200	25
	d) Finishing (bevelling, decorating, etching, silvering)	300	22
	e) Brilliant cutting	700	19
	f) Inspection:		
	1) General	200	19
	2) Fine	700	19

Sl No.	*Industrial Buildings and Processes*	*Average Illumination, lux*	*Limiting Glare Index*
(1)	(2)	(3)	(4)
xxxi)	Glove making:		
	a) Pressing, knitting, sorting, cutting	300	22
	b) Sewing:		
	1) Light	300	22
	2) Medium	450	22
	3) Dark	700	22
xxxii)	Hat making		
	a) Stiffening, braiding, cleaning, refining forming, sizing, pouncing, flanging, finishing ironing	150	22
	b) Sewing:		
	1) Light	300	22
	2) Medium	450	22
	3) Dark	700	22
xxxiii)	Hosiery and knitwear:		
	a) Circular and flat knitting machines universal winders, cutting out, folding and pressing	300	22
	b) Lock stitch and overlooking machines:		
	1) Light	300	22
	2) Medium	450	22
	3) Dark	700	22
	c) Mending	1 500	19
	d) Examining and hand finishing, light, medium, dark	700	19
	e) Linking or running-on	450	19
xxxiv)	Inspection shops (Engineering)		
	a) Rough work, for example, counting, rough checking of stock parts, etc.	150	28
	b) Medium work, for example, ‘Go’ and ‘No-go’ gauges, sub-assemblies	300	25
	c) Fine work, for example, radio and telecommunication equipment, calibrated scales, precision mechanisms, instruments	700	22
	d) Very fine work, for example, gauging and inspection of small intricate parts	1 500	19
	e) Minute work, for example, very small instruments	3 000[2)]	19
xxxv)	Iron and steel works		
	a) Marshalling and outdoor stockyards	10-20	—
	b) Stairs, gangways, basements, quarries, loading docks	100	—
	c) Slab yards’ melting shops, ingot stripping soaking pits, blast furnace working areas, picking and cleaning lines, mechanical plants, pump houses	100	28
	d) Mould preparation, rolling and wire mills, mills motors rooms, power blower houses	150	28
	e) Slab inspection and conditioning, cold strip mills, sheet and plate finishing, tinning, galvanizing, machine and roll shops	200	28
	f) Plate inspection	300	—
	g) Tinplate inspection	Special lighting	—

Sl No.	*Industrial Buildings and Processes*	*Average Illumination, lux*	*Limiting Glare Index*
(1)	(2)	(3)	(4)
xxxvi)	Jewellery and watchmaking		
	a) Fine processes	700[1)]	19
	b) Minute processes	3 000[1)]	10
	c) Gem cutting, polishing, setting	1 500[3)]	—
xxxvii)	Laboratories and test rooms		
	a) General laboratories, balance rooms	300	19
	b) Electrical and instrument laboratories	450	19
xxxviii)	Laundries and drycleaning works		
	a) Receiving, sorting, washing, drying, ironing (calendering), despatch	200	25
	b) Drycleaning, bulk machine work	200	25
	c) Fine hand ironing, pressing, inspection mending, spotting	300	25
xxxix)	Leather dressing		
	a) Vats, cleaning, tanning, stretching, cutting, fleshing and stuffing	150	28
	b) Finishing, staking, splitting and scrafing	200	28
xl)	Leather working		
	a) Pressing and glazing	450	22
	b) Cutting, scarfing, sewing	700	22
	c) Grading and matching	1 000[3)]	19
xli)	Machine and fitting shops		
	a) Rough bench and machine work	150	28
	b) Medium bench and machine work, ordinary automatic machines, rough grinding, medium buffing and polishing	300	25
	c) Fine bench and machine work, fine automatic machines, medium grinding fine buffing and polishing	700	22
xlii)	Motor vehicle plants		
	a) General sub-assemblies, chassis assembly, car assembly	300	25
	b) Final inspection	450	25
	c) Trim shops, body sub-assemblies, body assembly	300	25
	d) Spray booths	450	—
xliii)	Paint works		
	a) General automatic processes	200	25
	b) Special batch mixing	450	22
	c) Colour matching	700[3)]	19
xliv)	Paint shops and spraying booths:		
	a) Dipping, firing rough spraying	150	25
	b) Rubbing, ordinary painting, spraying and finishing	300	25
	c) Fine painting, spraying and finishing	450	25
	d) Retouching and matching	700[3)]	19
xlv)	Paper-works:		
	a) Paper and board making:		
	1) Machine houses, calendering pulp mills, preparation plants, cutting, finishing, trimming	200	25
	2) Inspection and sorting (over hauling)	300	22
	b) Paper converting processes:		
	1) Corrugated board, cartons, containers and paper sack manufacture, coating and laminating processes	200	25

Sl No.	*Industrial Buildings and Processes*	*Average Illumination, lux*	*Limiting Glare Index*
(1)	(2)	(3)	(4)
	2) Associated printing	300	25
xlvi)	Pharmaceuticals and fine chemicals works:		
	a) Raw material storage	200	28
	b) Control laboratories and testing	300	19
	c) Pharmaceuticals manufacturing: grinding, granulating, mixing and drying, tableting, sterilizing and washing, preparation of solutions and filling, labelling, capping, cartoning and wrapping, inspection	300	25
	d) Fine chemical manufacture:		
	1) Plant processing	200	25
	2) Fine chemical finishing	300	25
xlvii)	Plastics works:		
	a) Manufacture (*see* Chemical works)	—	—
	b) Processing:		
	1) Calendering, extrusion	300	25
	2) Moulding-compression, injection	200	25
	3) Sheet fabrication:		
	i) Shaping	200	25
	ii) Trimming, machining, polishing	300	25
	iii) Cementing	200	25
xlviii)	Plating shops:		
	a) Vat and baths, filter pressing, kin rooms, moulding, pressing, cleaning, trimming, glazing, firing	150	28
	b) Enamelling, colouring, decorating	450[3)]	19
xlix)	Printing works:		
	a) Type foundries:		
	1) Matrix making, dressing type, hand and machine casting	200	25
	2) Front assembly, sorting	450	22
	b) Printing plants:		
	1) Machine composition, imposing stones	200	25
	2) Presses	300	25
	3) Composing room	450	19
	4) Proof reading	300	19
	c) Electrotyping:		
	1) Block-making, electroplating, washing, backing	200	25
	2) Moulding, finishing, routing	300	25
	d) Photo-engraving:		
	1) Block-making, etching, masking	200	25
	2) Finishing, routing	300	25
	e) Colour printing: Inspection area	700[3)]	19
l)	Rubber processing:		
	a) Fabric preparation creels	200	25
	b) Dipping, moulding, compounding calendars	150	25
	c) Tyre and tube making	200	25

Sl No.	Industrial Buildings and Processes	Average Illumination, lux	Limiting Glare Index
(1)	(2)	(3)	(4)
li)	Sheet metal works:		
	a) Benchwork, scribing, pressing, punching shearing, stamping, spinning, folding	200	25
	b) Sheet inspection	Special lighting	
lii)	Soap factories:		
	a) Kettle houses and ancillaries, glycerine evaporation and distillation, continuous indoor soap making, plants:		
	1) General areas	150	25
	2) Control panels	200-300	25
	b) Batch or continuous soap cooling, cutting and drying, soap milling, plodding:		
	1) General areas	150	25
	2) Control panels, key equipment	200-300	25
	c) Soap stamping, wrapping and packing, granules making, granules storage and handling, filling and packing granules:		
	1) General areas	150	25
	2) Control panels, machines	200-300	25
	d) Edible products processing and packing	200	25
liii)	Structural steel fabrication plants:		
	a) General	150	28
	b) Marking off	300	28
liv)	Textile mills (cotton or linen):		
	a) Bale breaking, blowing, carding, roving, slubbing, spinning (ordinary counts), winding, heckling, spreading, cabling	150	25
	b) Warping, slashing, dressing and dyeing, doubling (fancy), spinning (fine counts)	200	25
	c) Healding (drawing-in)	700	—
	d) Weaving:		
	1) Patterned cloths, fine counts dark	700	19
	2) Patterned cloths, fine counts light	300	19
	3) Plain 'grey' cloth	200	19
	e) Cloth inspection	700[1)]	—
lv)	Textile mills (silk or synthetics):		
	a) Soaking, fugitive tinting, conditioning or setting of twist	200	25
	b) Spinning	450	25
	c) Winding, twisting, rewinding and coning, quality slashing:		
	1) Light thread	200	25
	2) Dark thread	300	25
	d) Warping	300	25
	e) Healding (drawing-in)	700	—
	f) Weaving	700	19
	g) Inspection	1 000[3)]	19
lvi)	Textile mills (woollen):		
	a) Scouring, carbonizing, teasing, preparing, raising, brushing, pressing, back-washing, gilling, crabbing and blowing	150	25

Sl No.		*Industrial Buildings and Processes*	*Average Illumination, lux*	*Limiting Glare Index*
(1)		(2)	(3)	(4)
	b)	Blending, carding, combing (white), tentering, drying, cropping	200	25
	c)	Spinning, roving, winding, warping, combing (coloured), twisting	450	25
	d)	Healding (drawing-in)	700	—
	e)	Weaving:		
		1) Fine worsteds	700	19
		2) Medium worsteds, fine woollens	450	19
		3) Heavy woollens	300	19
	f)	Burling and mending	700	19
	g)	Perching:		
		1) Grey	700	—
		2) Final	2 000[3]	—
lvii)		Textile mills (jute):		
	a)	Weaving, spinning, flat, jacquard carpet looms, cop winding	200	25
	b)	Yarn calender	150	25
lviii)		Tobacco factories: All processes	300[3]	22
lix)		Upholstering, furniture and vehicles	300	22
lx)		Warehouses and bulk stores:		
	a)	Large material, loading bays	100	28
	b)	Small material, racks	150	25
	c)	Packing and despatch	150	25
lxi)		Welding and soldering:		
	a)	Gas and arc welding, rough spot welding	150	28
	b)	Medium soldering, brazing and spot welding, for example, domestic hardware	300	25
	c)	Fine soldering and spot welding, for example, instruments, radio set assembly	700	22
	d)	Very fine soldering and spot welding, for example, radio valves	150	19
lxii)		Woodworking shops:		
	a)	Rough sawing and bench work	150	22
	b)	Sizing, planning, rough sanding, medium machine, and bench work, gluing, veneering, cooperage	200	22
	c)	Fine bench and machine work, fine sanding and finishing	300	22

[1] Optical aids should be used where necessary.
[2] Supplementary local lighting may be required for gauge glasses and instrument panels.
[3] Special attention should be paid to the colour quality of the light.
[4] Supplementary local lighting should be used at important points.
[5] Supplementary local lighting and optical aids should be used where necessary.

ANNEX F
(*Clause* 10)

POWER FACTOR IN INDUSTRIAL INSTALLATIONS

F-1 The general guidelines for power factor compensation is given in Part 1/Sec 17 of the Code. For guidance, the natural power factor for some three phase electrical installations are given in Table 4. The recommended capacitor ratings at rated voltage, for direct connection to ac induction motor in industries are given in Table 5.

Table 4 Power Factor for Three Phase Electrical Installations
(*Clause* F-1)

Sl No.	Type of Installation	Natural Power Factor	Sl No.	Type of Installation	Natural Power Factor
(1)	(2)	(3)	(1)	(2)	(3)
i)	Cold storage and fisheries	0.76-0.80	xviii)	Flour mills	0.61
ii)	Cinemas	0.78-0.80	xix)	Gas works	0.87
iii)	Metal pressing	0.57-0.72	xx)	Textile mills	0.86
iv)	Confectionery	0.77	xxi)	Oil mills	0.51-0.59
v)	Dyeing and printing (textile)	0.60-0.87	xxii)	Woolen mills	0.70
vi)	Plastic moulding	0.57-0.73	xxiii)	Potteries	0.61
vii)	Film studios	0.65 to 0.74	xxiv)	Cigarette manufacturing	0.80
viii)	Newspapers	0.58	xxv)	Cotton press	0.63-0.68
ix)	Heavy engineering works	0.48-0.75	xxvi)	Foundries	0.59
x)	Rubber extrusion and moulding	0.48	xxvii)	Tiles and mosaic	0.61
xi)	Pharmaceuticals	0.75-0.86	xxviii)	Structural engineering	0.53-0.68
xii)	Oil and paint manufacturing	0.51-0.69	xxix)	Chemicals	0.72-0.87
xiii)	Silk mills	0.58-0.68	xxx)	Municipal pumping stations	0.65-0.75
xiv)	Biscuit factory	0.60	xxxi)	Oil terminals	0.64-0.83
xv)	Printing press	0.65-0.75	xxxii)	Telephone exchange	0.66-0.80
xvi)	Food products	0.63	xxxiii)	Rolling mills	0.72-0.60
xvii)	Laundries	0.92	xxxiv)	Irrigation pumps	0.52-0.70

Table 5 Capacitor Ratings at Rated Voltage
(*Clause* F-1)

Rated Output of Motors kW	Capacitor Rating in kVAR for Motor Speed					
	3 000 rev/min	1 500 rev/min	1 000 rev/min	750 rev/min	600 rev/min	500 rev/min
(1)	(2)	(3)	(4)	(5)	(6)	(7)
2.25	1	1	1.5	2	2.5	2.5
3.7	2	2	2.5	3.5	4	4
5.7	2.5	3	3.5	4.5	5	5.5
7.5	3	4	4.5	5.5	6	6.5
11.2	4	5	6	7.5	8.5	9
15	5	6	7	9	11	12
18.7	6	7	9	10.5	13	14.5
22.5	7	8	10	12	15	17
37	11	12.5	16	18	23	25
57	16	17	21	23	29	32
75	21	23	26	28	35	40
102	31	33	36	38	48	55
150	40	42	45	47	60	67
187	46	50	53	55	68	76

NOTES

1 The reference to speed of motor has been made since the manufacturers provide information on that basis.

2 The capacitive current supplied by condensers directly across induction motor terminals should not exceed the magnetizing current of the induction motors, to guard against excess transient torques and overvoltages.

3 Should a consumer desire to improve the power factor beyond a value which is limited by considerations of magnetizing kVAR of the motor as stated in Note 2, then he may install the calculated capacitor kVAR as a separate circuit with its independent controlgear.

NATIONAL ELECTRICAL CODE

PART 5

PART 5 OUTDOOR INSTALLATIONS

0 FOREWORD

As compared to the various types of indoor installations covered in other Parts of this Code, outdoor installations are distinct in nature by virtue of their being exposed to moderate to heavy environmental conditions. In addition, electric power in outdoor installations is normally utilized for specific purposes such as, lighting or for meeting the needs of heavy machinery (example, open cast mines). In the case of the latter, the duties would be more onerous than those normally encountered in indoor situations, thereby calling for special considerations in their design.

Keeping the above in view, Part 5 of this Code deals with installations erected outdoor. Some outdoor installations are erected to serve for a small duration of time after which they are meant to be dismantled. Such installations are called temporary installation. For convenience, and keeping other aspects of safety provisions in view, this duration is defined as not exceeding six months. Permanent outdoor installations are those which are generally in use for longer periods of time. This Part 5 of this Code basically deals with these two types of outdoor installations.

Part 5 consists of the following Sections:

Section 1 Public Lighting Installations
Section 2 Temporary Outdoor Installations
Section 3 Permanent Outdoor Installations

Even though installations for lighting of public thoroughfares are permanent in nature, they are dealt with separately in Section 1.

It may, however, be noted that small outdoor locations around building installations (example, gardens around hotel installations or storage yards in industries) do not fall under the scope of Part 5. For requirements pertaining to this, reference should be made to relevant parts of this Code.

SECTION 1 PUBLIC LIGHTING INSTALLATIONS

0 FOREWORD

One of the most common forms of permanent outdoor installations is the public lighting installations intended for lighting of public thoroughfares. With the availability of variety of light sources for such installations and the need for proper illumination of a variety of traffic routes and city centres it has been found necessary to lay down guidelines for designing on efficient and economical lighting installation.

This Section of this Code is intended to cover general principles governing the lighting of public thoroughfares and to lay down recommendations on the quantity and quality of lighting to be provided. The actual details of design would entirely depend on the local circumstances.

The requirements given in this Section are, as far as practicable aligned with the recommendations of the International Commission on Illumination (CIE) modified to suit the local conditions and regulations.

1 SCOPE

1.1 This Part 5/Section 1of the Code covers requirements of public lighting installations in order to provide guidance to those concerned with the preparation of public lighting schemes, their installation and maintenance (*see also* SP 72).

1.2 This Section deals only with electric lighting sources and does not include gas or other types of lighting.

1.3 This Section also does not cover exterior lighting installations, such as those which apply for parks, shopping enclaves, flood lighting of routes and structures of architectural importance, etc.

2 REFERENCES

This Part 5/Section 1 of the Code should be read in conjunction with the following Indian Standards:

IS No.	*Title*
SP 72 : 2010	National Lighting Code
1885 (Part 16/ Sec 2) : 1968	Electrotechnical vocabulary : Part 16 Lighting, Section 2 General illumination lighting fittings and lighting for traffic and signalling
1944 (Parts 1 and 2) : 1970	Code of practice for lighting of public thoroughfares: Part 1 General principles; Part 2 Lighting of main roads (*first revision*)
1944 (Part 5) : 1981	Code of practice for lighting of public thoroughfares: Part 5 Lighting of grade separated junctions, bridges and elevated road (Group D)
1944 (Part 6): 1981	Code of practice for lighting of public thoroughfares: Part 6 Lighting of town and city centres and areas of civic importance (Group E)

3 TERMINOLOGY

3.0 For the purpose of this Section, the following terms together with those provided in IS 1885 (Part 16/ Section 2) shall apply.

3.1 Terms Relating to Highways

3.1.1 *Highway* — A way for the passage of vehicular traffic over which such traffic may lawfully pass.

3.1.2 *Layout* — All those physical features of a highway other than the surfacing of the carriageway, which have to be taken into account in planning a lighting installation.

3.1.3 *Carriageway* — That portion of a highway intended primarily for vehicular traffic.

3.1.4 *Dual Carriageway* — A layout of the separated carriageways, each reserved for traffic in one direction only.

3.1.5 *Central Reserve* — A longitudinal space dividing a dual carriageway.

3.1.6 *Service Road* — A subsidiary road between principle road and buildings or properties facing thereon or a parallel road to the principal road and giving access to the premises and connected only at selected points with the principle road".

3.1.7 *Cycle Track* — A way or part of a highway for use by pedal cycles only.

3.1.8 *Footway* — That portion of a road reserved exclusively for pedestrians.

3.1.9 *Verge* — The unpaved area flanking a carriageway, forming part of the highway and substantially at the same level as the carriageway.

3.1.10 *Shoulder* — A strip of highway adjacent to and level with the main carriageway to provide an opportunity for vehicles to leave the carriageway in an emergency.

3.1.11 *Refuge* — A raised platform or a guarded area so sited in the carriageway as to divide the streams of traffic and to provide a safety area for pedestrians.

3.1.12 *Kerb* — A border of stone, concrete or other rigid material formed at the edge of a carriageway.

3.2 Terms Relating to Lighting Installation

3.2.1 *Lighting Installation* — The whole of the equipment provided for lighting the highway comprising the lamps, luminaires, means of support and electrical and other auxiliaries.

3.2.2 *Lighting System* — An array of luminaires having a characteristic light distribution sited in a manner concordant with this distribution. (Lighting systems are commonly designated by the name of the characteristic light distribution, for example, cut-off, semi-cut-off, etc.)

3.2.3 *Luminaire* — A housing for one or more lamps, comprising a body and any refractor, reflector, diffuser or enclosure associated with the lamp(s).

3.2.4 *Outreach* — The distance measured horizontally between the centre of the column or wall face and the centre of a luminaire (*see* Fig.1).

3.2.5 *Overhang* — The distance measured horizontally between the centre of a luminaire mounted on a bracket and the adjacent edge of the carriageway (*see* Fig. 1).

3.2.6 *Mounting Height* — The vertical distance between the centre of the luminaire and the surface of the carriage (*see* Fig. 1).

3.2.7 *Spacing* — The distance, measured along the centre line of the carriageway, between successive luminaires in an installation (*see* Fig.1).

NOTE — In a staggered arrangement, the distance is measured, along the centre line of the carriageway, between a luminaire on one side of the carriageway and the next luminaire, which is on the other side of the carriage. It is not the distance measured on the diagonal joining them, nor the distance between successive luminaires on the same side of the carriageway.

3.2.8 *Span* — That part of the highway lying between successive luminaires in an installation.

3.2.9 *Width of Carriageway* — The distance between kerb lines measured at right angles to the length of the carriageway (*see* Fig. 1).

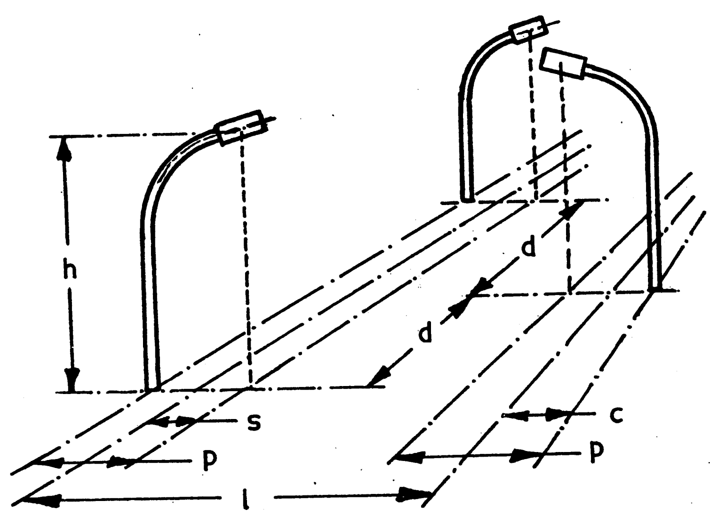
3.2.10 *Arrangement* — The pattern according to which luminaires are sited on plan, for example, staggered, axial, opposite.

3.2.11 *Geometry* (*of a Lighting System*) — The inter-related linear dimensions and characteristics of the system, namely the spacing, mounting height, width, overhang and arrangement.

3.3 Photometric Terms

3.3.1 *Luminous Flux* — The light given by a light source or a luminaire or received by a surface irrespective of the directions in which it is distributed. The unit of the luminous flux is the lumen (1m).

3.3.2 *Lower Hemispherical Flux or Downward Flux* — The luminous flux emitted by a luminaire in all directions below the horizontal.



o	=	location of columns	*p*	=	outreach
h	=	mounting height of luminaires	*s*	=	overhang
d	=	width of the carriage way	*c*	=	clearance

FIG. 1 SITING OF LUMINARIES: CHARACTERISTIC DIMENSIONS

3.3.3 *Luminous Intensity* — The quantity which describes the light-giving power of a luminaire in any particular direction. The unit of luminous intensity is the candela (cd).

3.3.4 *Illumination* — The luminous flux incident on a surface per unit area. The unit of illumination is the lumen per square metre (lux).

3.3.5 *Luminance* (*at a Point of Surface and in a Given Direction*) — The luminous intensity per unit projected area of a surface. If a very small portion of a surface has an intensity *I* candelas in a particular direction and its orthogonal projection (that is, its projection on a plane perpendicular to the given direction) has an area *D*, the luminance in this direction is *I/D* candelas per unit area. The usual unit is the candela per square metre (cd/m^2).

3.3.6 *Luminosity* — The attribute of visual sensation according to which an area appears to emit more or less light. It is some time called brightness.

NOTE — Luminosity is the visual sensation which correlates approximately with the photometric quantity 'luminance'.

3.3.7 *Light Output* — The luminous flux emitted by a luminaire.

3.3.8 *Light Distribution* — The distribution of luminous intensity from a luminaire in various directions in space.

3.3.9 *Symmetrical* (*Converse Asymmetrical*) *Distribution* — A distribution of luminous intensity which is substantially symmetrical (conversely asymmetrical) about the vertical axis of the luminaire.

3.3.10 *Axial* (*Converse Non-axial*) *Distribution* — An asymmetrical distribution in which the directions of maximum luminous intensity lie (do not lie) in vertical planes substantially parallel to the axis of the carriageway.

3.3.11 *Peak Intensity Ratio* — The ratio of the maximum intensity to the mean hemispherical intensity of the light emitted below the horizontal.

3.3.12 *Mean Hemispherical Intensity* — The downward flux divided by 6.28 (2π) (This is the average intensity in the lower hemisphere).

3.3.13 *Intensity Ratio* (*in a Particular Direction*) — The ratio of an actual intensity from the luminaire (in a particular direction) to the mean hemispherical intensity.

3.3.14 *Beam* — The portion of the light output of the luminaire contained by the solid angle subtended at the effective centre of the luminaire containing the maximum intensity, but no intensity less than 90 percent of the maximum intensity.

3.3.15 *Beam Centre* — A direction midway between the directions for which the intensity is 90 percent of the maximum in a vertical plane through the maximum and on a conical surface through the maximum.

3.3.16 *Isocandela Curve* — A curve traced on an imaginary sphere with a source at its centre and joining all the points corresponding to those directions in which the luminous intensity is the same or a plane projection of this curve.

3.3.17 *Isocandela Diagram* — An array of Isocandela curves.

3.3.18 *Polar Curve* — Curve of light distribution using polar co-ordinates.

3.4 Terms Relating to Luminaires

3.4.1 *Street Lighting Luminaire* — A housing for a light source or sources, together with any refractor, reflector, dispersive surround or other enclosure which may be associated with the source in order to modify the light distribution in a desired manner and protect the light source from weather conditions and insects and/or for the sake of appearance, brightness and other lighting characteristic the source.

3.4.2 *Cut-off Luminaire* — Luminaire employing the technique used for concealing lamps and surfaces of high luminance from direct view in order to reduce glare.

3.4.3 *Semi-cut-off Luminaire* — Luminaire employing the technique for concealing lamps and surfaces of high luminance from direct view in order to reduce glare but to a lesser degree than cut-off luminaire.

3.4.4 *Integral Luminaire* — Luminaire with all its accessories such as ballasts, starters, igniters, capacitors, etc. However integrally with the body of the luminaire.

3.4.5 *Post Top Luminaire* — Luminaire with arrangement for mounting the same symmetrically on the top of the column.

4 CLASSIFICATION

4.0 Ideally, both from the points of view of traffic safety and comfort, a high standard of lighting is advisable on all roads. The system of lighting, from good engineering point of view as well as economy should take into account all the relevant factors, such as the presence of factories, places of public resort, character of the street (whether a shopping area or a ring-road in non-built-up area), aesthetic considerations, the properties of the carriageway surface, the existence of lumps, bends or long straight stretches and overhanging trees.

4.1 The classification of lighting installations in public thoroughfares given in **4.2** is based on volume, speed and composition of the traffic using them. It is left to the local engineer to decide upon the category of the lighting for the given road. Further amplification of the types of thoroughfares can be had from Annex A, wherein description of terms are given for guidance.

4.2 Types of Roads

For the purposes of this Section, roads are classified as given in Table 1.

5 GENERAL PRINCIPLES

5.1 Aims of Public Lighting Installations

5.1.1 *Main Roads*

The aim of public lighting along main roads, bridges and flyovers (Groups A, B and D) is to permit users of the roads at night to move about with greatest possible safety and comfort so that the traffic capacity of the road at night is as much equal to that planned for day time as possible. Towards this end consideration has to be given while designing the lighting on road junctions and pedestrian crossings so that these can be easily identified by the drivers.

5.1.2 *Roads in Residential Areas*

The principle aim of public lighting along roads in residential areas (Group C) is to provide light along the stretch of carriage way and footpath for safety and comfort of road users mainly the pedestrians; consideration has to be given to ensure that the lighting is soft and does not cause glare.

5.1.3 *Roads in City Centres*

The main consideration while designing the lighting in city centres (Group E) is proper illumination of footpaths for pedestrians, besides the comfort of the drivers. Also care is required to easily identify flow of traffic and road dividers, islands, roundabouts, etc.

5.1.4 *Roads with Special Requirements* (*Group F*)

Separate considerations are required to be given for each of the following:

a) *Airports* — The main consideration in designing lighting of roads in the vicinity of airports is to ensure that under no circumstances, would a pilot mistake the stretch of the road as airport landing strip at night time. Also the lamps should not cause glare to the pilot either while taking off or more specifically while landing, which may interfere with his/her judgement.
b) *Railways and docks* — The driver of the railway is required to observe a number of signals along the tracks in the course of his work. It is necessary that none of the street lamps cause either glare to the driver or is mistaken by the driver for track signals. Similar considerations are applicable to navigators in the vicinity of docks.

5.2 Principles of Vision in Public Lighting

5.2.0 Though public lighting has to satisfy both drivers

Table 1 Road Classification
(*Clause* 4.2)

Sl No.	Group {as in IS : 1944 (Part 1 and 2)}		Description
(1)	(2)		(3)
i)	A		Main Roads:
		A1	Very important routes with rapid and dense traffic where safety, speed of traffic and comfort to drivers are the only consideration.
		A2	Other main roads with considerable mixed traffic like main city streets, arterial roads, etc.
ii)	B		Secondary roads—Roads which do not require lighting up to Group A standard.
		B1	Secondary roads of considerable traffic such as principal local traffic routes, shopping streets, etc.
		B2	Secondary roads with comparatively light traffic.
iii)	C		Residential and unclassified roads. These are roads not included in Groups A and B.
iv)	D		Grade separated junctions, bridges and elevated roads (*see* Note 2).
v)	E		Town and city centres and areas of civic importance (*see* Note 2).
vi)	F		Roads with special requirements (*see* Note 3).
vii)	G		Tunnels (roads underground).

NOTES

1 For the purposes of lighting installations, bridges are classified short or long when their lengths are less than or greater than 60 m.

2 Such areas are set apart in view of the fact that their standard of lighting is different from and higher than that described for other groups. Group E also includes important shopping streets, boulevards, promenades and such other places which are the focus of special activities after dark.

3 Group F includes roads in the vicinity of aerodromes, railways, docks and navigable waterways; where special lighting requirements are to be met in addition to compliance with general principles.

and pedestrians, it is in practice the requirements of the drivers which are more stringent. The following principles are considered essential [*see also* IS 1944 (Parts 1 and 2)].

5.2.1 *Requirements of Drivers*

These are as follows:

a) Visibility of the whole of the road and its details such as entry of side-roads, traffic signs, etc;
b) Visual guidance on the alignment of the road;
c) Clear visibility of objects in time;
d) Good seeing condition by silhouette vision;
e) Continuity and uniformity of lighting; and
f) General or special lighting of signs.

5.2.2 *Visual Field of the Driver*

The visual field of the driver comprises, in order of decreasing importance:

a) The carriageway;
b) The surrounds to the road, including signs; and
c) The sky, including the bright luminaires.

5.2.3 *Visibility*

The phenomenon of visibility is directly related to contrast. Good contrast should always be produced:

a) between the carriageway and all objects which indicate its boundaries; and
b) between any obstacles which may be present and the background against which it appears; since the characteristics of the obstacles may vary over a very wide range, any factor which tends to increase contrast should be exploited.

5.2.4 *Glare and Visual Comfort*

Glare in public lighting is generally caused by the luminaires. Other factors that can lead to glare are presence of undesirable large surface of high reflection factor, specular surfaces, excessively bright shop windows, advertisement signs or road direction signs.

5.3 Criteria of Quality

5.3.0 The following four factors contribute to the fundamental criteria of quality of public lighting:

a) Level of luminance,
b) Uniformity of luminance,
c) Limitation of glare, and
d) Optical guidance.

5.3.1 *Level of Luminance*

The level of luminance should be adequate to provide visibility which guarantee for the user a maximum of safety and sufficient visual comfort. It is obvious that it is the road surface luminance rather than the illumination level which provides for an accurate measure of the effective light in a street lighting installation. However, with the present state of technique and the knowledge of reflection properties of road surfaces, the calculation and measurement of luminance are likely to present difficulties. Reference may be made to **8.1** regarding illumination values to be provided on the road surfaces.

5.3.2 *Uniformity of Luminance*

This provides visual comfort for the driver.

5.3.3 *Limitation of Glare*

It is required to control the glare due to luminaires at a value which keeps the visual discomfort below an acceptable level.

5.3.4 *Visual Guidance*

A good visual guidance is required especially in long stretches of the road and even more on complicated intersections, roundabouts, etc. Most of the long range guidance is offered by the luminaires.

6 DESIGN

6.1 Layout for Roads

The design, spacing and column heights are governed by the road-width and the classification of the roads. Typical layouts for various road width are given in Table 2.

Table 2 Classification of Roads and Recommended Arrangement of Columns

Sl No.	Width of Carriage Way m	Group	Arrangement as in Fig.	Column Height *H* m	Spacing *S*
(1)	(2)	(3)	(4)	(5)	(6)
i)	24	A1	2F	9-14	2.5-3.0 *H*
ii)		A2	2E	9	2.5 *H*
iii)	18-20	A1	2D	9-14	2.5-3.0 *H*
iv)			2C	9	2.5 *H*
v)		A2	2D	9	2.5 *H*
vi)			2C	9	2.5 *H*
vii)		B1	2C	9	3.0 *H*
viii)	12	A2	2C	9	2.5 *H*
ix)		B1	2C	9	3.0 *H*
x)		B2	2B	9	3.0 *H*
xi)		C	2B	9	2.0 *H*
xii)	9	B2	2B	9	3.0 *H*
xiii)		C	2B	7	3.5 *H*
xiv)	6	C	2C	7	3.5 *H*

6.2 Layout for Flyovers

The design and column heights for flyovers are governed by the layout of flyovers, height above

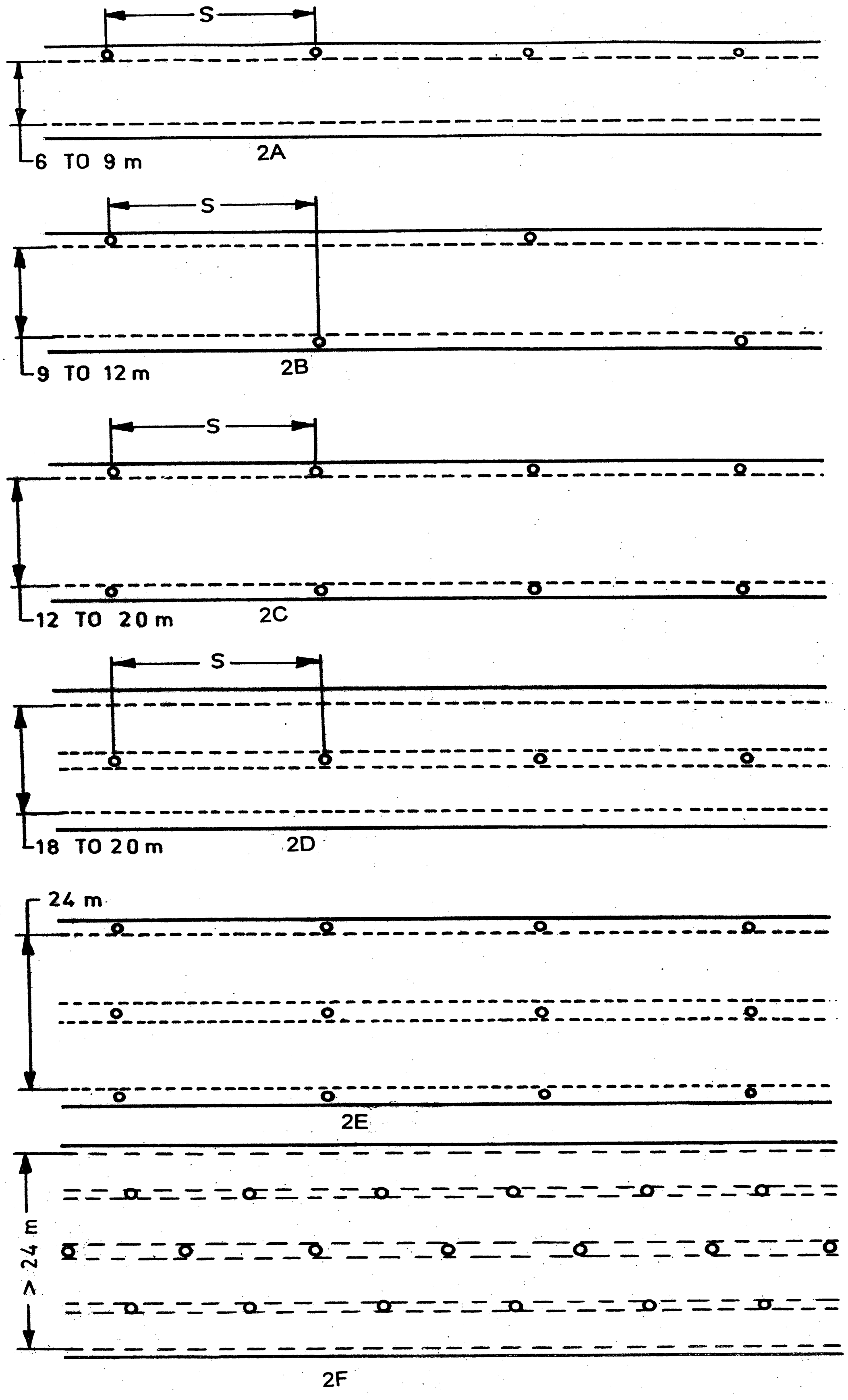


FIG. 2 STANDARD LAYOUTS FOR ROADS (SIX ALTERNATIVES)

normal ground level and the width of the low level roads. The spacing may be governed by the structural design of the flyovers. The layout of typical flyovers is given in Fig. 3A to 3D.

6.2.1 The layout with recommended arrangements, column heights and spacing for various road widths on flyover are given in the Table 3.

Table 3 Recommended Arrangement of Columns on Flyovers

Sl No.	Width of Carriage Way m	Group	Arrangement as in Fig.	Column Height[1] *H* m	Spacing *S*
(1)	(2)	(3)	(4)	(5)	(6)
i)	12	D	3C	9	2-2.5 *H*
ii)		D	3B	9	2 *H*
iii)	9	D	3A	9	2 *H*

[1] Above the flyover road level.

6.2.2 The layouts with recommended arrangements, column heights and spacing for various road widths of low level road are given in Table 4.

Table 4 Recommended Arrangement of Columns on Flyovers (Low Level Roads)

Sl No.	Width of Carriage Way m	Group	Arrangement as in Fig.	Column Height[1)] *H* m	Spacing *S*
(1)	(2)	(3)	(4)	(5)	(6)
i)	Over 20	D	3C	9	2.5 *H*
ii)	10 - 20	D	3D	14	1.5 *H*
iii)	Upto 10	D	3A	9	2.5 *H*

[1)] Above low level road

6.3 Junctions

Spacing of the junction columns should be 50 to 75 percent of the normal spacing of columns on the main roads. These columns may be installed on the traffic islands located at the junctions.

6.3.1 The level of illumination of the junction should be substantially different from the nearby roads. The junctions may be lighted by either of the following methods:

a) *Higher level of illumination* — In case this scheme is adopted the level of illuminations should be 150 percent of that of the roads.
b) *Change in height of columns* — The size of columns adopted at the junction should be higher than those adopted on roads. Recommended sizes are given in Table 5.
c) *Change in the colour of the light source* — In case the main road is lit by HPMV lamps, the junction could be lit by HPSV lamps or *vice versa*.

Table 5 Recommended Variation in Height of Columns of Junctions
(*Clause* 6.3.1)

Sl No.	Height of Columns on Roads	Recommended Height of Columns at Junctions
(1)	(2)	(3)
i)	7	9
ii)	9	14
iii)	14	High mast

6.3.2 The different types of junctions commonly encountered are discussed below in details as they require special consideration:

a) *Simple two road junction* — This type of junction should be illuminated by locating the columns in such configuration that the junction is noticed by fast moving traffic. The design would depend upon existence of traffic islands at the junctions. Typical layout of such junctions are shown in Fig. 4A to Fig. 4C.
b) *Junction of two major roads* — These junctions would generally be provided with traffic island at suitable locations to regulate flow of traffic. The lighting columns could be located in the islands to advantage. However, if the junctions are too wide or the islands do not permit planting of poles within the desired spacing, special considerations are required.

   Typical layout of such junctions are shown in Fig. 5A to 5C.
c) *Multiple road junctions* — The lighting of multiple road junction would depend upon the geographical layout of the roads, the width of the various roads and most important, the traffic conditions. At such junctions invariably entry for traffic may not be permitted on all the roads. Similarly, the traffic islands design would change from location to location. Special consideration will have to be given to the design of lighting of such junction.

   Typical layout of such junctions are shown in Fig. 6A to 6D.

6.4 Roundabouts

6.4.0 Multiple road junctions with roundabouts are much easier to design as a definite central roundabout is available to locate the columns. Two types of roundabouts are discussed below:

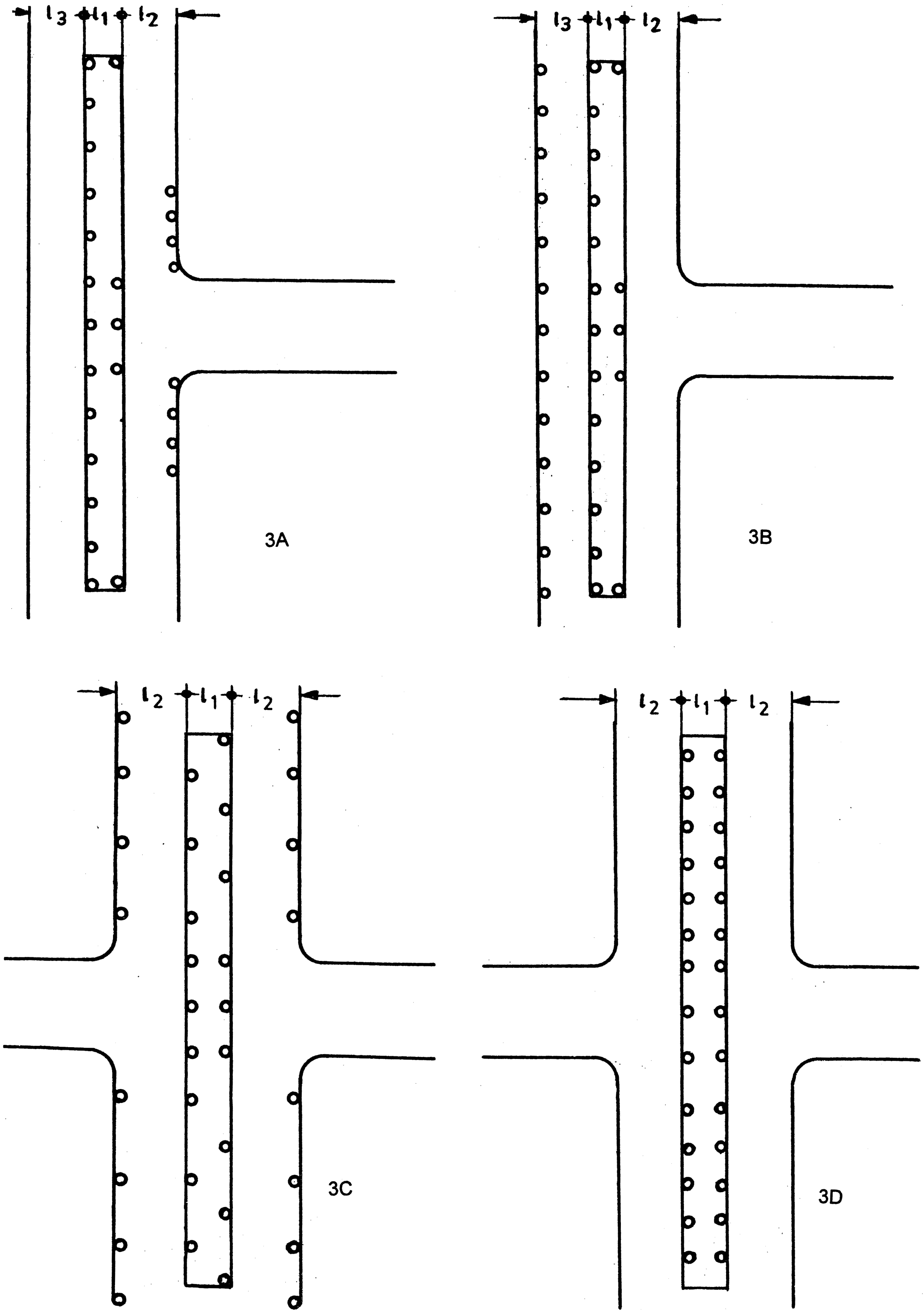
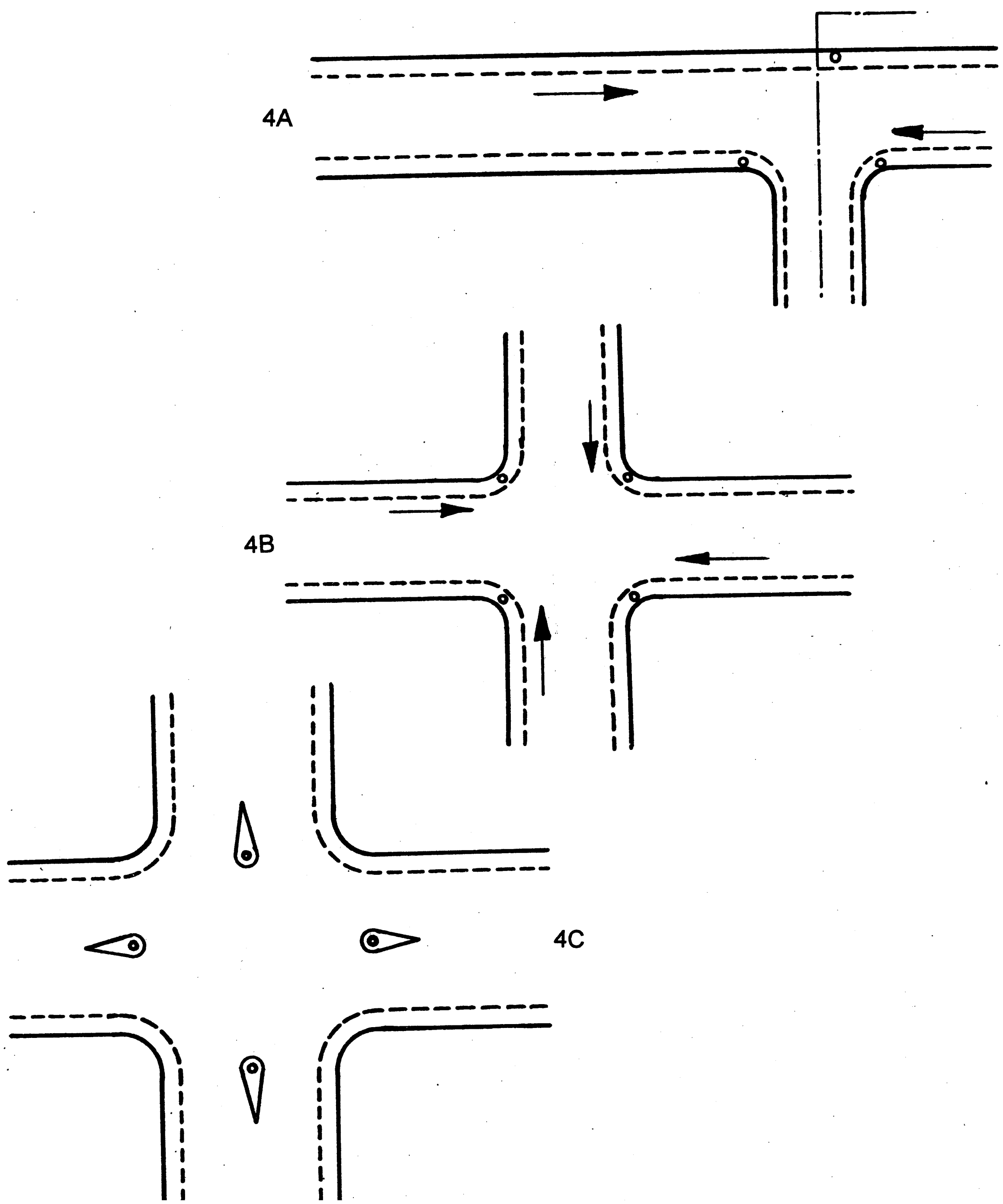


Fig. 3 Standard Layouts for Flyovers (Four Alternatives)

a) *Islands which are clear or have only parking lots* — The lighting of these could be advantageously achieved by use of high mast as given in Fig. 7A and 7B or semi-high mast lighting as in Fig. 7C and Fig. 7D.

b) *Islands which have gardens or other construction which would be obstruction to line of vision of traffic* — The lighting of these



● = Locations of Columns

FIG. 4 SIMPLE TWO ROAD JUNCTIONS (THREE ALTERNATIVES) could be either by semi-high mast as in Fig. 8A or conventional lighting as in Fig. 8B and 8C.

6.5 Road Lighting in the Vicinity of Aerodrome

6.5.1 *General Requirements*

When a proposed road lighting scheme is within 5 km of the boundary of an aerodrome it is essential that

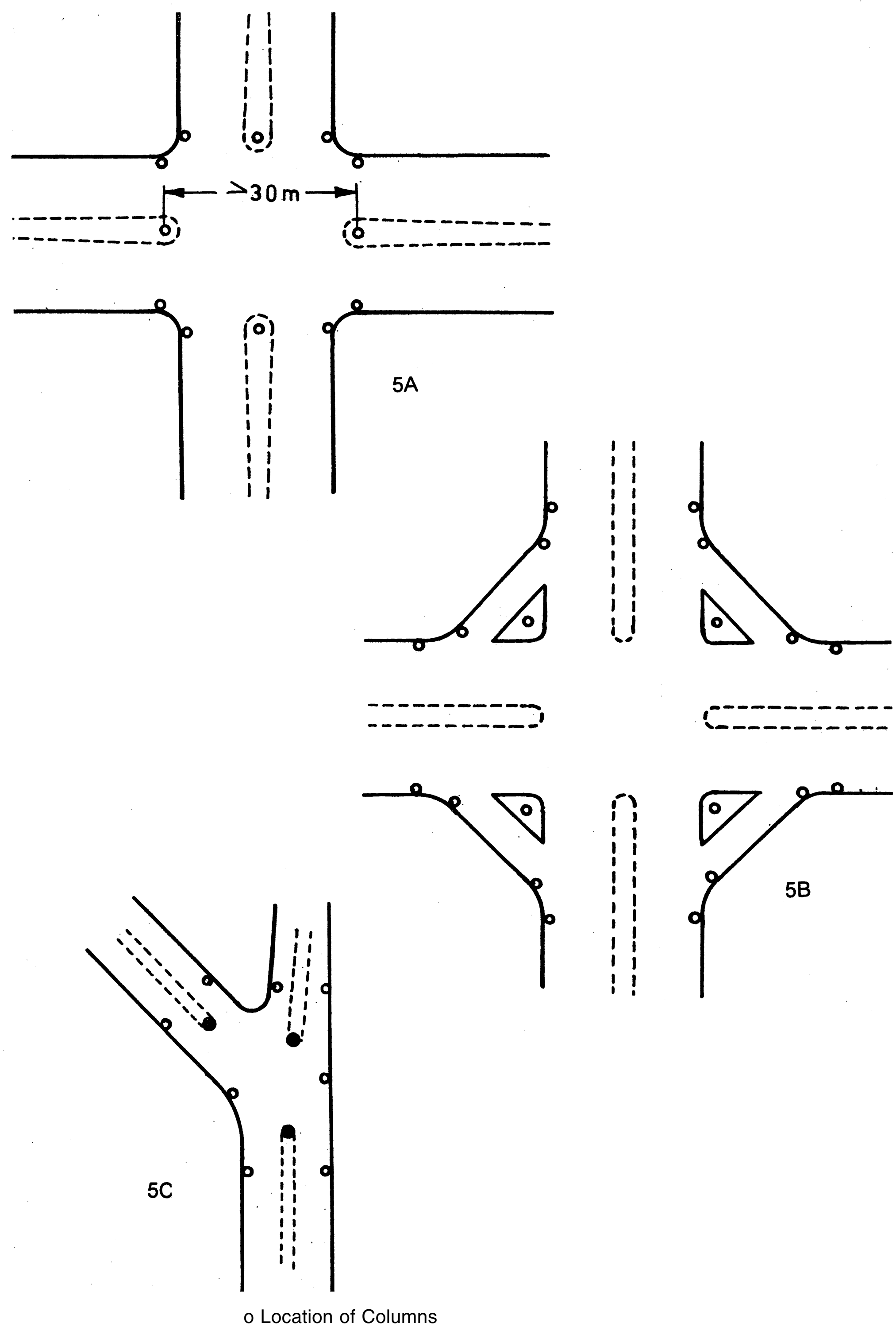


FIG. 5 JUNCTION OF TWO MAJOR ROADS (THREE ALTERNATIVES)

appropriate aviation authority is consulted regarding any restrictions and precautions to be observed that may be necessary.

6.5.2 The aviation authority may have a specific interest in the pattern of the layout, the mounting height, the colour and intensity, distribution of light emitted above the horizontal so that lighting installation does not present any danger to the air navigation. The following points should, therefore, be kept in view while designing lighting scheme in the vicinity of the aerodromes:

a) The light provided in the vicinity of an aerodrome shall be properly screened so as to avoid any glare which may otherwise endanger safety of an aircraft arriving and departing from an aerodrome.

b) Lights mounted on the electric poles/pylons shall not cause an obstruction to the arriving

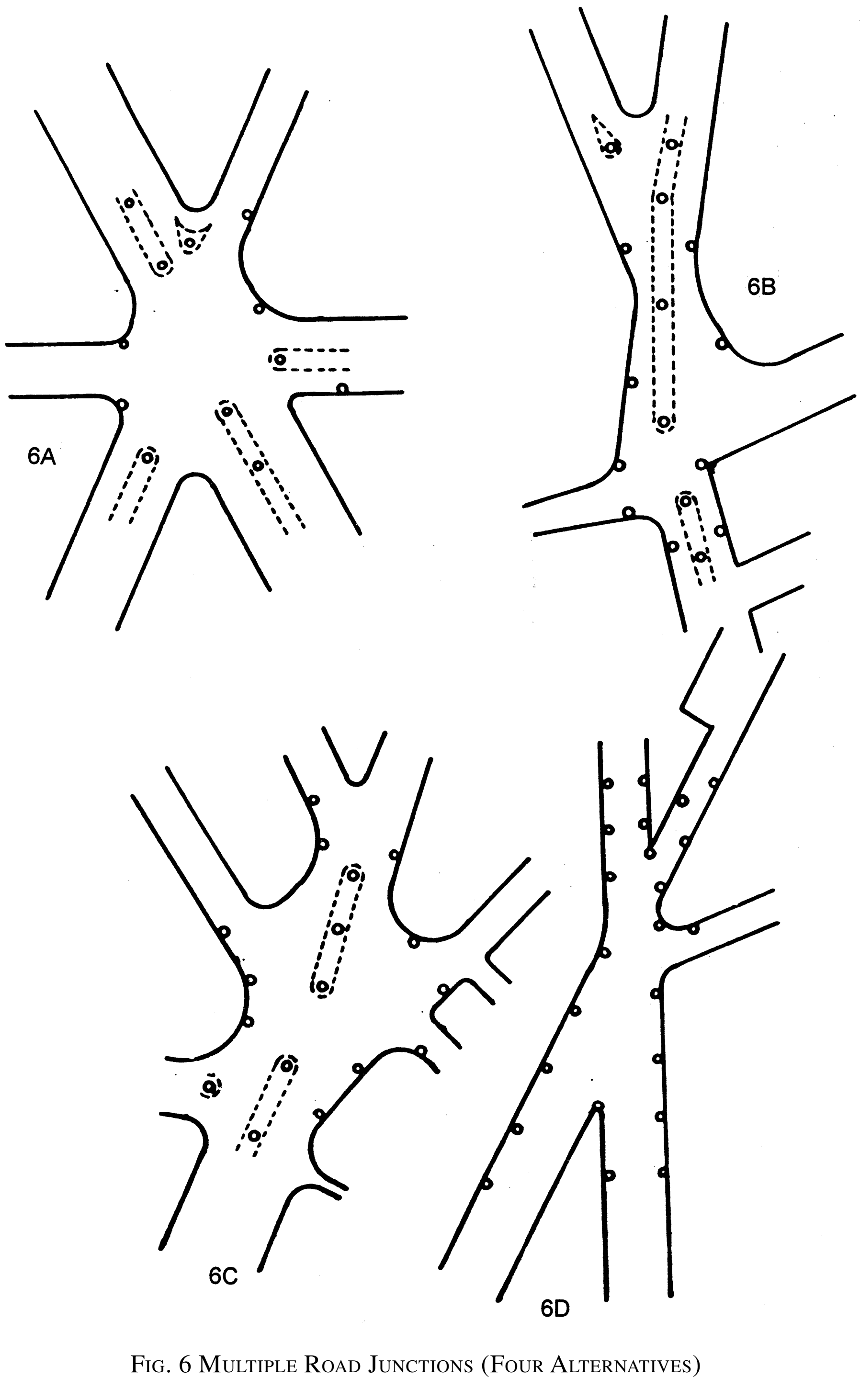


FIG. 6 MULTIPLE ROAD JUNCTIONS (FOUR ALTERNATIVES)

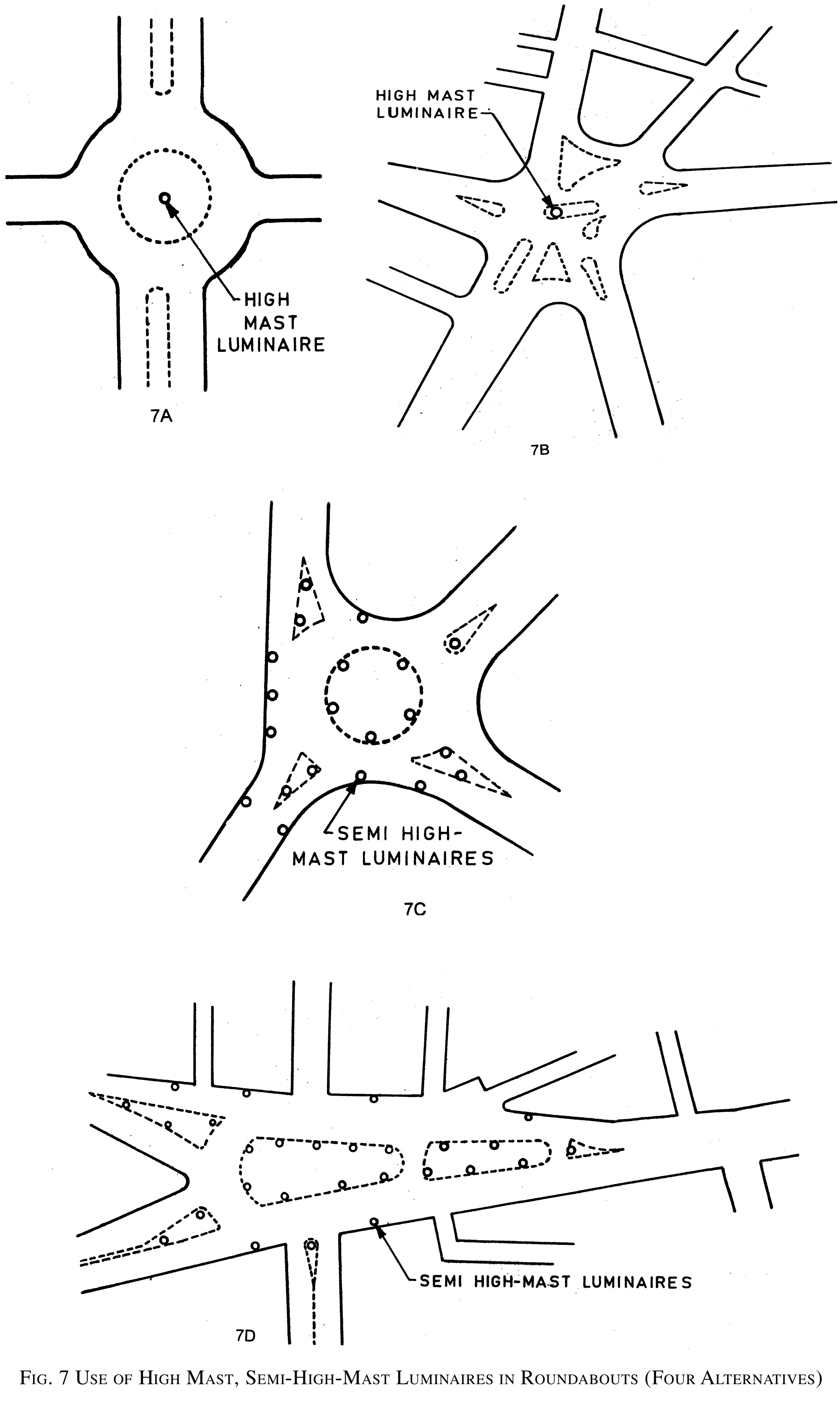


FIG. 7 USE OF HIGH MAST, SEMI-HIGH-MAST LUMINAIRES IN ROUNDABOUTS (FOUR ALTERNATIVES)

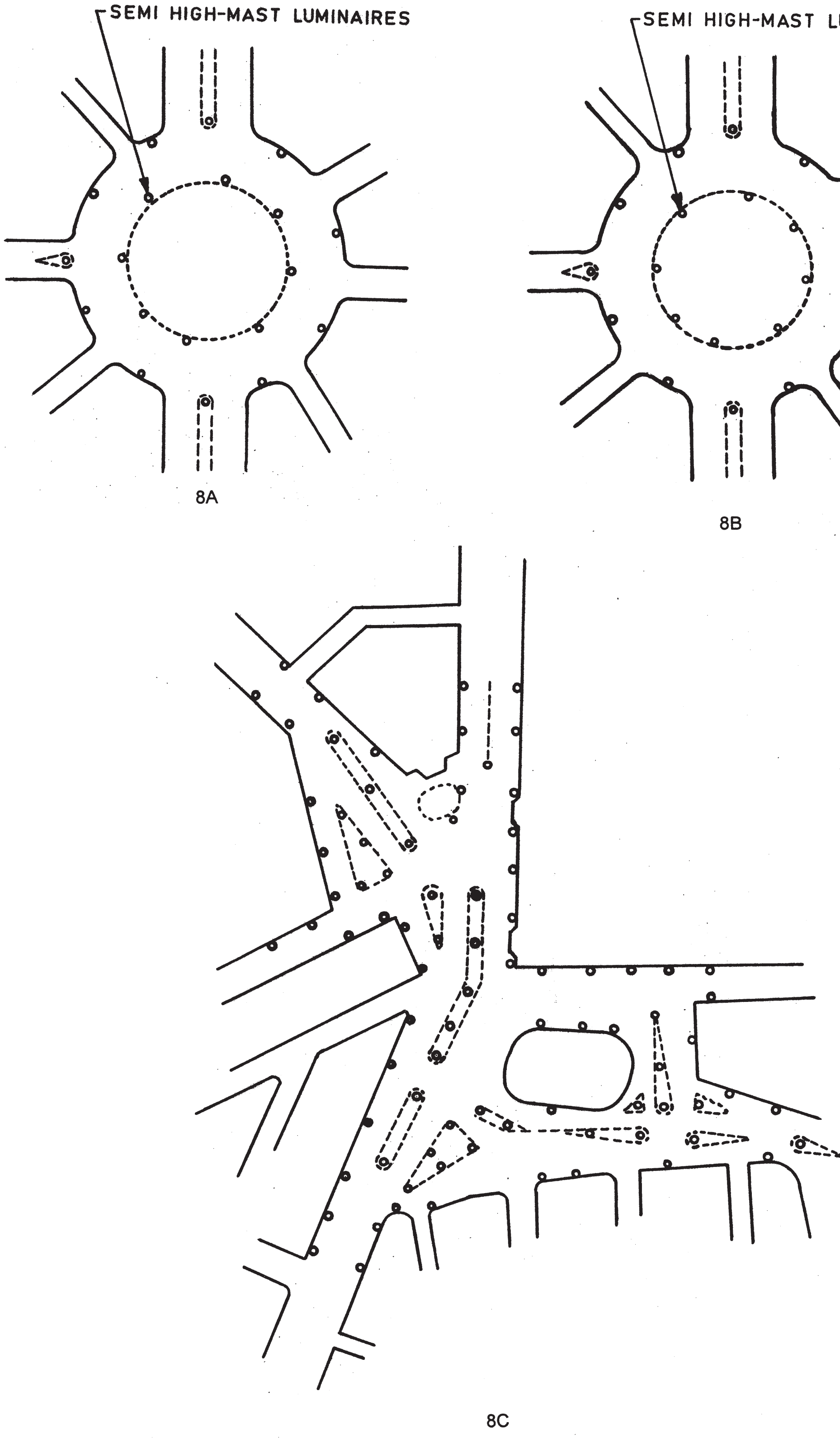


Fig. 8 Use of Semi-Mast or Conventional Lighting in Roundabouts (Three Alternatives)

and departing aircraft from an aerodrome in terms of obstacle limitation specified by the airport authorities.

c) It is particularly important to ensure that lighting of the road cannot ever be confused with the ground lighting of the flight paths by the pilots. Following conditions should be ensured:
   1) In case roads are not parallel to landing strips,
      i) Uniform design and spacing of columns is not recommended.
      ii) Arrangement of mounting columns on opposite as in Fig. 2D is not recommended.
   2) In case roads are parallel to landing strips, no lighting should be provided on the stretch of road near the landing strip.

6.6 Road Lighting in Vicinity of Railways, Docks and Navigable Waterways

6.6.0 *General*

In lighting for roads in the vicinity of railways, docks and navigable waterways, because of the colour of the light source may interfere with the proper recognition of signal system, it is essential that this interference is avoided, but local conditions vary so widely that it is not possible to lay down any rigid code applicable to all circumstances.

6.6.1 *Requirements*

The following requirements are likely to apply in all places where roads are so located that their lighting installation may affect the operation of railways, docks and navigable waterways.

6.6.2 *Consultations*

It is essential that prior consultation is made with the appropriate authorities regarding any special provision that may be necessary. These provisions should be met in a way that is mutually acceptable so that they may be incorporated at the design stage.

6.6.3 *Colour*

Where any form of road lighting is employed there is a risk of confusion with signal light. This may necessitate careful selection of light source, siting of luminaires or the use of appropriate screened luminaire at certain points and heights.

6.6.4 *Glare and Masking*

The position of individual light source on the road may fall in line with signal lights and even when fairly remote may mask them or make them difficult to recognise or may hamper the vision because of glare. If these cannot be avoided by re-siting, it may be necessary to employ screening to obviate the interference even though the colour of the light source is not objectionable.

6.6.5 *Screening*

In all cases where screening of a light source is required this should preferably be achieved by means of properly designed luminaires and not by addition of unsightly screens to normal luminaires.

6.6.6 *Siting*

If the road is bordered by water (lake, river or canal) and if the lighting is single sided, it is recommended that the columns be sited, if possible, on the waterside.

7 SELECTION OF EQUIPMENT

7.1 Electric Light Sources

7.1.0 The choice of source for public lighting is guided by the following considerations:

a) Luminous flux,
b) Economy (determined by lumens/watt and life),
c) Dimensions of the light sources, and
d) Colour characteristics.

7.1.1 The sources normally used in public lighting are:

a) Incandescent lamps,
b) Mixed incandescent and high pressure mercury vapour lamps,
c) High pressure mercury vapour lamps with clear or fluorescent bulbs,
d) Tubular fluorescent lamps,
e) Sodium vapour lamps,
f) Mercury-halide lamps, and
g) High pressure sodium vapour lamps.

7.1.1.1 *Incandescent lamps*

For new installations the employment of incandescent lamps is very limited in practice. They are sometimes used for residential streets when initial cost is to be kept low. They are not usually employed in traffic routes.

7.1.1.2 *Mixed incandescent and mercury vapour lamps*

These lamps may sometimes be employed in modernising an installation to obtain higher levels without the need for ballasts required for discharge lamps.

7.1.1.3 *High pressure mercury vapour lamps* (*HPMV*)

These lamps have higher luminous efficacy and longer life than mixed incandescent and mercury lamps. These are suitable for installations where colour rendering is of lesser importance and where high powers are needed.

7.1.1.4 *Tubular fluorescent lamps*

These lamps have high luminous efficacy and long life. They are suitable for installations where colour appearance and colour rendering are important and where large multiple lamp luminaires are acceptable. The choice between high pressure mercury vapour fluorescent lamps and fluorescent tubes is in general determined by local considerations of aesthetics and cost of installation.

7.1.1.5 *Sodium vapour lamps*

The use of sodium lamps is convenient when colour rendering is not important and when a high luminous efficacy is desired. Their colour is sometimes useful to provide visual guidance. It is also particularly suitable under foggy conditions.

7.1.1.6 *Mercury halide lamps*

These lamps are improved versions of HPMV lamps and having very much higher efficiencies in the order of 80 lm/W combined with good colour characteristics.

7.1.1.7 *High pressure sodium vapour lamps*

These lamps are improved versions of sodium vapour with efficiency of the order of to 100 lm/W with colour rendering satisfactory and of dimensions suited to fittings of small size and accurate light control.

7.2 Luminaires

7.2.0 The luminaire has double role of protecting the light source from the weather and redistributing the luminous flux of the source.

In the choice of the luminaire the following points should be considered:

a) Nature and power of the source or sources;
b) Nature of the optical arrangements and the light distribution which they provide;
c) Light output ratio;
d) Whether the luminaire is open or closed type;
e) Resistance to heat, soiling and corrosion;
f) Protection against collection of dust and insects;
g) Resistance to atmospheric conditions;
h) Ease of installation and maintenance;
j) Presence or absence of auxiliaries; and
k) Fixing arrangements, the weight and area exposed to wind pressure.

The influence of all these factors varies according to local circumstances and it is difficult to recommend one solution rather than another, but the attention of lighting designers may be drawn to the fact that the most economical installation can be achieved only by the choice of the most suitable luminaire, selected according to the relative importance of the above mentioned factors. There is, however, one essential characteristic of luminaires the choice of which directly influences the quality of the lighting, that is, the general form of its distribution curves of luminous intensity particularly in directions near the usual directions of vision.

7.2.1 The following general forms of light distribution are considered according to the degree of glare which is acceptable:

a) Post top integral luminaires,
b) Post top non-integral luminaires,
c) Cut-off integral luminaires,
d) Cut-off non-integral luminaires,
e) Semi-cut-off integral.
f) Non-cut-off tubular luminaires, and
g) Flood-lighting luminaires.

7.2.1.1 *Cut-off luminaire*

A luminaire whose light distribution is characterised by a rapid reduction of luminous intensity in the region between 80° and the horizontal. The intensity at the horizontal should not exceed 10 cd per 1 000 lm of flux from the light sources and the intensity at 80° is of the order of 30 cd per 1 000 lm. The direction of the maximum intensity may vary but should be below 65°.

The principal advantage of the cut-off system is the reduction of glare and its use is favoured under the following conditions:

a) Matt carriageway surfaces;
b) Absence of buildings;
c) Presence of large trees;
d) Long straight sections;
e) Slight humps, bridges; and
f) Few intersections and obstructions.

7.2.1.2 *Semi-cut-off luminaire*

A luminaire whose light distribution is characterised by a less severe reduction in the intensity in the region 80° to 90°. The intensity at the horizontal should not exceed 50 cd per 1 000 lm of flux from the light sources (*see* Note) and the intensity at 80° is of the order of 1 000 cd per 1 000 lm. The direction of the maximum intensity may vary but should be below 75°. The principal advantage of the semi-cut-off system is a greater flexibility in siting, and its use is favoured under the following conditions:

a) Smooth carriageway surfaces;

b) Buildings close to carriageway, especially those of architectural interest; and
c) Many intersections and obstructions.

NOTE — Subject to a maximum value of 1 000 cd whatever is the luminous flux emitted.

7.2.1.3 *Non-cut-off luminaire*

A luminaire whose luminous intensity in directions making an angle equal to or greater than 80° from the downward vertical is not reduced materially and the intensity of which at the horizontal may exceed the values specified for the semi-cut-off distribution, but should not nevertheless exceed 1 000 cd. *Non-cut-off luminaires are permissible only when a certain amount of glare may be accepted and when the luminaires are of large size and of reduced brightness*. In certain cases they have some advantages in increasing the illumination of facades.

7.2.1.4 *Inclination*

Attention should be given to the inclination of luminaires. An upward inclination which is generally called for reasons of aesthetics, should be employed with care. Too great an inclination of the luminaire may modify, particularly in certain directions, the cut-off qualities of the luminaires and in certain situations (for example, when there are roads at several levels, bends, roundabouts, etc) this inclination may lead to unexpected glare.

8 GUIDELINES FOR SPECIFIC LOCATIONS

8.1 Several factors contribute to good public lighting and those are enumerated for guidance in various parts of IS 1944. Recommendations are made on the various components of design of public lighting installations and those require detailed calculations of the level and uniformity of illumination on the road surface and of glare. Several criteria may not be satisfied for want of data such as characteristics of surface, etc. To get some idea of the extent to which the installation would perform, it may be preferable to make a temporary trial installation of a few luminaires on a stretch of road to be lighted.

8.2 Tables 6 to 8 give a summary of recommendations on the various types of thoroughfares. These shall be used as ready reckoners, though for a detailed guidance reference should be made to the relevant part of IS 1944.

NOTE — Recommendations for Groups C, F and G lighting are under consideration.

9 POWER INSTALLATION REQUIREMENTS

9.1 The electrical design aspects of public lighting installations not only take into account the illumination principles, but also economic considerations giving allowance for cost of electrical control units, cable ducts, switching, etc.

Table 6 Lighting Installation in Group A and B Roads
(*Clause* 8.2)

Sl No. (1)	Description (2)		Group A1 (3)	Group A2 (4)	Group B1 (5)	Group B2 (6)
i)	Average level of illumination on road surface, lux		30	15	8	4
ii)	Ratio minimum/average illumination ratio		0.4	0.4	0.3	0.3
iii)	Transverse variation of illumination, percent		33	33	20	20
iv)	Type of luminaire:	Preferred	Cut-off	Cut-off	Cut-off or Semi-cut off	Cut-off or Semi-cut-off
		Permitted	Semi-cut-off	Semi-cut-off	Non-cut-off	Non-cut-off
v)	Mounting height, m		9-10	9-10	7.5-9	7.5-9
vi)	Maximum spacing of luminaire/height ratio		Cut-off = 3 Semi-cut-off = 3.5		Cut-off = 3 Semi-cut-off = 3.5 Non-cut-off = 4	

NOTES

1 In Group A lighting, the level and uniformity of illumination shall be as high as possible and the glare strictly reduced.

2 In Group B lighting, greater tolerances on uniformity and glare are admitted, which may be justified by the character of the roads and by the presence of facades.

3 Mounting heights less than 7.5 m are undesirable except in special cases, such as lighting of residential roads or roads bordered by trees.

Table 7 Lighting Installations in Group D Roads
(*Clause* 8.2)

Sl No. (1)			Description (2)		Remarks (3)
i)	A.		*Grade Separated Junctions*		
		1)	Lighting by conventional street lighting technique		
			Complex junctions:		
			a)	General principles	As in IS 1944 (Parts 1 and 2)
			b)	Mounting height, m	10-12
			c)	Luminaire	cut-off
			d)	Light sources	HPMV or HPSV lamps
		2)	Lighting by high-mast lighting		
			a)	Minimum service level value (lux)	30
			b)	Uniformity ratio $\frac{E_{Min}}{E_{Avg}}$	0.4
			c)	Height of masts, m	Not less than 20
			d)	Choice of luminaire	*see* IS 1944 (Parts 1 and 2)
ii)	B.		*Bridges*		
		1)	Short bridges (≤60 m)		Normal street lighting techniques with minor adjustments [*see* IS 1944 (Part 5)]
		2)	Long bridges (> 60 m)		*See* IS 1944 (Part 5)
		3)	Bridges of historical importance		Special considerations apply
		4)	Parapet lighting		
			a)	Mounting height, m	Not greater than 1
			b)	Separation between rows of lighting, m	Not greater than 12
			c)	Choice of lamps	Tubular fluorescent lamps, HPSV lamps or other linear sources of luminance weatherproof, dustproof, verminproof, robust
		5)	Foot-bridges		
			a)	Illumination, lux	Not less than 6
iii)	C.		*Elevated Roads*		
			a)	General lighting	Similar to heavy traffic roads
			b)	Choice of luminaire	Cut-off

9.1.1 *Lamps and Luminaires*

9.1.1.1 All lamps and luminaires and other fittings used in public lighting installations shall conform to the relevant Indian Standards.

9.2 Cables

9.2.1 Underground cables shall be laid for power supply to the street lamps. For roads under Groups A, B and D, separate mains shall be laid for group control of lamps on these roads. The street lighting cables shall be terminated in separate junction boxes or street lighting pillars. The pillars shall be provided with electrically operated contactors of suitable current rating. Auxiliary terminals of these contactors could provide facility of return indication in case of supervisory remote control. The contactor circuits shall be provided with externally mounted switches for local manual operation. A typical street lighting pillar with control circuit is shown in Fig. 9.

9.2.2 The cable circuits for each section of the roads shall be so designed as to prevent important section of the roads from being completely off in case of a fault on the underground cables. For roads under Groups A1, A2 and D, each stretch of road shall be lit by two independent circuits, preferably emanating from two separate street

Table 8 Lighting Installations in Group E Roads
(*Clause* 8.2)

Sl No. (1)	Description (2)	Remarks (3)
i)	*Main squares* [*see* IS 1944 (Part 6)]:	
	1) Average level of illumination, lux	20
	2) Mounting height, m	10-15
ii)	*Shopping streets/promenades*	Special considerations
iii)	*Pedestrian precincts*	
	1) Average horizontal illuminance (footway level), lux	20
	2) Average horizontal illuminance (under canopies), lux	50
	3) Mounting height, m	5-6
	4) Luminaires	Special considerations
iv)	*Public car parks* (*above ground*)	
	1) Average horizontal illuminance, lux	10
	2) Luminaires preferred	Floodlight luminaries on high masts
v)	*Pedestrian stairways/footbridges*	
	1) Average level of illuminance (surface of footbridge), lux	6
	2) Average level of illuminance (sub-ways), lux	10

lighting pillars. For junctions also, the lamps shall be divided into at least two circuits in such a way that in case of fault on one circuit the entire junction or a section of it does not become completely dark.

9.2.3 In case of roads in groups A, B and D, the cables shall preferably be terminated into the column junction boxes by looping rather than 'T' joints.

9.2.4 Underground cables of suitable sizes should be utilised for the purpose of control. The recommended sizes of the cables for various installation are shown in Table 9.

Table 9 Recommended Types and Sizes of Cables

Sl No. (1)	Road Group (2)	Minimum Size of Cables mm^2 (3)	Type of Cables (4)
i)	A1	16	3-phase, 4-core
ii)	A2	16	3-phase, 4-core
iii)	B1	16	3-phase, 4-core
iv)	B2	16	Single phase/3-phase, 4-core
v)	C	16	Single phase/3-phase, 4-core
vi)	D	16	3-phase, 4-core

9.2.5 The junction boxes with suitable sized contactors with independent fuses shall be provided for each phase. The contactors shall be controlled by electrically operated switches mounted for external manual/local operation.

9.3 Power Supply

The supply to the street lights may be either through overhead wires or underground cables. The supply to lamps on roads under Groups A, B and D, should preferably be by underground cables laid specially for street lighting purposes. In case overhead wires are employed these should also be suitable for street lighting purposes.

9.4 Control of Street Lighting Installations

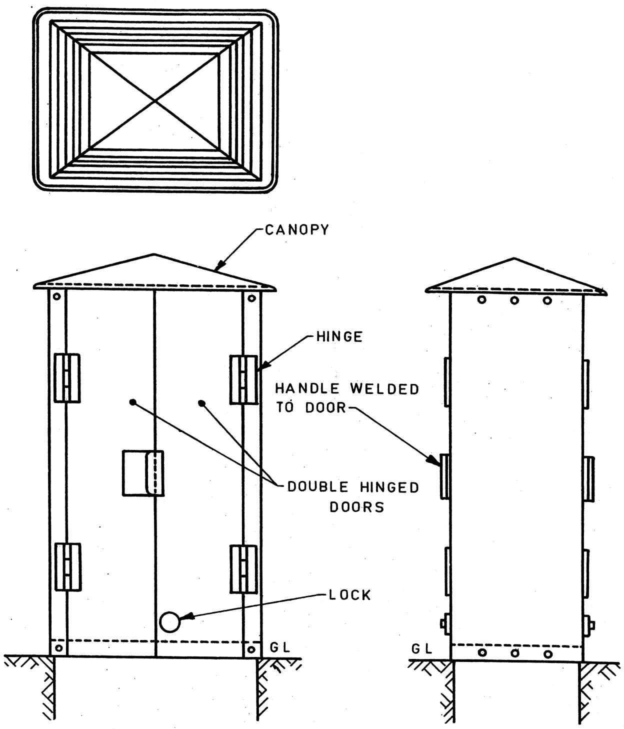
9.4.1 The contactors may be provided with additional circuitry for remote/automatic control. Following schemes for remote control are recommended:

a) *Special relay control* — This may be achieved by special control cables laid up to the street lighting pillar. Special relays operated by normal supply or electronic impulses may be provided. This scheme enables return indication of the operation by auxiliary contacts of the contactors.
b) *Ripple control* — This may be achieved by injecting audio frequency impulse through suitable power supply network and installing suitable sensors at control points.

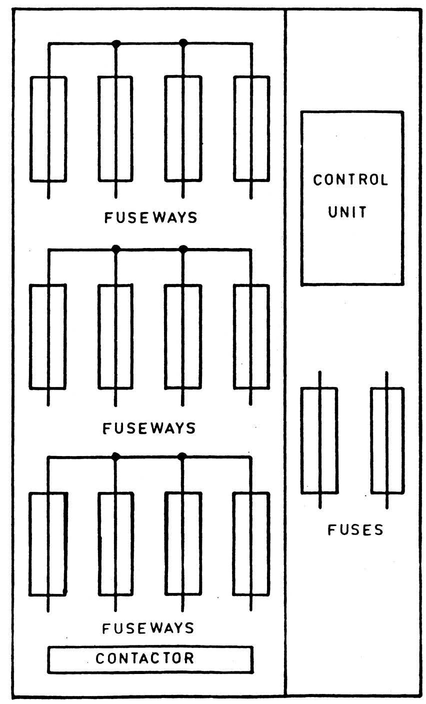
9.4.2 *Automatic Control*

The contactors may, alternately, be controlled automatically by use of auto-control devices. The following controls are recommended:

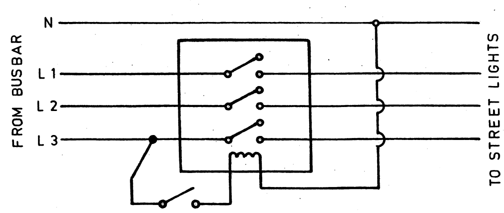
a) *Photoelectric control* — This may be achieved by installing suitably mounted photoelectric switches near the control points. The photoelectric switch shall be mounted so as to be free from the glare caused by headlights of motor vehicles and protected from the weather.
b) *Time Switches* — The local electrically operated contractors may be controlled through time switches. The time switches may be manually spring would or electrically operated. In case of electrical operation the time switches



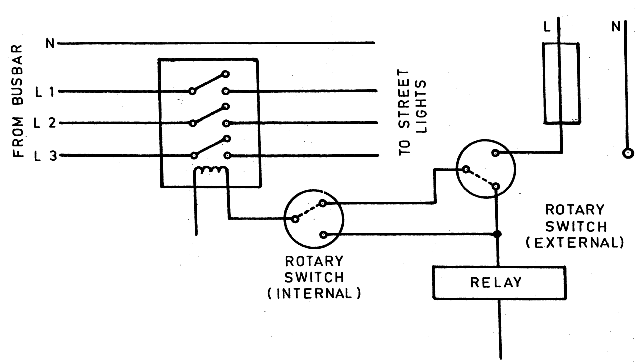
9A Typical Street Lighting Pillar



9B Inside Layout



9C Typical Contactor Wiring (Manual)



9D Typical Wiring For Remote/Auto Control

FIG. 9 A TYPICAL STREET LIGHTING PILLAR

should be of electrically-wound mechanically-operated variety so as to prevent their being affected by variations in supply frequency. However, these would need to be regulated from time to time due to seasonal variations.

c) *Electronic Control Switches* — It should be possible to install pre-programmed electronic micro-processors, with one year seasonal variations. These could be installed for each individual lamp. With suitable design these could also be utilised to switch off unwanted lights after peak traffic hours are over.

8.4.3 *Black-out Control* — Black-out control may be required to be adopted in case of war in vulnerable areas. This could be achieved by either of the following schemes:

a) *Remote Control* — Special control cables are laid (alternatively, use of telephone cables) to give control impulse to group control points. The control could then be utilised to switch off the lamps instantaneously on demand by civil defence authorities.
b) *Ripple Control* — In case special control cables are not available, ripple control equipment could be used with suitable sensing devices at the control points. When the need arises, the entire area could be switched off by ripple control impulse.
c) *UHF control* — Electronic relays responding to pre-determined control frequency could be installed at each switching point. This could be programmed to switch off on demand by a pre-determined control frequency signal.

9.4.4 *Brown-out Control*

Brown-out control is necessary in vulnerable cities with heavy vehicular traffic at the time of war, where complete black-out is not practicable. Even in such cases, complete black-out would be necessary at the time of possible air raids. Following alternatives for brown-out control are recommended:

a) *Voltage control* — This could be advantageously adopted in areas where the source of lighting is filament lamp. Applying reduced voltage to such lamps would automatically reduce the illumination to any desired level. In case of discharge lamps this scheme would not be suitable.
b) *Ripple control* — In case ripple control is adopted, it would be possible to programme alternate (or any other combination) lamps to respond to specified ripple control signals. In case of necessity, brown-out could be effected by switching off alternate lamps and complete black-out by switching off all the lamps.
c) *Multiple Lamp Luminaires* — On main roads the luminaires adopted could have two or more lamps, each controlled either by different phase or by separate ripple control signals. In case of necessity, either one or two phases could be switched off, or alternately alternate lamps be switched off by suitable ripple control signals.
d) *Replacement of lamps* — In case of prolonged brown-out operations, the wattage of the lamps could be reduced by replacing the same with lower wattage lamps. This, though could not be achieved on short notice is recommended in case of prolonged operations.

10 MISCELLANEOUS CONSIDERATIONS

10.1 Aesthetics

The aesthetics of a lighting installation are principally judged by day. Half of the time, the lighting installation serves no useful purpose; an attractive or at least a non-disturbing daytime appearance which harmonises well with the surroundings is, therefore, of great importance. Aesthetic considerations should relate to the unit formed by the luminaire and its support and the situation in which it is placed.

Firstly, the unit formed by the luminaire and its support should be considered. Secondly, the siting of the luminaires in the scene may lead to unpleasant effects even if the luminaires themselves considered in isolation, are aesthetic.

There are no simple or universal rules for aesthetically satisfactory design and layout since every city, town and village has its own character and what may look well in one place may be incongruous in another.

The points of general application are:

a) Design and siting;
b) Columns and surroundings:
c) Size and type of luminaire;
d) Form of bracket;
e) Assembly of column, bracket and luminaire;
f) Arrays of luminaires; and
g) Material and colour.

10.2 Lighting Columns as Hazards

A motor vehicle involved in an accident frequently leaves the carriageway and the probability of this happening increases with the speed of the vehicle. If the vehicle collides with a lighting column the severity of injuries to the occupants is likely to be increased. There is evidence to suggest that the number of such collisions decreases with the increase of distance of the column from the edge of the carriageway.

Normally the clearance between column and carriageway should be at least 1.5 m. Where there is a footway close to the carriageway, the column should be sited behind the footway. In exceptional cases a smaller clearance may be used.

ANNEX A

(*Clause* 4.1)

TYPES OF ROADS

Sl No. (1)	*Term* (2)	*Description of Type of Road* (3)
i)	Road	A general term denoting any public way for purposes of vehicular traffic
ii)	Street	A road which has become partly or wholly defined by buildings along one or both frontages
iii)	Motorway	A road reserved for motor traffic, accessible only from interchanges and on which, in particular, stopping and parking are prohibited. Roads of this type should have two or several separate and one-way carriageways
iv)	Express road	A road similar to, but lacking some feature of a motorway, for example: a) not dual-carriageway b) not fully access-controlled c) not all intersections grade-separated
v)	All purpose road	Road usable by all traffic (including pedestrians and cyclists) Used to distinguish other roads from motorways
vi)	Trunk road/ Major road	A main route in the through com munication system of a country
vii)	Minor road	A road which has, or to which is assigned, a lesser traffic value than that of a major road
viii)	Ring road	A road round an urban area enabling traffic to avoid the urban centre
ix)	Radial road	A road providing direct communication between the centre of an urban area and the outer districts
x)	Commercial street	Street with frontages comprising a high proportion of commercial premises (usually unlit at night), and with a high proportion of heavy goods vehicles in the traffic stream
xi)	Shopping street	Street with frontages comprising a high proportion of shops or other premises which may be lit at night and with heavy pedestrian (and possibly pedal cycle) traffic
xii)	Resident street	Street with the majority of frontages comprising private houses
xiii)	Collector road/ Distributor road	A link between the radial or ring roads and the local access streets
xiv)	Local street	Street giving direct access to buildings and land with a minimum of through traffic
xv)	Service road	A subsidiary road between principle road and buildings or properties facing thereon or a parallel road to the principal road and giving access to the premises and connected only at selected points with the principle road
xvi)	Footway	That portion of a road reserved exclusively for pedestrians
xvii)	Cycle track	A way, or part of a road, reserved for use only by bicycles

SECTION 2 TEMPORARY OUTDOOR INSTALLATIONS

0 FOREWORD

Electrical installations are often required to be designed and erected for use for short periods of time ranging from a few hours to few months and are connected to the supply source in open ground. Such installations are generally unprotected from environmental hazards as compared to installations in buildings.

The major risks in the use of power in such installation arise from short circuit resulting in fire accidents and exposure to live wire resulting in shock. It is, therefore, imperative to lay down the necessary precautions to be observed for such installations from the point of view of safety.

Temporary installations covered in this section are enumerated in **5** and are classified based on the duration of their existence in use. It may be noted that this section basically intends to lay down additional safety measures to be adopted in the design of temporary installations, and the general guidelines for outdoor installations under heavy conditions from the point of view of selection and use of equipment given in Part 5/Section 3 shall also be referred to.

1 SCOPE

This Part 5/Section 2 of the Code covers the requirements for outdoor electrical installations of temporary use.

2 REFERENCES

This Part 5/Section 2 of the code should be read in conjunction with the following Indian Standards:

IS No.	*Title*
5613 (Part 1/ Sec 1) : 1985	Code of practice for design, installation and maintenance of overhead power lines: Part 1 Lines up to and including 11 kV, Section 1 Design
5613 (Part 1/ Sec 2) : 1985	Code of practice for design, installation and maintenance of overhead power lines: Part 1 Lines upto and including 11 kV, Section 2 Installation and maintenance
SP 7 : 2005	National Building Code of India

3 TERMINOLOGY

For the purpose of this Section 2, the following definition in addition to those given in Part 1/Section 2 of this Code shall apply.

3.1 Temporary Installations (Outdoor) — An electrical installation open to sky or partially covered, intended to be used for a temporary period not exceeding 6 months.

NOTE — In special cases, the guidelines specified in this Section shall be applicable for longer durations subject to fresh inspection and tests with the prior approval of the supply authority (*see also* **9.3**).

4 CLASSIFICATION

4.1 The temporary outdoor electrical installations covered in this Section are those intended for the following purposes:

a) *Temporary installations for durations not exceeding* 6 *months* — Outdoor installations open to sky or partially covered, erected in the vicinity of construction sites solely for the purposes of supplying the electrical needs of building construction work such as lighting and power loads.

NOTES

1 Construction site installations for very long periods of times, where the equipment are quite similar to those in heavy conditions shall conform to the requirements in Part 5/Sec 3 of this Code.

2 Construction site installations are those which include sites where the following are carried out:

a) Construction of new building;
b) Works of repair, alternation, extension or demolition of existing buildings; and
c) Public engineering works.

The construction site installations are also characterised by frequent modifications.

b) *Temporary installations for durations not exceeding* 45 *days* — These include fairly large loads such as for exhibitions, fairs, etc.

NOTE — Exhibition or fair site lighting installations of the permanent type shall conform to the requirements specified in Part 5/Section 1 of this Code.

c) *Temporary installations for durations not exceeding* 7 *days* — These include installations site of temporary nature intended for a week long public function or outdoor lighting installations of buildings and parts in view of festival and other reasons.

d) *Temporary installations for durations not exceeding* 24 *hours* — These include temporary installations which cater to loads for the purposes of marriages, reception, religious and other public function, etc.

5 GENERAL CHARACTERISTICS OF TEMPORARY INSTALLATIONS

General guidelines on the assessment of characteristics of installations in buildings are given in Part 1/Sec 8 of this Code. For the purposes of installations falling under the scope of this section, the characteristics defined below generally apply.

5.1 Environment

The following environmental factors shall apply to temporary outdoor installations:

Environment (1)	*Characteristics* (2)	*Remarks* (3)
Presence of water	Possibility of splashes from any direction	External lighting fittings, construction site equipment, etc
	Possibility of jets of water in any direction	Temporary installations in parts
	Partial or total covering by water	
Presence of foreign solid bodies	Presence of small objects	
	Presence of dust in significant quantity	
Impact	High severity	Construction demolition sites
Vibrations	Medium severity	Constructions, demolitions sites
Presence of flora/mould growth	No harmful hazard	
Presence of fauna	Hazard from fauna (insects, birds, small animals)	
Solar radiation	Solar radiation of harmful intensity and/or duration	
Seismic effects	—	Depends on the location of the installation
Lighting	Hazard from exposure of equipment	Generally applicable for installations located outdoors

5.2 Utilization

The following factors of utilization apply:

Utilisation (1)	*Characteristics* (2)	*Remarks* (3)
Capability of persons	Uninstructed persons	Majority of occupants say in an exhibitions circus fairs
	Instructed persons adequately advised or supervised by skilled persons	Applies to operating staff
Contact of persons with earth potential	Frequent	Construction sites
Conditions of evacuation during emergency	Low density occupation easy conditions of evacuation	Small gatherings, such as for marriages and similar functions
	High density occupation, difficult conditions of evacuation	Circus, large public gatherings inside an enclosure, etc.
Nature of processed	Fire risk	*Shamianahs*, tents
Construction of structure	Combustible	The nature of construction materials used in temporary installations may be combustible. Such as wooden cloth structures in tents
	Structural design flexible or unstable	Structures which are weak or subject to movement, such as tents, removable partitions etc.

6 GENERAL REQUIREMENTS FOR TEMPORARY OUTDOOR INSTALLATIONS

6.1 Temporary installation shall in general conform to the requirements stipulated in the relevant Section of Part 1 of this Code, in respect wiring of circuits, location and installation of equipment, etc. Additional requirements are given in **7** *(see also* SP 7).

6.2 If the equipment used in temporary and provisional places of work in the open, such as building sites are similar to those used in surface mining applications, references shall be made to the guidelines contained in Part 5/Section 3 of this Code.

7 ADDITIONAL REQUIREMENTS FOR TEMPORARY OUTDOOR INSTALLATIONS

7.1 Supply Intake Arrangements

7.1.0 The type of outdoor installations will depend on the magnitude and duration of the installation. Depending on the availability of spare capacity, of the existing distribution system, the supply intake arrangements could be through either of the following:

a) A HV feeder,
b) A HV feeder and step-down transformer,
c) A service line at voltages below 250 V, or
d) A tapping form one of the existing service connection.

One construction site may be served by several sources of supply, including fixed or mobile power generators. All the circuits supplied from the same point of supply comprise one installation and it is important to clearly differentiate them; in particular, a single distribution point, cabinet or distribution board shall consist of only components belonging to one and the same installation except for circuits for standby supplies, signalling or control.

7.1.1 *Commissioning of Substation*

In case the loads at construction sites or to exhibitions, circuses, etc, are large and the power supply authority has no network in the vicinity of the temporary installation that could be utilised then it would be necessary to establish a temporary substation where the switchgear and transformer can be installed. The substation site shall be so selected that it is as close to the load centre as possible.

The power supply authority's line should be brought up to the substation in a separate enclosure. If overhead line is laid up to the temporary substation, then the supporting poles, conductors, materials of the line, insulation and the method of stringing the conductors and the mechanical strength of the line as a whole shall conform to the relevant provisions of IS 5613 (Part 1/ Section 1) and IS 5613 (Part 1/Section 2). In case supply at voltages above 650 V is required, a suitable enclosure to install the switchgear and the metering arrangement shall also be erected.

7.1.2 *Power Distribution*

7.1.2.1 At the origin of each installation a unit containing the main control gear and the principal protective device shall be provided. The main switch shall be installed in an earthed metallic enclosure and as close to the metering point as possible (*see also* **7.2.1.1**).

7.1.2.2 Means of emergency switching shall be provided on the supply to all current using equipment on which it may be necessary to disconnect all live conductors in order to remove a hazard.

7.1.2.3 The enclosure or the cupboard in which the main-switch is installed shall be such that the equipment within shall be unaffected by the environmental conditions (*see* **5.1**).

7.1.2.4 The main switch on the installation shall be connected to the point of supply by means of an armoured cable or insulated wires and the termination of this cable shall be adequately protected from rain water.

7.1.2.5 The main switches shall be located at a height not exceeding 1.5 m so as to be accessible in emergencies.

7.1.2.6 The cable shall be laid either underground or supported in the air. Precautions shall be taken to ensure that this cable when laid underground is done so with the same meticulous care as is, done for a permanent installation. In case the cable passes underneath the passages, it shall be laid in whole or split pipes. When laid over ground, the cables shall either be cleated with saddles of proper size along the walls of a permanent structure if available, or alternatively, it shall be supported on rigid poles. The height of the cable shall not be less than 2 m when run inside the compound and at least 5 m when run along or across road. Crossing of the road shall preferably be avoided. An independent earthing shall be established inside the installation premises. In case overhead wires are used in the installation they should conform to the relevant Indian Standards mentioned in **7.1.1**.

7.1.2.7 In selecting the equipment and cables, the rating shall be decided taking the environmental conditions into account.

7.1.2.8 The supply intake point shall be placed outside the periphery of area which is accessible to the general public.

7.1.2.9 In cities, towns and thickly populated localities, it is advisable to wire up the installation with insulated wires including for main circuits in open compounds or running along or across roads. For main circuits, cables shall be used, preferably laid underground. Alternatively, they shall be cleated along the walls of structures with proper saddles. When laid underground, the cable shall be laid at a depth of 900 mm, covered with sand, bricks and earth for providing mechanical protection.

7.1.2.10 For temporary installations in cities and towns for purposes described under **4.1**(b), (c) and (d), bare conductors shall not be used. Only in the case of load for purposes mentioned under **4.1**(a) especially outside cities and town bare conductors are permitted.

7.1.2.11 In cities and towns, if the premises where temporary electric supply required is isolated, then:

a) mixed wiring of insulated and bare conductor — overhead wiring, and
b) mixed wiring, partly underground and partly overhead may be used.

In such an event, the underground part of the installation and the overhead part of the installation shall separately conform to the requirements as mentioned in this Section.

7.2 Control of Circuits

7.2.1 *Main Circuit*

7.2.1.1 A device shall be provided on the incoming cable to each supply unit and each distribution unit for switching and isolating. With this type of arrangement it shall be possible to switch off the supply at the intake point or at the distribution point.

7.2.1.2 The main switch shall be adequately protected from ingress of water. The incoming and outgoing cable/wires of the main switch shall be firmly supported so that cable and wire ends connected to the main switch shall not be subjected to any mechanical force, transmitted to it from any portion of the cables and wires.

7.2.1.3 The main switch shall be installed on a firm and vertical surface, which can withstand the mechanical vibrations created at the installation site as well as the wind pressure at the location.

7.2.1.4 There shall be adequate ventilation in the room where main switches are installed and there shall be operational space around the switch in accordance with good practice. The switch room shall be accessible at any time of the day or night to authorised persons.

7.2.2 *Sub-circuit*

7.2.2.1 On large temporary installations like those on construction sites, at exhibitions, circuses, etc, the outgoing end of the main switch shall be connected to busbar of adequate size and various sub-circuits shall be connected to this busbar through double or triple pole switches, depending upon whether they are single phase or 3 phase circuits. The switches shall be mounted on a firm support and shall be at a height between 1 m and 2 m from the floor level. The sub circuit switch shall be so spaced that there shall be a minimum clear distance of 60 mm between the switches for ease of operation.

7.2.2.2 The outgoing wires from the sub-circuit switches inside the enclosure shall be cleated firmly on wooden battens or taken through conduits which are fixed by means of saddles to the masonry wall or wooden partition wall. The lead wires connected to the sub circuits switches shall be suitably supported on wall with clips and shall not be left hanging. Spans more than 2 m shall have guide wire support.

7.2.2.3 The distribution boards the sub-circuits shall be at an accessible height but not less than 1 m. The distribution boards shall be fixed on firm supports or on pole firmly planted in the ground.

7.2.2.4 Taped joints shall not be used at heights less than 3 m. The taped joints shall be properly supported and preferably clamped on either side of the joint so that the joint is not subject to a strain. For series lights used for decorative purposes no taped joint shall be used.

7.2.2.5 A broken bulb of a lamp in a series circuit is a risk and therefore series lamps shall not be strung or hung at heights less than 3 m. A defective series lamp shall not be allowed to remain in its position and shall be immediately removed.

7.2.2.6 *Installation at construction sites*

The entire area where the temporary supply will be used, shall be indicated beforehand and in case the electric supply is required at construction site for pipe lines, then a drawing may also be given to the electric supply authority. On this drawing various points from where different appliances/equipment are intended to be used, may also be indicated. All switches, sockets and fixed appliances shall be protected from rain by enclosing these in cubicles. Sub-circuit distribution board shall be installed, at a place where it is safe from atmospheric conditions. If such a place is not available, the distribution board shall be placed in a cubicle. In a 3 phase circuit the loads on the 3 phases shall be balanced. At the point of supply the load on the neutral shall not be more than 20 percent of the computed value of the load in the phases.

7.2.3 *Earthing*

7.2.3.1 All appliances and equipment on temporary installation shall be connected to a system of duplicate earthing—one of the power supply Authority and one local. Wherever armoured cables are used, the armouring shall be connected to earthing arrangement of power supply Authority. For local earthing, an independent earth continuity wire shall be used.

7.2.3.2 For local earthing the earth electrode shall be buried near the supply intake point. The earth continuity wire shall be bare round conductors/strips and shall be a single core insulated wire and shall be connected to the local earth plate and taken along the cable connecting the supply intake point and the main switch in the installation. The connection from this earth continuity wire shall be taken to various sub-distribution boards and terminated on a busbar. All appliances and equipment connected to sub-distribution board shall get their duplicate earth connection from the earth continuity busbar on the sub-distribution board.

8 PROTECTION AND SAFETY

8.1 The installation as a whole shall be protected against overload, short circuit and earth leakage by suitable protective devices.

8.2 Temporary supply is generally used at public places and for public functions and, therefore, extreme care shall be taken to ensure that there is no risk of any type of hazard either from electrical shock or fire.

No flammable material shall be stored near the service intake point or the operational area of electrical equipment or appliances. For large public functions, exhibitions, etc, suitable fire extinguishers shall be kept at the supply intake point and near the main switch of the installation.

In construction sites, protection of persons against indirect contact shall be assured by automatic disconnection of supply appropriate to the system of earthing. Socket outlet shall either be protected by residual current devices having operating current not exceeding 30 mA or be supplied by safety extra-low voltage or electrical separation of circuit each socket outlet being supplied by a separate transformer.

9 TESTING AND COMMISSIONING

9.1 Supply to all temporary installations should be connected by a specific date for the user and therefore the installation work meant for types of installations in **4.1**(a), (b) and (c) shall be ready at least 24 h prior to connection of supply, so as to properly test the installation and find the loads in different sub-circuits. In the case of installation described in **4.1**(c) there should be a period of at least 6 h after completion of the work and prior to connecting supply for the purpose of testing the installation and visual inspection.

9.2 The various tests on the installation shall be carried out as laid down in Part 1/Section 10 of this Code.

9.3 When the specified duration of use of the installation as defined in **3.1** is required to be extended beyond the stipulated period of 6 months, the guidelines specified in this Section shall be applicable subject to fresh inspection and tests as above, with the prior approval of the supply authority.

SECTION 3 PERMANENT OUTDOOR INSTALLATIONS

0 FOREWORD

Outdoor installations of the permanent nature require special treatment as compared to temporary installations of short durations (less than 6 months) primarily owing to the continuous exposure of the former installation and equipment forming part of it to heavy conditions of service at site. The design and selection of equipment and components have to take into consideration the expected loading, operating characteristics and cycle duty, as well as the special and arduous environmental, operational, transportation and storage conditions.

This Section of the Code attempts to cover the general requirements applicable to equipment and auxiliaries for a variety of permanent outdoor site installations which are enumerated in **4**. It is intended to provide necessary guidelines for such installations in this Section for the purposes of the practicing engineers and the relevant authorities.

The general characteristics of permanent outdoor installations are enumerated in **5**. The object of this Section is to set out the guiding principles so as to ensure the safety of persons, livestock, property and the proper functioning.

In the preparation of this Section considerable assistance has been derived from IEC 60621 : 1987 'Electrical installations for outdoor sites under heavy conditions including open-cast mines and quarries', issued by the International Electrotechnical Commission.

1 SCOPE

1.1 This Part 5/Section 3 of this Code covers requirements for permanent outdoor installations, for operations of equipment and machinery therein used for the purposes such as:

a) Winning, stacking and primary processing;
b) Secondary processing;
c) Transport conveying;
d) Associated pumping and water supply systems;
e) Haulage trucks;
f) Power generating and distribution systems;
g) Control, signal supervisory and communication system; and
h) Ancillaries.

1.2 This Section does not cover temporary and provisional places of work of durations less than 6 months for which reference shall be made to Part 5/ Section 2 of this Code.

NOTE — However this Section shall be applicable to building sites and earth-moving sites as far as the equipment used therein are similar to those used in surface mining application.

2 REFERENCES

This Part 5/Section 3 of this Code should be read in conjunction with the following Indian Standards:

IS No.	*Title*
1255 : 1983	Code of practice for installation and maintenance of paper insulated power cables (up to and including 33 kV)
10028 (Part 2) : 1981	Code of practice for selection, installation and maintenance of transformers : Part 2 Installation
IS/IEC 60947 (Part 1) : 2003	Specification for low voltage switchgear and controlgear: Part 1 General rules

3 TERMINOLOGY

3.0 For the purpose of this Section, the definitions given in Part 1 along with the following shall apply:

3.1 Operations (Electrical) — The process of performing work through the controlled application of electrical power. This process includes:

a) *Operating* —which means, switching, adjusting, controlling and supervision,
b) *Servicing* — which means maintenance, alterations, removal of faults and testing.

3.2 Operating Area — An area accessible to operating personnel in the normal performance of their duties.

3.3 Electrical Operating Area — An area accessible only by the opening of a door or the removal of a barrier. The area shall be clearly and visibly marked by appropriate signs.

3.4 Closed Electrical Operating Area — An area accessible only through the use of a tool or key the area shall be clearly and visibly marked by appropriate signs.

3.5 Working Level (Bench) — That part of an open-cut mine or quarry on which machinery and/or rolling stock are in operation. The working level and/or working area may change location with the progress of operations.

3.6 Winning and Stacking Machinery — Winning and stacking machines are used in the process of uncovering or detaching materials from the earth's surface or stacking such material. These machines are designed to be able to change location according to operational requirements. They include the following:

a) Excavators, namely: bucket-wheel excavators, bucket-chain excavators, draglines, shovels and other excavators, reclaimers, ditch bunker loaders, etc;
b) Spreaders and stackers;
c) Mobile conveyor bridges;
d) Mobile conveyors, including tripper carriages;
e) Loading stations, including hoppers and surge bins;
f) Floating dredgers; and
g) Mobile electric drills.

3.7 Transport Conveying System — A movable or stationary mechanical item of plant designed for the conveying of materials continuously from one location to another.

They include the following:

a) Belt conveyors,
b) Chain conveyors,
c) Bucket conveyors,
d) Paddle or scraper conveyors,
e) Screw conveyors, and
f) Hydraulic conveyors systems.

3.8 Primary Processing Machinery — Any machinery necessary to prepare material won from the earth prior to its transport to the final processing or utilization areas.

3.9 Secondary Processing Machinery — Any machinery necessary to process at a point remote from the open cut or quarry, material won from the earth.

3.10 Fixed Apparatus — An apparatus or assembly of apparatus which is permanently installed in a determined place and which is not normally moved during or between periods of use.

3.11 Portable Apparatus — An apparatus or assembly of apparatus intended to be normally held in the hand during use and which can be carried by a person.

NOTE — Cables are not included as part of apparatus.

3.12 Mobile Apparatus — An apparatus or assembly of apparatus which is too heavy to be portable but which is capable of being moved without discontinuity of electric power during use.

3.13 Movable Apparatus — An apparatus or assembly of apparatus which is too heavy to be portable, but which is moved between periods of use, with its electric power source disconnected.

3.14 Haulage Truck — An electrically powered vehicle usually operating on rubber tyres used for transport of materials and which may have a self-contained or external power supply.

3.15 Movable Railway System — A railway system which is designed to be movable to another location without dismantling.

3.16 Self-Contained Power Supply — An electrical installation in which the generation and utilization plants are housed within the same structure.

3.17 External Power Supply — An electrical installation in which the generation and utilization plants are not housed within the same structure.

3.18 Exposed Conductive Part — A conductive part which can be touched readily and which normally is not live but which may become live under fault conditions.

NOTE — Typical exposed conductive parts are walls of enclosures, operating handles, etc.

3.19 Earthable Point — That point of the power system, for example, of the transformer and/or generator, which would be connected to earth if the system were to be earthed.

NOTE — The earthable point may be the neutral point depending on the type of power system.

3.20 Insulation Monitoring and Warning Device — A device which causes a signal to be given in the event of reduced insulation resistance to earth.

3.21 Movable Distribution Cable — An insulated cable that may be moved from time to time according to the operation without necessarily following the movements of the machinery.

3.22 Drum Cable — An insulated cable specially designed to be frequently reeled on and off a cable drum or reeler mounted on a mobile machine.

3.23 Trailing Cable — An insulated cable specially designed to be towed by a mobile machine.

3.24 Overhead Traction (Trolley) Wire — An electric line having bare conductors used for supplying vehicles (for example, locomotives) by means of a collector or pantograph.

3.25 Overhead Traction Distribution Line (Feeder) — An electric line having bare conductors used for the interconnecting line between the power source and traction wire.

3.26 Overhead Collector Wire — An electric line used for supplying moving machinery, such as a reclaimer, by means of a collector.

3.27 Overhead Distribution Line (Feeder) — An interconnecting electric line between distribution substation and load point.

3.28 Return Conductors — Conductors (which may be rails) used for carrying the return current.

3.29 Safety Circuits and Devices — Circuits and devices designed to prevent danger to personnel or livestock and damage to plant in the event of abnormal or unintentional operation.

4 TYPES OF PERMANENT OUTDOOR INSTALLATIONS

The types of permanent outdoor installations covered by this Section are given in **4.1**. The general characteristics and service conditions enumerated in **5.1** cannot be made uniformly applicable to all such installations. Depending on the site conditions and the nature of the operation involved, a judicious estimate has to be made of the environmental factors that influence the performance of the installation.

4.1 The following are the types of permanent outdoor installations covered by this Section:

a) *Open-cut or open-cast mine* — An open air site for the extraction of materials or minerals such as coal, bauxite, iron-ore, etc.

   NOTE — Underground mines are excluded from the scope of this Section. However surface installations of underground mines are covered by this Section, to the extent that the operations therein are identical with those described in **1.1**.

b) *Quarry* — An open air site for the extraction of materials such as limestone, gravel, clay, etc.

c) *Dockyards* — Includes loading and unloading areas, container terminal, railway yards, repair docks, passenger berths, jetty's, etc.

d) *Airport aprons* — A defined area on a land aerodrome, intended to accommodate aircraft for the purposes of loading and unloading passengers, mail or cargo, refuelling parking or maintenance.

e) *Railway marshalling yards* — A yard with facilities for receiving classifying and dispatching railway rolling stock.

5 GENERAL CHARACTERISTICS OF PERMANENT OUTDOOR INSTALLATIONS

The design and the selection of components shall be on the basis of expected loading, operating characteristics and cyclic duty taking into consideration the protection required in special and arduous environmental, operational, transportation and storage conditions.

5.1 Some of these conditions, are listed below which may differ from their normal values:

a) Altitude;
b) Low and/or high ambient temperature;
c) Supply voltage variations;
d) Supply frequency variations;
e) Insecure power supply and transients;
f) High or low humidity;
g) Environment (dust, wind pressure, marine atmosphere, etc);
h) Flammable and/or explosive material/or atmosphere;
j) Vermin, including rodents or other small animals;
k) Localities prone to natural calamities; and
m) Ecological impact.

6 RULES FOR EQUIPMENT AND AUXILIARIES

6.0 General

6.0.1 *Exchange of Information*

Before ordering electrical equipment for outdoor sites, information regarding the duties, location and installation conditions under which they would operate, should be gathered by the engineers responsible for their procurement, installation and maintenance so that the electrical equipment or apparatus is procured to suit those conditions. Necessity for special measures may be decided in consultation with all concerned.

6.0.2 *Relevant Standards*

The electrical specifications of all components shall be not less than that required by the relevant Indian Standard.

6.0.3 *Materials*

Materials used in component construction shall be appropriate for the environmental conditions, including temperature, altitude, moisture, etc.

6.0.4 *Protection*

Protection shall be provided against damage and/or overheating during normal operation or in expected fault conditions.

6.0.5 *Operating Conditions*

Components shall be designed to meet such conditions as vibration, acceleration, deceleration, slewing and angles of inclination (tilting and mounting) which may occur under expected operational conditions.

6.0.6 *Site Conditions*

Components shall be installed so that design features such as cooling systems shall not be impaired by external factors such as position, blocking of ventilation ducts, hostile environment, etc.

6.0.7 *Combustible Materials*

If combustible material (for example, gas, dust or liquid) is present in such quantity as to create a hazard and contact is possible between any exposed part of the component and the combustible material, the temperature of the exposed part shall not exceed the limits specified in Part 7 of this Code.

6.0.8 *Noise Limitations*

Consideration shall be given in the design to limit the noise level in accordance with local rules.

6.1 Selection of Equipment and Ancillaries

6.1.1 *Rotating Machines*

Rotating machines used in applications where high acceleration, overspeed, reversing or braking may be employed shall be so selected that they are capable of withstanding the expected stresses on parts such as rotor windings or cages, stators, stator end windings, shafts and couplings, rotating machines shall be so located or guarded to prevent inadvertent contact with moving parts.

6.1.2 *Transformers*

Transformers shall be so selected that:

a) the bracing of the core, coils, internal leads and the tank of transformers on mobile and movable installations are capable of withstanding vibrations;
b) they are totally enclosed; and
c) dry type transformers including cooling system are protected against harmful ingress of dust.

The following additional protective measures are suggested from fire:

a) Use of dry type transformers,
b) Use of flame-retardant cooling medium, and
c) Protective measures as specified in IS 10028 (Part 2) for transformers with flammable cooling medium.

Adequate precautions shall be taken to prevent spillage of the cooling medium causing pollution.

6.1.3 *Static Converters*

The following precautions are recommended:

a) Protection against harmful effects of over-voltage, and transient over-voltage conditions;
b) Protection against interference with communication or electrical control equipment;
c) Protection against spurious operation due to electrical coupling with other apparatus;
d) Protection against interaction between earthing systems of the input, output and control circuits;
e) Feedback supervision, where necessary; and
f) Measures to limit harmonics.

6.1.4 *Switching Devices*

The following measures are recommended for switching devices for outdoor sites:

a) Selection of proper design that no unintentional switching may be caused under expected operational and risk conditions;
b) Ensuring, where required suitable means to enable isolators to be locked;
c) Suitable labelling of switching devices which are not meant for interrupting load or fault currents; and
d) Suitable installation precautions to prevent hazards to personnel from electric areas, automatic movement of the mechanism, etc.

6.1.5 *Cables*

6.1.5.1 *Phase conductors*

Selection of phase conductor size should take into consideration the expected load current, short-circuit current and duration of fault, voltage drop and the mechanical strength required for the expected method of handling. The voltage drop should be calculated for both starting and maximum load conditions. Where supplying cyclic loads, the current-carrying capacity should be based on the long time (for example, 10 min) rms current expected.

6.1.5.2 *Protective conductor*

All multicore cables of the movable distribution, drum and trailing types, shall contain a protective conductor. In high voltage systems, special measures shall be taken to guard against deterioration of the earthing circuit. This may be achieved by either:

a) monitoring the protective conductor against increase in resistance by the use of pilot cores, high frequency monitoring or other means, or
b) cables should be specially designed and used in accordance with the requirements of relevant Indian Standard whether or not they are used on a drum.

The protective conductor may be in the form of core(s) and/or screen(s).

For certain classes of movable distribution cables, the armouring may, subject to the requirements of **6.1.5.3**, form the protective conductor.

6.1.5.3 *Armouring as protective conductor*

Where the cross-sectional area of a single composite strand of the armouring is greater than 6 mm^2, the metallic armouring of a movable distribution cable may be used as a protective conductor provided that the security against breakage of the armouring (taking into account strength, elongation, lay, etc) is at least equal to that of all the conductors; and provided that the armour conductivity is at least equal to that of a protective conductor of the required nominal cross-sectional area which would otherwise be required.

6.1.5.4 *Limiting temperatures under short circuit*

Cables shall be selected so as to ensure that the maximum allowable conductor temperature, considering the type of insulation, is not exceeded under expected short-circuit fault conditions.

6.1.5.5 *Protection against partial discharge*

For flexible cables having nominal voltages greater than 3.8/6.6 kV, measures shall be provided to minimize internal partial discharge or to render such effects harmless (for example, field gradient control).

Suitable protective measures shall be applied to reduce the touch and step voltages. Such measures may consist of:

a) metallic screens, or
b) substantial semi-conductive elements in contact with the protective conductor.

6.1.5.6 *Semi-conducting layers*

Where cables are fitted with substantial longitudinal semi conducting layers for the purpose of providing a current path to the protective conductor in the event of a fault, the resistance between the semi conducting element and the protective conductor should be tested to ensure that it is suitable to carry the prospective fault current.

6.1.5.7 *Provision of screens and/or armouring for cables above 1 000 V*

Where flexible cables are handled manually while energized, they shall have metallic screens and/or armouring or shall be provided with conducting elastomeric screens of substantial cross-sectional area and so placed as to limit the touch and step voltages that may arise in the event of a cable fault.

In cases where cables are handled only by means of special insulated tools, these requirements shall apply only for voltages above 3.8/6.6 kV.

6.1.5.8 *Identification of protective conductor*

Unless otherwise required, the following applies:

a) For cables rated at up to and including 1 000 V, in which the protective conductor is insulated, such insulation, or outer taping, shall be distinctly and indelibly coloured green and yellow also (*see* Part 1/Section 4 of this Code) over its whole length so that in any 15 mm length one of these colours shall cover at least 30 percent and not more than 70 percent of the surface, the other colour covering the remainder of the surface; and
b) For cables rated at above 1 000 V, in which the protective conductor is insulated, such insulation or outer taping shall at least be identified at each end by the green/yellow colour combination applied in accordance with the foregoing paragraph. Suitable supplementary identification may also be used.

6.1.5.9 *Partial discharge performance*

For cables rated at above 3.8/6.6 kV each production length (minimum length 150 m) of movable distribution cable, drum cable and trailing cable shall be tested by the cable manufacturer for partial discharge.

6.1.5.10 *Terminations of flexible cables*

Flexible cables shall be terminated in such a way that their ends are not under stress or under tension effects, and that excessive bending and compressing are avoided.

6.1.5.11 *Power cable twist limitation*

Where the normal mode of operation of the machine requires infrequent rotation through an arc of up to 360º in either direction, the distance between the clamping supports of the cable shall be not less than 50 times the largest cable diameter in the cable run. Where the normal mode of operation of the machine requires frequent rotation through an arc of up to 360º in either direction, the distance between the clamping supports of the cable shall be not less than 100 times the largest cable diameter in the cable run. Where cables designed specially for this purpose are used, the above ratios may be reduced to 25 and 50 times respectively.

6.1.5.12 *Sheathing*

Cables may be laid directly on or in the ground provided that the outer sheath is designed for the operating conditions.

Cables having extruded metallic sheaths, for example, cables with lead alloy or aluminium sheaths or mineral-insulated metal-sheathed cables, shall not be used where fatigue may occur, due to vibration, frequent handling or ground movement.

6.1.5.13 *Segregation of power and control cores*

a) *Single-core cables* — Single-core cables which are installed in a common duct, conduit or sleeving may be used for several circuits, both power and control.

   All such cables (except bare earthing conductors) shall be insulated for the maximum voltage applied to any cable in the duct, conduit or sleeving.

   When using single-core cables for alternating current circuits, all conductors of a given circuit shall follow the same magnetic path to neutralize the resultant magnetic flux.

b) *Multicore cables* — For voltages up to and including 1 000 V, multicore cables may be used for several circuits, both power and control.

   For voltages above 1 000 V, the only control core(s) which may be included in a multicore cable, shall be the earth continuity check pilot.

   Multicore cables containing power and control cores shall comply with the following requirement as appropriate:

   1) Any cable containing pilot, control and, supervisory cores shall have such cores insulated from all other conducting elements of the cable;
   2) Cables operating at above 1 000 V in an unearthed system shall have either metallic screens or individual conductive rubber screens separating the power cores from the pilot core(s);
   3) Cables operating at above 1 000 V in an earthed system shall have metallic screens separating the power cores from the pilot core(s); and
   4) Cables operating at up to and including 1 000 V shall have pilot, control or supervisory cores separated from power cores by conductive rubber screens if on an unearthed system or metallic screens if on an earthed system. Alternatively, for either system, the pilot, control or supervisory cores shall be insulated to a voltage level equal to that of the power cores.

c) *Composite multicore cables on reeling drums* — Multicore cable which contain power, pilot, control or supervisory cores may be used for reeling drum applications, subject to the voltage limitations given in (b) above provided that the cable is specially designed for such reeling duty.

6.1.5.14 *Separation of cables in racks*

Where power and control cables, multicore and single-core are used on a common rack, tray or duct, the degree of mutual interference shall be considered.

6.1.5.15 *Bending radius for flexible cables over* 25 *mm diameter*

The recommended minimum bending radius for flexible cables during installation and handling in service is six times the cable diameter for cable not constructed in accordance with **6.1.5.5**(a) or (b), and eight times the cable diameter for cables which are constructed in accordance with **6.1.5.5**(a) or (b).

6.1.6 *Cable Connectors*

6.1.6.1 *Use of plug/socket connectors*

Where plug and socket connectors are used at voltages above 1 000 V, measures shall be taken to prevent the plug from being engaged with, or disengaged from, the socket while the circuit is energized.

The measures shall consist of one or both of the following:

a) The provision of isolating switches which are interlocked with the plug/socket so as to prevent connection or disconnection while the circuit is energized and to prevent switching the circuit when the plug/socket connection is incomplete.
b) The provision of protective conductor monitoring by means of either a pilot core, by high frequency monitoring, or by other means.

The measures under (b) are intended as a safety feature and should not be used for normal isolation purposes.

6.1.6.2 *Use of bolted plug/socket connectors and bolted connections*

Where bolted plug/socket connectors or bolted connections are used, interlocking is not required provided suitable and adequate operational procedures are implemented.

6.1.7 *Control Circuits and Control Devices*

Control circuits and control devices shall not automatically reset after tripping unless resetting of the control device either does not cause automatic restarting of the device or there is no hazard to personnel created by automatic restarting or fire.

For unearthed control circuits, measures shall be taken to limit the leakage and capacitance currents that they shall not exceed 70 percent of the drop-out currents. For unearthed control devices, an insulation monitoring device shall also be provided for safety.

6.1.8 *Safety Circuits and Safety Devices*

Any safety circuits shall incorporate fail-safe principle as far as reasonably possible. Some of the principles suggested are:

a) closed circuit principle,
b) proving function operation principle, and
c) fail-safe principles with solid state switching devices.

7 GENERAL RULES FOR PROTECTION IN OUTDOOR INSTALLATIONS

The general rules for protection for electrical installation inside buildings, as enumerated in Part 1/ Section 7 of this Code are applicable for outdoor installations of permanent nature covered by the Scope of this Section. The additional requirements applicable for permanent outdoor installations are given in the following clauses.

7.1 Protection Against Direct Contact

7.1.1 *Complete Protection by Means of Barriers or Enclosures*

7.1.1.1 The minimum electrical clearances in air between field installed bare conductors and between such conductors and earthed parts (such as barriers and enclosures) shall be in accordance with Table 1 or 2.

NOTES

1 These tables need not apply within electrical apparatus wiring devices or manufactured assemblies nor when the installation is covered by other sections of this Code.

2 Tables 1 and 2 take into consideration the fact that the system voltage may vary up to 20 percent from the rated operating voltage.

3 Tables 1 and 2 may be used to indicate clearance distances between conductors and earth in a TN or TT system by using the phase-to-earth voltage.

4 These minimum clearance distances in Tables 1 and 2 do not take into consideration such factors as creepage distances, different voltage levels in the same area nor extreme environmental conditions, etc.

7.1.1.2 All live parts shall be inside enclosures or behind barriers providing at least the degrees of protection in accordance with Table 3.

7.1.1.3 Barriers and enclosures shall be firmly secured in place, and taking into account their nature, size and arrangement, they shall have sufficient stability and durability to resist the strains and stresses likely to occur in outdoor conditions.

7.1.1.4 Where access to the installation is necessary by removal of barriers, opening of enclosures, etc, these shall:

a) necessitate the use of key or tool; or
b) involve provision of an interlocking device such that the removal, opening or withdrawal without the use of a key or tool necessitates previous switching off of all live parts; or
c) ensure automatic disconnection when removal, opening or withdrawal without the use of a key or tool is attempted.

7.1.2 *Partial Protection by Placing Live Parts Out of Reach* (*see* Table 3)

7.1.3 *Partial Protection by the Provision of Obstacles* (*see* Table 3)

7.2 Protection Against Indirect Contact

7.2.1 The provisions of Part 1/Section 7 of this Code shall apply.

8 REQUIREMENTS FOR PERMANENT OUTDOOR INSTALLATIONS

8.1 Winning, Stacking and Primary Processing Machinery

8.1.1 *Mounting of Components*

For the mounting of motors, limit switches, sockets, etc, special protective connections to the structural parts of the installation are not required if the connecting surfaces between the electrical equipment housing and structural parts provide an adequate conducting area. In such cases, the normal mounting bolt or screw connection is adequate.

This is also applicable for the mounting of all types of electrical equipment in cubicles, termination boxes, etc.

Where the equipment is required to operate under corrosive atmospheric conditions or extreme vibrating conditions, a separate protective conductor shall be connected to motors, limit switches, etc.

8.1.2 *Off-Board Mobile and Movable Auxiliary Equipment*

For mobile and movable off-board auxiliary equipment (such as welding equipment, vulcanising transformers, etc.) where the protective conductor is not monitored nor visible, a visible main equipotential bonding conductor shall be provided between such auxiliary equipment and plant.

8.1.3 *Insulation Monitoring Device for IT Systems*

In the case of an IT system, an insulation monitoring device is not required for power circuits which are supplied by a power source from within the machine,

Table 1 Clearance Distances for Indoor Installations

(*Clause* 7.1.1.1)

Maximum rms value of rated operating voltage, kV	1	3	6	10	20	30	45	60	110
Minimum distance for installations subject to overvoltages, mm	40	65	90	115	215	325	520	700	1 100
Minimum distance for installations protected against overvoltages or connected to cables, mm	40	60	70	90	160	270	380	520	950

Table 2 Clearance Distances for Outdoor Installations

(*Clause* 7.1.1.1)

Maximum rms value of rated operating voltage, kV	10	20	30	45	60	110	150	220
Minimum distance for installations subject to overvoltages, mm	150	215	325	520	700	1 100	1 550	2 200
Minimum distance for installations protected against overvoltages or connected to cables, mm	150	160	270	380	520	950	1 350	1 850

Table 3 Minimum Protection Against Direct Contact by Barriers or Enclosures (Applicable to Live Parts Only)

(*Clauses* 7.1.1.2, 7.1.2 *and* 7.1.3)

Sl No. (1)	Voltage Band (ac) (2)	Within Operating Areas (3)	Within Electrical Operating Areas (4)	Within Closed Electrical Operating Areas (5)
i)	$50 < U \le 1\,000$ V	Complete protection IP2X[1] or IP4X for top surfaces or barriers or enclosures which are readily accessible. This applies in particular to those parts of enclosures which might serve as a standing surface	Partial protection IP1X[1] if $U \le 660$ V or no simultaneously accessible parts at different voltages are situated within arm's reach	No protection IP0X if $U \le 660$ V Partial protection IP0X[1] if $U > 660$ V or no simultaneously accessible parts at different voltages are situated within arm's reach
		See Note 1	Complete protection IP2X if $U > 600$ V or IP4X if $U > 660$ V for top surfaces or barriers or enclosures which are readily accessible This applies in particular to those parts of enclosures which might serve as a standing surface *See* Note 1	*See* Note 1
ii)	$U > 1\,000$ V	Complete protection IP5X within arm's reach Partial protection IP2X beyond arm's reach	Complete protection IP5X[1] within arm's reach Partial protection IP1X[1] beyond arm's reach	Partial protection IP1X[1]

$U =$ rated voltage of the installation between lines

NOTES

1 The use of floor plug and socket connector is not precluded but such sockets shall be covered when not in use.

2 For details on IP classifications, *see* IS/IEC 60947 (Part 1). As used in the present standard, the IP classification is intended to specify only the degree of protection required to protect persons from contact with live parts. Additional protection may be required for protection from contact with moving parts or to prevent ingress of solid foreign bodies, such as dust.

3 In the case of dc voltages, the voltage bands in the above table may be increased in the ratio of 1 : 1.5, namely, up to 1 500 V and above.

[1] For electrical operating areas and closed electrical operating areas, protection equivalent to IP1X is also considered to be achieved by placing out of reach or by the interposition of obstacles, for example, by means of protective barriers or handrails.

such as by a transformer having electrical isolated windings or by a generator or storage battery.

8.1.4 *Insulation Monitoring Devices for Vulcanising Heating Platens*

In IT systems, insulation monitoring devices are not required for vulcanising heating platens where the power circuit is supplied from a transformer having electrically isolated windings.

8.1.5 *Electric Hand Tools*

Under consideration.

8.1.6 *Electric Hand Lamps*

Under consideration.

8.1.7 *Drives*

The following recommendations apply to drives with a periodic or cyclic duty as well as to certain other drives with a continuous duty.

8.1.7.1 *Effect on voltage levels*

The effects of equipment starting and of the duty cycle on voltage levels, which may result in damage or the malfunction of equipment, shall be taken into consideration to ensure the safety of personnel and equipment.

8.1.7.2 *Supply systems*

The effect of load fluctuations on the supply system shall be considered, taking account any restrictions imposed by the electricity supplier.

8.1.8 *External Power Supply Systems*

8.1.8.1 *System design*

The supply system shall meet the requirements of cyclic or periodic loads, motor starting, and inherent ac motor oscillations due to transient load changes. For protection requirements, *see* **7**.

8.1.8.2 *Overcurrent protection*

Overload and short-circuit protection for transformers, cables, etc, shall take into consideration the starting requirements and cyclic nature of the load.

8.1.8.3 *Automatic reclosing or transferring*

Where regeneration may delay the operation of undervoltage devices, automatic reclosing or transferring devices should not be used in the power distribution system unless such device has sufficient time delay to allow motor disconnection, the device is fitted with 'out of step' protection, or the combination of supply system and motor design characteristics is such as to permit automatic re-energisation.

8.1.8.4 *System voltage*

It is important that the equipment manufacturer and user mutually understand whether the voltage specified is under no-load or full load conditions.

8.1.9 *Self-Contained Power Systems*

8.1.9.1 *System design*

The power generation systems shall meet the requirements of motor starting, regeneration, peak load, rms load and frequency stability.

8.1.9.2 *Fire protection*

Consideration should be given to the need for special and/or additional fire protection due to the fuels used (*see* **6**).

8.1.9.3 *Earthing*

When the supply of electrical energy is self-contained within stationary, mobile, or movable items of equipment and there is no external supply, such equipment need not be connected to the general mass of the earth.

8.1.9.4 *Supply to off-board equipment*

When power is supplied to off-board mobile and movable equipment conditions given in **8.1.2** are applicable.

8.1.10 *Cable Types*

Under consideration.

8.1.11 *Control Circuits and Control Devices*

8.1.11.1 *Shock vibration and voltage fluctuations*

The effect of shock, vibration or voltage fluctuations on control devices shall be taken into consideration, ensuring that safety of personnel and equipment is not endangered by inadvertent operation of control devices.

When mechanically latched control devices are used and re-energisation following loss of supply power would endanger personnel or equipment, means shall be provided to automatically trip the latched control device on loss of supply power. The device shall also be tripped on operation of protective devices.

8.1.11.2 *Synchronous motor control*

a) *Automatic field removal* — Where synchronous motors are used to drive any part of the installation, automatic motor field removal on disconnection is required.
b) *Automatic field excitation control* — Where synchronous motors are used to drive periodic

or cyclic loads, an automatic field excitation control is recommended.

c) *Power loss protection* — Where synchronous motors are used to drive loads which may be regenerative, means shall be provided to trip the motor starting switch or incoming line switch upon loss of power supply. Frequency sensitive devices are recommended. When automatic reclosing or transferring devices are used in the distribution system, conditions given in **8.1.8.3** are applicable.

8.1.11.3 *Stop control*

The devices described in the following paragraphs shall not be used for purposes of isolation or immobilisation to allow work to be carried out on parts which would otherwise be electrically energised or moving:

a) *Stop control circuits* — The circuits of stop control and of other safety protection devices should be as simple, reliable and direct acting as is practical.
b) *Location of stop controls* — A stop control shall be located near each start control, except for lift call control. Additional stop controls may be provided.
c) *Locking of stop controls* — Where required, provision shall be made to guard against unauthorised starting. Acceptable methods include locking of stop controls in the 'off' position or ensuring that only the person operating the stop control has access to the start control.
d) *Pullwire stop controls* — Stop controls operated by a pullwire shall be arranged so that a pull on the wire in any direction will stop the controlled equipment. The stop controls shall be of a type in which the contacts are opened by a positive mechanical action and can only be reclosed by a further mechanical action.

8.1.11.4 *Interlocking of start controls*

Where equipment can be started from more than one location, the control system shall permit operation from only one nominated location at anyone time, unless start-up alarms are used, the equipment is in sight from all starting locations, or the equipment is guarded against inadvertent access.

8.1.12 *Emergency Stopping and Emergency Devices*

8.1.12.1 *Emergency stopping*

Disconnection of power or other equally effective means shall be provided for stopping the drive under emergency conditions. The power disconnect device may be a manually or remotely operated power circuit-breaker, contactor, etc.

Emergency stopping can be accomplished by means other than disconnection of power, provided that such means otherwise comply with the intent of **8.1.11.3**. For example, when rotation conveners are used, disconnection of the external excitation is permitted if protection against self excitation is provided.

8.1.12.2 *Emergency devices*

Where the cut-out devices are actuated remotely they will be arranged as series tripping system. However, shunt tripping devices may be used providing the tripping device and its stored energy tripping supply are monitored and regularly maintained.

Emergency devices may be arranged to operate simultaneously in a number of different circuits. A number of emergency devices may be arranged in groups; each group may operate in single or multiple circuits.

Where several circuits are divided the respective contact elements shall be connected in series. However, shunt tripping systems may be used providing the abovementioned conditions are maintained.

The emergency device may use remote control systems, for example, audio-frequency of time-multiplex operations, providing at least the same protective measures as for the above devices are applied to ensure positive and reliable operations. However, the simultaneous existence of two or more faults within the remote controls system need not be expected.

8.1.13 *Provision for Supply Isolation*

A means of mains supply isolation shall be provided to isolate the power circuits from the equipment or parts thereof inclusive of control and motor circuits.

However, separate means of isolation may be provided for control circuits, which may remain energised after disconnection of power circuits, provided special measures for the safety of personnel and equipment have been implemented.

8.2 Secondary Processing Machinery

Under consideration.

8.3 Transport Conveyor Systems

8.3.1 *Mounting of Components* (*see* **8.1.1**)

8.3.2 *Equipotential Bonding Conductor and Conductivity of Structural Parts*

Where electrical equipment supplied at a voltage in excess of 50 V is mounted on a conveyor structure and the cable to the equipment does not include a protective conductor, an equipotential bonding conductor shall be provided to the electrical equipment unless the structural parts of the conveyor are mechanically fastened and/or electrically bonded together. The conductivity of the metallic structural parts of the conveyor and its fastenings shall be at least equal to that of the otherwise necessary equipotential bonding conductor.

8.3.3 *Off-board Mobile and Movable Auxiliary Equipment* (*see* **8.1.2**)

8.3.4 *Insulation Monitoring Device for IT Systems* (*see* **8.1.3**)

8.3.5 *Insulation Monitoring Devices for Vulcanising Heating Platens* (*see* **8.1.4)**

8.3.6 *Electric Hand Tools*

Under consideration.

8.3.7 *Electric Hand Lamps*

Under consideration.

8.3.8 *Cables*

8.3.8.1 *General*

Where cables without semi conductive sheaths, metallic screens or armouring are suspended from structures or frames of movable conveyors, such structures and frames shall be considered as extraneous conductive parts and shall be included as part of the whole plant in the design of the protective measures against indirect contact, that is, by ensuring that all metallic parts are linked together.

8.3.8.2 *Power supply cables*

Under consideration.

8.3.9 *Stop Controls*

The devices described in the following clauses shall not be used for purposes of isolation or immobilisation to allow work to be carried out on parts which would otherwise be electrically energised or moving.

8.3.9.1 *Stopping sequence*

The operation of a stop control on a conveyor shall stop that conveyor and:

a) all upstream conveyors to a controlled loading point,
b) cause the material from all upstream conveyors to be diverted to an alternative route,
c) initiate braking to stop the conveyor in safe time, and
d) prevent run-back.

On very long conveyor systems, however, the operation of a stop control within one stop zone need not stop all upstream conveyors beyond that zone, provided that the conveyor upstream of the zone is proved to be unloaded, such as by sensors.

Although the stop control may be reset automatically, restarting shall be initiated manually.

8.3.9.2 *Location of stop controls*

Stop controls shall be provided. It is recommended that stop controls be located at the head and tail ends of a conveyor and that pullwire stop controls be used along the length of the conveyor. All accessible points along the pull wire operated stop control are considered as stop controls. Where individual stop controls are used, they shall be located not more than 15 m from any accessible point along the conveyor. Stop controls shall be accessible from any side of a conveyor to which there is access.

NOTE — Manually operated stop controls may also provide the function of an emergency stop.

8.3.10 *Stopping of Downhill Conveyors*

Under consideration.

8.4 Pumping and Water Supply Systems

8.4.1 *Deep-well Type Pumps*

8.4.1.1 *Risers as protective conductors*

Where a continuous metallic riser pipe is fitted between the motor and the well head, no protection conductor is required between the motor and the protective conductor connected directly to the fixed riser provided that:

a) the supply cable is terminated close to the well head,
b) the conductivity of the metallic riser (stand pipe) and the connections (couplings) shall be at least equal to the conductivity of the protective conductor which would otherwise be necessary, and
c) personnel do not have access down the well.

8.4.1.2 *Continued operation after first earth fault*

Operation may continue after the first earth fault only when all of the following conditions are met:

a) An IT system is used,
b) Personnel do not have access down the well, and
c) Equipotential bonding is provided.

NOTE — Electrically initiated explosive devices should not be stored or used in the vicinity of such installations as hazards may exist due to fault currents flowing in the ground when systems continue to operate following the first earth fault.

8.4.1.3 *Equipotential bonding*

An equipotential bonding conductor shall be installed between the main earth terminals of the supply and the well head(s), where the conductor shall be connected directly to the fixed riser. Where transformers are located at the well head, their enclosures shall be connected to this bonding conductor.

The equipotential bonding conductor shall be so dimensioned that the voltage drop between any two points (of resistance value *R*) that may be contacted simultaneously shall not exceed 50 V. That is:

$$R \leq \frac{50}{K \times I_n} \text{ ohms}$$

where I_n (in amperes) is the rated current of the power fuses or, in the case of circuit-breakers, 0.2 times the releasing current for the instantaneous or short-time delay trip; and *K* is a multiplying factor.

NOTE — A value of $K = 2.5$ is suggested for the time being.

8.4.14 *Exemption from insulation monitoring device*

An insulation monitoring device (or earth fault detector) is not necessary.

8.4.1.5 *Double line to earth faults*

Protection shall be provided to disconnect the supply in the case of a double fault (phase-earth-phase).

A device such as one which detects a change in neutral displacement on the occurrence of the first and second earth faults, may be provided. Disconnection follows the second fault.

8.5 Pumps Other than Deep-well Types

Under consideration.

8.6 Power Supply Cables

Under consideration.

8.7 Control Circuits and Control Devices

Under consideration.

8.8 Safety Circuits and Safety Devices

Under consideration.

9 ADDITIONAL GUIDELINES FOR INSTALLATIONS IN SPECIFIC AREAS

9.0 General

9.0.1 The requirements given in **4** to **8** are applicable to the specific areas described in this Section in so far as the operations are identical with those described.

9.0.2 Guidance from relevant experts shall be taken in respect of specific areas before installation work begins.

9.1 Lighting of Aircraft Aprons

The provisions of relevant Indian Standards shall apply.

9.2 Lighting of Ports and Harbours

The provisions of relevant Indian Standards shall apply.

9.3 Lighting Installations in Railway Marshalling Yards

9.3.1 *Classification*

9.3.1.1 The classification in respect of yard area is based on the speed and intensity of traffic both vehicular and otherwise.

a) *Multipurpose yard* — A marshalling yard with facilities for receiving, classifying and despatching vehicles to their several destination. They also deal with traffic originating at or destined for centres.

b) *A reception yard* — A yard in which the loads of incoming trains may stand clear of running lines while waiting for their turn to be dealt with.

c) *A classification yard* — A yard in which trains are broken up on the different lines for the various directions or stations irrespective of station order, so as to form them into trains and prepare them for correct marshalling.

9.3.1.2 The railway yards are also classified into five main categories depending on their handling capacity and way of working:

a) *Gravity yard* — A yard where natural gradient is available. It is utilized for classification and sorting of loads. Shunting is done without engine.

b) *Hump yard* — Hump yard created by raising track levels in specified crest of 2 to 2.5 m height. Hump yards are those where shunting necks have shape of a camel hump. These yards are mechanized where wagon level crosses 2 500 wagons/day. Normally one hump handles 1 000 to 1 500 wagons/day. The number of humps can be increased depending on the work-load.

c) *Flat yard* — Yards with flat shunting neck are called flat yard. It deals from 300 to 700 wagons/day. It is mostly suitable for metre gauge.

d) *A sorting yard* — This is a yard in which wagons are separated in station order and reformed into trains in special order to meet the requirements of the section ahead or any other special transportation requirements.

e) *A departure yard* — This is a yard in which loads are kept waiting for departure.

9.3.1.3 Each yard can be of anyone of the three formations based on method of construction:

a) Baloon or classification type,
b) ladder type, and
c) Grid type.

NOTE — Yards with grid type formation are reception-*cum*-despatch yards.

9.3.1.4 For the purpose of illumination, most important locations are 'king points' and 'queen points' and order of priority for lighting is determined accordingly.

NOTES

1 King points are the first pair of points that the wagon meets after passing over the hump summit and these divide the hump yard into two portions.

2 Queen points are the second pair of points the wagon meets on either of the two diverging lines taking off from the king points and these divide the classification lines into four sub-portion. These are two in each hump yard.

9.3.2 Different segments (functions) of yards are:

a) classification yard — zone-wise,
b) sorting yard — station-wise,
c) reception yard,
d) despatch yard, and
e) through goods yard.

9.3.3 *Design*

9.3.3.1 For the purpose of designing the lighting system, the recommended height of tower is 30 m.

9.3.3.2 *Selection of equipments*

a) *Light sources* — The following sources of light are recommended for the purpose of yard lighting.
   1) High pressure mercury vapour lamps.
   2) High pressure sodium vapour lamps.

   Each luminaire may be provided with 2 lamps of 400 W or 1 lamps of 1 000 W.

b) *Luminaires* — Flood lighting types of luminaires are recommended for yard lighting installation.

9.3.3.3 Levels of illumination would depend on the type of marshalling yard. The levels given below are recommendatory:

Type	*Minimum*	*Maximum*	*Special Location Like Shunting Neck, King Points, etc*
(1)	(2)	(3)	(4)
Important yard	1.2 lux	5 lux	10 lux
Small yards	0.5 lux	1.2 lux	5 lux

9.3.4 *Power Installation Requirements*

9.3.4.0 The source of electric supply shall be located at a suitable place nearest to the yard.

9.3.4.1 The power supply to the towers shall be through underground armoured cables.

Minimum size of cable shall be 10 to 16 mm^2 4 core.

9.3.4.2 Means shall be provided to control supply to group of towers with controlgear located in feeding substation/switching substation.

9.3.4.3 The cables shall be preferably terminated on column junction boxes by looping joints, rather than 'T' joint.

9.3.4.4 The junction boxes shall be provided with suitable sized contactors with independent fuses for each phase. The contactors shall be controlled by electrically operated switch mounted for external manual local operation.

Laying of cables in yard, along the track and across the tracks should be done in accordance with IS 1255.

NATIONAL ELECTRICAL CODE

PART 6

PART 6 ELECTRICAL INSTALLATIONS IN AGRICULTURAL PREMISES

0 FOREWORD

This Part of the Code is primarily intended for covering the specific requirements of electrical installations in agricultural premises which include premises where livestock are present and farm produce are handled or stored. With the increase in sophistication in organising the farm output of the country, and the use of electricity for certain essential purposes, it has been felt necessary to cover the requirements of such installations as a part of the Code.

Installations in agricultural premises are different from those covered in other Sections of the Code in that the external influences on the electrical services are quite different from those encountered elsewhere. Even though the overall power requirements for such installations would be small, the presence of livestock and other extraneous factors necessitate laying down specific requirements.

1 SCOPE

1.1 This Part 6 of the Code covers requirements for the fixed electrical installations in agricultural premises excluding dwellings or similar locations situated in these premises.

1.2 This Part applies to premises where livestock are present.

NOTE — Examples of such premises are stables, cow houses, sheepfolds, stalls, hen-houses, piggeries, etc.

2 TERMINOLOGY

For the purpose of this Part, the definitions given in Part 1/Section 2 of the Code shall apply.

3 CLASSIFICATION

3.1 Installations in agricultural premises shall be broadly classified into:

a) Farm houses and agricultural processing units, and
b) Livestock houses.

3.1.1 *Farm Houses and Agricultural Processing Units*

Farm houses and agricultural processing units are premises where livestock are not normally present and are those utilized solely for the purposes of handling, processing or storing farm inputs and produce.

3.1.2 *Livestock Houses*

Livestock houses are premises where livestock are present for long periods of time during the day (such as in a dairy farm) with or without associated farm units.

3.1.2.1 Livestock houses are further classified depending on the type of climatic conditions:

a) Plain areas with moderate rainfall,
b) Arid areas and high altitude areas, and
c) Heavy rainfall areas and high rainfall humidity areas.

3.1.2.2 Livestock houses can also be classified depending on the type of animal or bird housed. For example:

Animal/Bird Housing	*Sub-Classification*
Poultry housing	Layer house, Brooder house; Stationary, Portable
Sheepfolds (sheep and goats)	—
Piggeries	—
Horse stables or equine houses	—
Cattle housing	Cattle sheds for average farmer (3 milch animals with their calves and pair of bullocks) Cattle sheds for rural milk producer (average of about 20 animals) Organized milk produces (130 animals) Large dairy farm (about 500 animals)

4 GENERAL CHARACTERISTICS OF AGRICULTURAL PREMISES

General guidelines on the assessment of general characteristics of buildings are given in Part 1/Section 8. For the purpose of installations covered by this Part the conditions given below apply.

4.1 Environment

The following conditions generally apply:

Environment (1)	*Characteristics* (2)	*Remarks* (3)
Presence of water	Possibility of splashes from any direction	Locations where equipment may be subjected to splashed water, for example external lighting fittings
	Possibility of jets of water from any direction	Locations where hose-water is used regularly
Presence of foreign solid bodies	Presence of dust in significant quantity	Applies to barns, stores and stalls
Presence of corrosive or polluting substances	a) Intermittent or accidental subjection to corrosive or polluting substances b) Continuously subjected to corrosive or polluting substances	Applies to locations in which livestock are present or fertilizers or plan protective products are stored or handled
Presence of flora and/or mould growth	Harmful hazard present	—
Presence of fauna	Harmful hazard present	Insects, birds and small animal
Electromagnetic influences	Harmful presence of induced currents	

4.2 Utilization

The following conditions apply:

Utilization (1)	*Characteristics* (2)	*Remarks* (3)
Electrical resistance of human body	Low to resistance due to wet conditions	—
Contact of persons with earth potential	Persons are frequently in touch with extraneous conductive parts or stand on conducting surfaces	
Conditions of evacuation during emergency	Low density occupation difficult conditions of evacuation High density occupation easy conditions of evacuation	Special precautions to be taken where animals are present
Nature of processed or stored materials	Flammable material including dust	Barns
Building design	Propagation of fire is facilitated and risks due to structural movement of structures which are weak	

5 SUPPLY CHARACTERISTICS AND PARAMETERS

5.1 Information shall be exchanged among the people concerned on the electrical needs of the premises before installation work begins. Each installation may have to cater to the services required in the subunits of the premises which depend on the type of agricultural premises as enumerated in 4.

5.1.1 In agricultural farms the following sub-units are present:

a) Outdoor processing,
b) Indoor processing,
c) Heating/cooling,
d) Cold storage,
e) Stores, and
f) Office.

5.1.2 In sheepfolds, the following sub-units are present:

a) Sheds such as flock shed, ram or buck shed, sick shed, etc;
b) Sheering and store room; and
c) Shepherd house.

5.1.3 In cattle housing, the following sub-units are present:

a) Sheds for animals,
b) Milk recording and testing room,
c) Utensils room,
d) Ration room,
e) Stores, and
f) Office.

5.1.4 In meat houses and abattoirs, the following sub-units are present:

a) Animal sheds before slaughter,
b) Slaughter shed,
c) Flaying, dressing and washing,
d) By-products handling,
e) Inspection,
f) Laboratory, and
g) Office.

5.2 Wiring Systems

5.2.1 Main switchgear shall not be installed

a) within reach of livestock, or
b) in any position where access to it may be impeded by livestock.

5.2.2 Where an installation serves more than one building, it shall be possible to isolate and control the buildings individually.

5.2.3 Means of access to all live parts of switchgear and other fixed live parts where different nominal voltages exist shall be marked to indicate the voltages present.

5.2.4 *Cables*

5.2.4.1 All cables shall be placed out of reach of livestock and clear of all vehicular movement.

5.2.4.2 Where additional protection against mechanical damage to cables is required, it shall, wherever possible, be provided by the use of non-metallic materials.

5.2.4.3 Where long runs of cable must be placed along the sides of buildings, they shall wherever possible be placed on the outside of the buildings, and as high as practicable.

5.2.4.4 Where conductors or cables are carried overhead supported by buildings or by poles, the minimum height above ground shall be 6 m.

5.2.4.5 Cable couplers shall not be used in agricultural premises.

5.3 Selection and Erection of Equipment

Equipment shall be so selected that they suit the environmental conditions of use and shall be installed in such a way that their normal functioning is not affected by the external influences enumerated in **4**.

5.3.1 It is recommended to protect final sub-circuits by residual current devices, the rated operating residual current not exceeding 30 mA and as low as practicable but avoiding nuisance tripping.

5.4 System Protection

5.4.1 *Protection Against Electric Shock*

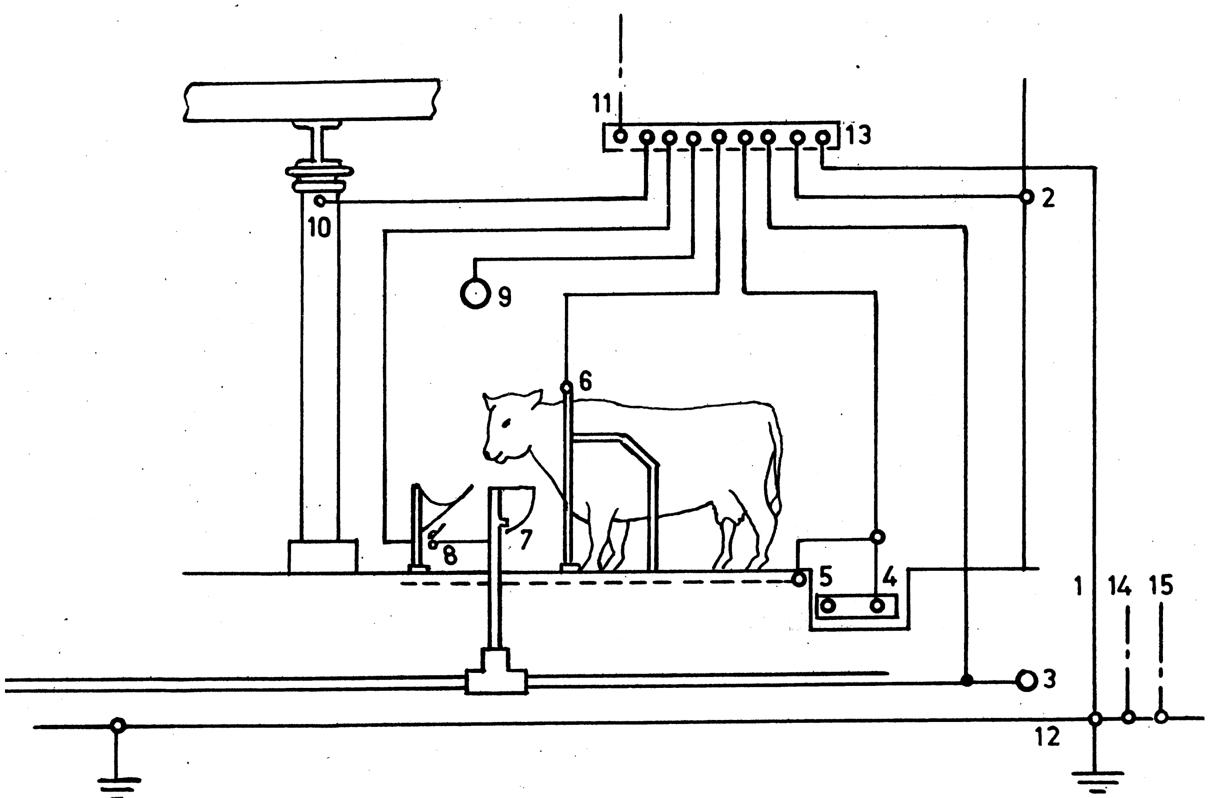
For the application of protective measure by safety extra-low voltage in locations in which livestock are present or situated outside, protection against direct contact shall be provided by:

a) barriers or enclosures affording at least the degree or protection IP2X, or
b) insulation capable of withstanding a test voltage of 500 V for 1 min.

For achieving protection by automatic disconnection of supply, the conventional voltage limit in locations in which livestock are present or situated outside is U_L = 25 V. These conditions are also applicable to locations directly connected through extraneous conductive parts to the locations where livestock are present.

Where electrical equipment is installed in livestock building, supplementary equipotential bonding shall connect all exposed conductive parts which can be touched by livestock and the protective conductor of the installation.

NOTE — A metallic grill connected to the protective conductor laid in the floor is recommended (*see* Fig. 1).



1. Earth conductor
2. Sheet metal and foil partitions
3. Water pipe
4. Manure removal device
5. Potential equalization, for example, structural steel mat
6. Tethering device
7. Automatic watering device
8. Feeding apparatus
9. Milking apparatus
10. Steel structure
11. Protective earth conductor (PE)
12. Earth electrode
13. Busbar for equipotential bonding
14. Earth electrode for lightning protection
15. Earth electrode for electric fences

FIG. 1 EXAMPLE OF EQUIPOTENTIAL BONDING ON AGRICULTURAL PREMISES

5.4.2 *Protection Against Fire*

Heaters used in the rearing and tending of livestock shall be secured or hung on a safe mounting so that an adequate spacing from both animals (risk of burns) and combustible materials (fire hazard) is assured. Due consideration shall be given to the evacuation of animals in case of emergency. Due considerations shall also be given to locations presenting fire-risks.

5.4.3 *Isolation and Switching*

For fire safety purposes, a residual current protective device shall be installed having a rated residual operating current of 0.5A. Devices for emergency electrical switching including emergency stopping shall not be installed within reach of livestock or in any position where access to them may be impeded by livestock, account being taken of the condition likely to arise in the event of panic by livestock.

6 SERVICES IN AGRICULTURAL PREMISES

Farm houses and livestock houses do not in general require sophisticated electrical services, but in the case of the latter, lack of proper ventilation or lighting leads to insanitation and discomfort to the livestock thereby leading to retarded growth, high mortality or poor fertility. The houses are required to be maintained reasonably cool in summer and warm in winter, with a regular supply of fresh air and light. The guidelines given in **6.1** to **6.3** shall be adhered to.

6.1 Poultry Housing

A minimum of 14 h day length shall be provided to the birds and artificial lighting shall be provided for the same. For the purposes, 1 W (GLS) or 0.75 W (fluorescent) per bird or 1 W per 28-38 cm are considered adequate. The light sources shall be hung at a height not less than 1.8 m above floor. For poultry sheds of 6 m width and below, one row of bulbs in the centre shall be adequate. For sheds of larger width two rows of lamps properly interspaced may be desirable.

6.2 Abattoir

In meat houses and abattoirs, in halls where meat or carcasses are hung, a temperature of not greater than 10°C would be required and air-conditioning may be required. In unrefrigerated work rooms, ample artificial light and ventilation shall be provided by electrical means. The overall intensity in every abattoir shall not be less than 200 lux throughout the slaughter hall and workroom and at places where meat inspection is carried out, the illumination shall be at least 500 lux.

6.3 Farm Cattle Housing

In large dairy farms, roof-lights shall be provided to give 50-200 lux of artificial lighting. The lamps shall be hung at a height not less than 2 m above floor level.

7 TESTING OF INSTALLATION

Before commissioning the installation shall be tested and inspected as given in Part 1/Section 13 of the Code.

8 MISCELLANEOUS PROVISIONS

8.1 For large scale livestock keeping, such as in a dairy farm, it shall be essential to provide:

a) a warning device for indicating failure of air circulation system; and

b) for continuity of supply, a fast acting emergency supply system is recommended.

8.2 Electric Fences

Where electric fences are in the vicinity of overhead lines, appropriate distances shall be observed to take account of induction currents, falling lines, etc.

Any earth electrode connected to the earth terminal of an electric fence controller shall be separate from the earthing system of any other circuit and shall be situated outside the resistance area of any electrode used for protective earthing.

8.3 Circuits of wirings which are only occasionally used, for example, during threshing time, shall be fitted with a separate switch marked accordingly.

NATIONAL ELECTRICAL CODE

PART 7

PART 7 ELECTRICAL INSTALLATIONS IN HAZARDOUS AREAS

0 FOREWORD

Explosive gas atmosphere is the atmosphere where mixture with air, under atmospheric conditions, of flammable substances in the form of gas or vapour, which, after ignition, permits self-sustaining flame propagation. Area in which an explosive gas atmosphere is present, or may be expected to be present, in quantities such as to require special precautions for the construction, installation and use of equipment is referred as a hazardous area and has to be treated in a special manner from the point of the design of electrical installation.

Many liquids, gases and vapours which in industry are generated, processed, handled and stored are combustible. When ignited, these may burn readily and with considerable explosive force when mixed with air in the appropriate proportions. With regard to electrical installations, essential ignition sources include arcs, sparks or hot surfaces, produced either in normal operation or under specified fault conditions.

This Part 7 of the Code is intended to provide guidelines for electrical installations and equipment in locations where a hazardous atmosphere is likely to be present, with a view to maximising electrical safety. The scope of this Part therefore includes installations in hazardous areas such a petroleum refineries and petrochemical and chemical industries. The requirements laid down herein are in addition to those specified in Part 4 of this Code.

It is recognized that when electrical equipment is to be installed in or near a hazardous area, it is frequently possible, by taking care in the layout of the installation, to locate much of the equipment in less hazardous or non-hazardous areas and thus reduce the amount of special equipment required.

NOTE — Hazardous areas can be limited in extent by construction measures, that is, walls or dams. Ventilation or application of protective gas will reduce the probability of the presence of explosive gas atmosphere so that areas of greater hazard can be transformed to areas of lesser hazard or to non-hazardous areas.

This Part includes generalised statements and recommendations on matters on which there are diverse opinions. It is, therefore, important that sound engineering judgement should be exercised while applying these guidelines.

1 SCOPE

1.1 This Part 7 of the Code covers recommendations for electrical installations in chemical industries, petroleum refineries and other similar areas where hazards of explosion due to gases and vapours exist, and in which flammable gases and volatile liquids are processed, stored, loaded, unloaded or otherwise handled.

1.2 In addition to the recommendations given in this Part 7, the electrical installations in hazardous areas shall comply, with the requirements for industrial installation in non-hazardous areas laid down in Part 4 of this Code.

1.3 This Part does not apply to installations in hazardous areas having ignitable dusts and fibres. As distinct from the hazardous areas on the surface, environmental conditions in mines demand special consideration. This Part of the Code does not include provisions for installations in underground mines.

1.4 In any plant installation, irrespective of size, there may be numerous sources of ignition apart from those associated with electrical apparatus. Precautions may be necessary to ensure safety but guidance on this aspect is outside the scope of this Part.

NOTE — Some examples of industrial locations which require application of the guidelines in this Part are given in Annex A.

2 REFERENCES

A list of standards for electrical equipment for explosive atmospheres is given at Annex B. Some of these standards deal with particular construction techniques, others with aspects of standardization which are relevant to more than one technique.

3 TERMINOLOGY

For the purpose of this Part, the following definitions shall apply, in addition to those given in Part 1 of this Code.

3.1 Flammable Material — A flammable material is a gas, vapour, liquid and/or mist which can react continuously with atmospheric oxygen and which may therefore, sustain fire or explosion when such reaction is initiated by a suitable spark, flame or hot surface.

3.2 Flammable Gas-Air Mixture — A mixture of flammable gas, vapour or mist with air, under atmospheric conditions, in which after ignition, combustion spreads throughout the unconsumed mixture.

3.3 Hazard — The presence, or the risk of presence, of a flammable gas-air mixture.

3.4 Explosive Gas Atmosphere — Mixture with air, under atmospheric conditions, of flammable substances in the form of gas or vapour, which, after ignition, permits self-sustaining flame propagation.

3.5 Hazardous Area — Area in which an explosive gas atmosphere is present, or may be expected to be present, in quantities such as to require special precautions for the construction, installation and use of equipment.

3.6 Explosive (Flammable) Limits — The extreme values for the concentration of a flammable gas or vapour in air under atmospheric conditions, under which flammable gas-air mixture can be ignited by an electrical arc or spark. These limits are called the 'lower explosive limit' (LEL) and the 'upper explosive limit' (UEL).

3.7 Flammability Range — The range of gas or vapour mixtures with air between the flammable limits over which the gas mixtures are continuously explosive.

3.8 Flammable Gas or Vapour — Gas or vapour which, when mixed with air in certain proportions, will form an explosive gas atmosphere.

3.9 Flammable Liquid — A liquid capable of producing a flammable vapour, gas or mist under any foreseeable operating conditions.

3.10 Flammable Mist — Droplets of flammable liquid, dispersed in air, so as to form an explosive gas atmosphere.

3.11 Liquefied Flammable Gas — Flammable gas which, under normal ambient pressures and temperatures, is in gaseous state but which is handled in a liquid state under the applied conditions of pressure and/or temperature.

3.12 Flash Point — The temperature at which the liquid gives so much vapour that this vapour, when mixed with air, forms an ignitable mixture and gives a momentary flash on application of a small pilot flame under specified conditions of test.

3.13 Boiling Point — The temperature of a liquid boiling at an ambient pressure of 101.3 kPa.

NOTE — For liquid mixtures the initial boiling point shall be considered. 'Initial boiling point' is used for liquid mixtures to indicate the lowest value of the boiling point for the range of liquids present.

3.14 Ignition Temperature — The lowest temperature at which ignition occurs in a mixture of explosive gas and air when the method specified in IS 7820 is followed.

3.15 Source of Release — A source of release is a point or location from which a gas, vapour, mist or liquid may be released into the atmosphere so that an explosive gas atmosphere could be formed.

3.16 Restricted Release — A release (normal or abnormal) of flammable gas or vapour which can be diluted below the lower flammable limit.

3.17 Unrestricted Release — A release (normal or abnormal) of flammable gas or vapour which cannot be diluted below the lower flammable limit.

3.18 Adequate Ventilation — Adequate ventilation is that which is sufficient to prevent accumulations of significant quantities of gas-air mixtures in concentration over one-fourth of the lower flammable limit.

Adequately ventilated area could be naturally ventilated or artificially ventilated.

3.19 Relative Density of Gas or Vapour — The density of a gas or a vapour relative to the density of air at the same pressure and the same temperature.

3.20 Non-hazardous (Safe) Area — Area in which an explosive gas atmosphere is not expected to be present in quantities such as to require special precautions for the construction, installation and use of equipment

3.21 Electrical Apparatus for Hazardous Areas — Electrical apparatus which will not ignite the surrounding flammable atmosphere in which it is used.

3.22 Ignition Capable Apparatus — Apparatus which in normal operation produces sparks, hot surfaces, or a flame which can ignite a specific flammable mixture.

3.23 Safety Measures — Measures taken to ensure that electrical apparatus cannot cause an explosion.

3.24 Type of Protection — Specific measures applied to electrical equipment to avoid ignition of a surrounding explosive atmosphere.

3.25 Maximum Surface Temperature — Highest temperature which is attained in service under the most adverse operating conditions (but within recognized tolerances) by any part or surface of the electrical equipment, which would be able to produce an ignition of the surrounding explosive atmosphere.

NOTES

1 The most adverse conditions include recognized overloads and fault conditions recognized in the specific standard for the type of protection concerned.

2 The relevant surface temperature may be internal and/or external depending upon the type of protection concerned.

3.26 Flame Arrester — A device for releasing gas from an enclosure in such a way that in case of an internal explosion there is no appreciable increase in internal pressure and the released gas will not ignite the surrounding flammable atmosphere.

3.27 Inert Gas — A gas which cannot be ignited when mixed with a flammable gas or vapour in any concentration.

4 STATUTORY REGULATIONS

4.1 In following the recommendations of this Part 7, the various statutes and regulations in force in the country, applicable to the installation and use of electrical apparatus in hazardous areas shall be kept in view.

4.2 Attention is invited to the fact that the manufacture and use of equipment in hazardous areas is controlled by the statutory authorities listed below for the area of their jurisdiction:

a) The Directorate General of Mines Safety, Dhanbad (Bihar);

b) The Chief Controllerate of Explosives, Petroleum and Explosives Safety Organisation, Nagpur (Maharashtra); and

c) The Directorate General Factory Advice Services and Labour Institute, Mumbai (Maharashtra).

4.3 Testing

Equipment to be installed in hazardous area have to be certified by a recognised testing authority.

4.4 Marking of equipment shall conform to IS/IEC 60079-0.

5 FUNDAMENTAL CONCEPTS

5.1 Flammable gases and vapours may cause a fire or explosion when the following three basic conditions are satisfied:

a) Presence of sufficient quantity of a flammable gas or vapour,

b) Mixing of flammable gas or vapour with air or oxygen in the proportions required to produce an explosive or ignitable mixture, and

c) Occurrence of ignition.

In applying this principle to any potential hazard, the quantity of the substance that might be liberated, its physical characteristics and the natural tendency of vapours to disperse in the atmosphere shall be recognised. Flammable substances, the potential release of which shall be considered in area classification of electrical installations (*see* **6**) include the following:

a) Non-liquefiable gases,

b) Liquefied petroleum gas, and

c) Vapour or flammable gas.

5.2 It is recommended that plants and installations in which flammable materials are handled or stored be so designed that the degree and extent of hazardous areas are kept to a minimum. Similarly consideration should be given to design and operation of process equipment to ensure that even when it is operating abnormally, the amount of flammable material released to the atmosphere is minimized in order to reduce the extent of the area made hazardous.

Once a plant has been classified, it is important that no modification to equipment or operating procedures is made without discussion with those responsible for the area classification. Unauthorized action may invalidate the area classification.

It is necessary to ensure that process equipment which has been subjected to maintenance shall be carefully checked during and after re-assembly to ensure that safety aspect or integrity of the original design has been maintained before it is returned to service.

5.3 Where it is necessary to use electrical apparatus in an environment in which there may be an explosive gas atmosphere and it is not possible to:

a) eliminate likelihood of an explosive gas atmosphere occurring around the source of ignition, or
b) eliminate the source of ignition.

Then measures should aim at reducing the likelihood of occurrence of either or both of the above factors so that the likelihood of coincidence is so small as to be negligible.

5.4 In most practical situations where flammable materials are used it is difficult to ensure that an explosive gas atmosphere will never occur. It may also be difficult to ensure that the electrical apparatus will never give rise to a source of ignition. Reliance is therefore placed on using electrical apparatus which has an extremely low likelihood of creating a source of ignition in situations where a flammable atmosphere has a high likelihood of occurring. Conversely where the likelihood of an explosive gas atmosphere is reduced, electrical apparatus which has an increased likelihood of becoming a source of ignition may be used.

6 CLASSIFICATION OF HAZARDOUS AREAS

6.0 General

The objective of the hazardous area classification is to ensure an adequately safe level of operation of electrical apparatus in flammable atmospheres using the fundamental concepts outlined in **5**.

The basis for hazardous area classification recognizes the differing degrees of probability with which flammable atmospheres (explosive concentrations of combustible gas or vapour) may arise in installations in terms of both the frequency of occurrence and the probable duration of existence on each occasion.

6.1 Area Classification

The area classification is given in Table 1.

6.2 Extent of Hazardous Area

6.2.1 A complete knowledge of the physical properties of the flammable materials involved is essential for classifying a hazardous area. Properties of primary interest from an ignition standpoint are:

a) relative density,
b) flammable limits,
c) flash point,
d) volatility,
e) ignition temperature, and
f) ignition energy.

Some of these characteristics have a direct influence on the degree and extent of hazardous areas while the others affect the design of electrical equipment.

6.2.1.1 *Relative density*

Where a substantial volume of gas or vapour is released into the atmosphere from a localized source, a relative density less than one, that is, lighter-than-air, for the combustible indicates the gas or vapour will rise in a comparatively still atmosphere. A vapour density greater than one, that is, heavier-than-air, indicates the gas or vapour will tend to sink, and may thereby spread some distance horizontally and at a low level. The latter effects will increase with compounds of greater relative vapour density.

NOTE — In process industries, the boundary between compounds which may be considered lighter-than-air is set at a relative vapour density of 0.75. This limit is chosen so as to provide a factor of safety for these compounds whose densities are close to that of air and where movement may not, therefore, be predicted without a detailed assessment.

6.2.1.2 *Flammable limits*

The lower the 'lower flammable limit' the larger may be the extent of the hazardous area.

6.2.1.3 *Flash point*

A flammable atmosphere cannot exist if the flash point is significantly above the relevant maximum temperature of the flammable liquid. The lower the flash point, the larger may be the extent of the hazardous area.

6.2.1.4 *Volatility*

Boiling point can be used for comparing the volatility

Table 1 Area Classification
(*Clause* 6.1)

Sl No. (1)	Area Classification (2)	Description (3)	Remarks (4)
i)	Zone 0	Place in which an explosive atmosphere consisting of a mixture with air of flammable substances in the form of gas, vapour or mist is present continuously or for long periods or frequently	This classification is applicable only where the hazard will exist continuously. In the petroleum industry such a condition is rarely encountered except in confined spaces, such as the vapour space of closed process vessels, storage tanks or closed containers. In Zone 0, any arc or spark would almost certainly lead to fire or explosion. Any electrical apparatus must afford a degree of protection as near as practicable to absolute. It is recommended to avoid installing electrical equipment in Zone 0 areas to the extent possible.
ii)	Zone 1	Place in which an explosive atmosphere consisting of a mixture with air of flammable substances in the form of gas, vapour or mist is likely to occur in normal operation occasionally	In Zone 1, the hazard is likely to occur at any time requiring fullest practicable application of measures.
iii)	Zone 2	Place in which an explosive atmosphere consisting of a mixture with air of flammable substances in the form of gas, vapour or mist is not likely to occur in normal operation but, if it does occur, will persist for a short period only	Zone 2 is applicable to areas where hazard is unlikely and may be caused only by the highly improbable and simultaneous occurrence of an arc or spark together with a hazardous atmosphere arising out of failure of conditions of control. It presupposes that any abnormal occurrence is rapidly dispersed so that possible contact with electrical apparatus is of minimum duration.

NOTES

1 Earlier, classified areas were called divisions.

2 This area classification deals only with risks due to combustible gases and vapours and combustible mists. It does not deal with dusts since these material can be quiescent for long periods of time until they are disturbed into suspension by a suitable mechanism (*see also* **1.3**).

3 By implication, an area not classified as Zone 0, Zone 1 or Zone 2, is deemed non-hazardous or safe and no special precautions are necessary.

of flammable liquids. The more volatile a liquid and the lower its flash point, the more closely it approximates a flammable gas.

6.2.1.5 *Ignition temperature and ignition energy*

Ignition temperature and ignition energy of a flammable gas or vapour are taken into account in the design of electrical apparatus for hazardous areas so that these do not present an ignition risk.

6.2.2 *Factors Affecting Extent of Hazard*

6.2.2.0 In addition to the properties of flammable materials involved, the following factors need to be considered for determining the degree and extent of hazardous areas while applying the guidelines given in IS 5572.

6.2.2.1 *Risk points*

Normal operation is the situation in which all plant equipment is operating within its design parameters. Minor releases of flammable material may be part of normal operation but leakages which entail repair or shut down are not part of normal operation.

Some examples of persistent risk points are as follows:

a) Interior of pressure vessels and pipes containing gas-air mixtures;
b) Free space above liquid level in tanks;
c) Free space immediately above open dipping baths, etc; and
d) The immediate vicinity of vapour exhausts and liquid outlets where these are designed to discharge as part of normal plant function.

Examples of occasional risk points are the immediate vicinity of mechanical glands, seals relying on wetting by the fluid being pumped and other localized spillage points and of vapour exhausts and liquid outlets designed to discharge only on plant malfunction.

6.2.2.2 *Temperature of process liquid*

The extent of a hazardous area may increase with increasing temperature of process liquid provided the temperature is above the flash point. It should be noted that the liquid or vapour temperature after the release maybe increased or decreased by the ambient temperature or other factors (for example, a hot surface).

NOTE — Some liquids (such as certain halogenated hydrocarbons) do not possess a flash point although they are capable of producing a flammable atmosphere; in these cases, the equilibrium liquid temperature corresponding to saturated concentration at lower flammable limit should be compared with the relevant maximum liquid temperature.

6.2.2.3 *Concentration of vapour*

For flammable liquids, the concentration of the released vapour is related to the vapour pressure at the relevant maximum liquid temperature. The lower the initial boiling point, the greater the vapour pressure for a given liquid temperature and hence the greater concentration of vapour at the release source resulting in greater extent of hazardous area.

6.2.2.4 *Rate of release*

The extent of hazardous area may increase with increasing rate of release of flammable material.

6.2.2.5 *Release velocity*

Due to an improved dilution for release of flammable gases, vapours and/or mists in the air, the extent of hazardous area may decrease if, with constant release rate, the release velocity increases above that which causes turbulent flow.

NOTE — Elevated or depressed sources of release will alter the areas of potential hazard.

6.2.2.6 *Air current*

Air currents may substantially alter the outline of the limits of potential hazard. A very mild breeze may serve to extend the area in those directions to which vapours might normally be carried. However, a stronger breeze may so accelerate the dispersion of vapours that the extent of potentially hazardous area would be greatly reduced.

6.2.2.7 *Ventilation*

With an increased rate of ventilation, the extent of hazardous area may be reduced. The extent may also be reduced by an improved arrangement of the ventilation system.

6.2.2.8 *Obstacles*

Obstacles (for example, dykes, walls) may impede the ventilation and thus may enlarge the extent. On the other hand, they may limit the movement of a cloud of an explosive gas atmosphere and thus may reduce the extent.

6.2.2.9 For vapours released at or near ground level, the areas where potentially hazardous concentrations are most likely to be found are below ground, those at ground are next most likely, and as the height above ground increase, the potential hazard decreases.

NOTE — For lighter-than-air gases, the opposite is true, there being little or no potential hazard at and below ground and greater potential hazard above ground.

6.2.3 *Internal Hazards*

6.2.3.0 In cases where electrical apparatus, like those used for measurement and control of process variable, are connected directly to gas or a liquid process equipment, this may introduce additional source of internal and/or external release and consequently influence the external area classification.

6.2.3.1 The hazards created inside the electrical apparatus by an internal release of flammable gas or vapour may be compared to the external area classification as follows:

a) Where pressurization with inert gas is applied, the internal releases cannot create a flammable gas atmosphere, because no oxygen is present.
b) Where dilution with air is applied in case of a restricted normal release the internal hazards are comparable to those in a safe area. This applies also when the abnormal release (when occurring) would be restricted. When, however, the abnormal release would be unrestricted, the internal hazards are comparable to the external hazards in Zone 2.
c) In all other types of protection, the internal hazards are comparable to the external hazards in Zone 2, provided that there is no normal release and that an abnormal release would be very infrequent and of a relatively short duration. When there is a normal release, the internal hazards are comparable to the hazards in Zone 0 and the abnormal release is not relevant.

6.2.3.2 When apparatus in which the internal hazards are comparable to Zone 2 is installed in a safe area or in Zone 2, the internal hazards determine the actual hazard condition, but when the same apparatus is installed in Zone 1 or Zone 0 the external hazards determine the actual hazard condition. When an apparatus in which the internal hazards are comparable to Zone 1 is installed in a Zone 0 hazardous area, the area classification would determine the actual hazard.

6.2.4 *Extent of Zones of Hazard*

6.2.4.1 The treatment of hazardous area, from the point of view of determining the extent of hazardous zones (and their classification) around the source of hazard differ in the following broad situations:

a) Open-air situations (freely ventilated process area):
   1) Source of hazard located near ground level, and
   2) Source of hazard above ground level,
b) Enclosed premises and surrounding area (process area with restricted ventilation).
c) Storage tanks:
   1) Floating roof, and
   2) Fixed roof tank with vent.

6.2.4.2 Detailed guidelines on the above situations can be had from IS 5572.

7 SPECIFIC GUIDELINES FOR ELECTRICAL INSTALLATIONS IN HAZARDOUS AREAS

7.1 General

7.1.1 *Mechanical Strength*

All apparatus shall be installed with due regard to the possibility of external mechanical damage. Where adequate protection cannot be ensured, for example, by location, reference should be made to the impact test requirements according to IS/IEC 60079-0 for the apparatus before deciding on any additional measures such as the provision of guards for transparent parts.

7.1.2 *Earthing and Bonding*

7.1.2.1 Earthing shall be in accordance with Part 1/ Section 14 of this Code. The connection between metal part to be grounded and the grounding conductor shall be made secure mechanically and electrically by using adequate metallic fitting. The earthing conductors shall be sufficiently strong and thick, and the portions of conductor which are likely to be corroded or damaged shall be well protected. Grounding conductors which shall not reach a hazardously high temperature due to the anticipated maximum earth fault current flowing, shall be used.

7.1.2.2 Protection against lightning shall be provided in accordance with Part 1/Section 15 of this Code. Specific guidelines for installations in hazardous locations are given in Annex C. Interconnection system with other buried metal services and/or earth terminations for equipment earthing for the purpose of equalizing the potential distribution in the ground should preferably be made below ground.

7.1.2.3 Portable and transportable apparatus shall be earthed with one of the cores of flexible cable for power supply. The earth continuity conductor and the metallic screen wherever provided for the flexible cable should be bonded to the appropriate metal-work of the apparatus and to the earthing pin of the plug.

7.1.2.4 Efficient bonding should be installed where protection against stray currents or electrostatic charges is necessary.

7.1.2.5 *Earthing and bonding of pipelines and pipe-racks*

Unless adequately connected to earth elsewhere, all utility and process pipelines should be bonded to a common conductor by means of earth bars or pipe clamps and connected to the earthing system at a point where the pipelines enter or leave the hazardous area, except where conflicting with the requirements of cathodic protection. In addition, it is recommended that steel pipe racks in the process units and off-site areas should be earthed at every 25 m.

7.1.3 *Automatic Electrical Protection*

7.1.3.1 It is essential that the severity and duration of faults internal or external to the electrical apparatus be limited, by external means, to values that can be sustained by the apparatus without disruptive effect.

7.1.3.2 All circuits and apparatus in hazardous areas shall be provided with means to ensure disconnection quickly in the event of excessive overloads, overcurrent, internal short-circuit or earth-fault conditions. In case of distribution systems with isolated neutral, an automatic earth-fault alarming device may be considered adequate, in addition to overload/ overcurrent and short-circuit protection.

7.1.3.3 Protection and control apparatus shall be normally located in a non-hazardous area. Where its installation in a potentially hazardous area cannot be avoided, such apparatus should be provided with the appropriate type of protection.

7.1.3.4 Apart from self-powered apparatus and hand lamps, earth-leakage protection or earth monitoring, or both should be included in the protection of the portable and transportable apparatus. Protection, of the circulating-current type, which automatically cuts off the supply in the event of the earth continuity conductor becoming disconnected, may, with advantage, be adopted as the earth-monitoring device.

7.1.4 *Isolation*

7.1.4.1 All electrical circuits should be provided with an effective means of complete circuit isolation, including the neutral. Such means of isolation should be provided for each item of electrical apparatus and/or each sub-circuit.

7.1.4.2 The means of isolation, when located in a hazardous area, shall be a switch which breaks all poles, including the neutral, and which is provided with an appropriate type of protection against explosive hazards. This applies equally to single phase sub-circuits. When the means of isolation is located in a non-hazardous area, the switch shall break all poles, the neutral being isolated by a removable link. The means of isolation shall be capable of being locked in the 'OFF' position.

7.1.4.3 When the means of isolation is not immediately adjacent to the associated apparatus, effective provision should be made to prevent the restoration of supply to the apparatus while the risk of exposure of live conductors to a flammable gas-air mixture continues.

7.1.5 *Operation and Maintenance*

7.1.5.1 None of the protection techniques for electrical equipment for explosive gas atmospheres are effective unless the apparatus is operated within the limits indicated by its nameplate marking and is properly maintained according to the recommendations of appropriate Indian Standards.

7.1.5.2 Care shall be taken when inspecting equipment in hazardous areas; circuits shall be made dead before removing covers. Flexible cables are a potential source of hazard; they should be frequently inspected, together with the portable apparatus. Equipment should be examined for mechanical faults, cracked glasses, deterioration of cement, slackened conduit joints and corrosion. Electrical tests should be carried out at fixed intervals.

7.2 Wiring Installation

7.2.0 *General*

Types of wiring and systems which may be used for installation in hazardous areas are:

a) cables drawn into screwed, solid drawn or seamless conduits, and
b) cables which are otherwise suitably protected against mechanical damage.

Requirements for the installation of general power systems may not apply to the installation of apparatus and systems with type of protection 'i' (intrinsic safety). For intrinsically safe circuits, there is normally no need to have special enclosures for the conductors. However, some protection will have to be afforded to such conductors primarily to prevent contact between conductors of intrinsically safe circuits and those of any other system, to avoid the possibility of arcing occurring at the point of contact or invasion of the intrinsically safe circuits by current arising from contact or electrostatic or electromagnetic induction. In addition, the conductors should be protected against mechanical damage (*see* **7.2.1.5**).

The diameter of each strand of the conductor shall be not less than 0.300 mm of copper or equivalent size of conductor in the case of aluminium conductors as specified in relevant Indian Standard.

For (b) the following types of cables may be used in principle:

1) Lead-sheathed and armoured cable;
2) Plastics or rubber-sheathed steel screen protected or armoured cable, with overall sheath;
3) Cables enclosed in a seamless aluminium sheath with or without armour, with an outer protective sheath;
4) Mineral insulated metal sheathed cable; and
5) Braided screen-protected flexible cables.

Unarmoured lead-covered cable is not acceptable. The sheath of a metal-sheathed cable should not be used as the neutral conductor.

7.2.1 *Factors Affecting Choice of Wiring System*

7.2.1.1 Screwed steel conduit systems are satisfactory for many situations but should not be used where vibration might cause fracture or loosening of joints and where excessive stress may be imposed as a result of its rigidity or where corrosion or excessive internal condensation of moisture is likely to occur.

7.2.1.2 Lead-sheathed and armoured cables are suitable for underground installation. Steel-wire/flat armour is preferred for underground use.

7.2.1.3 PVC-insulated and armoured cable, complying with IS 1554 (Part 1) with an extruded plastic outer sheath may be used for above ground or underground installation. Lead-sheathed cable should be used where spillages may affect the integrity of the cable and or allow migration of the liquid through the cable.

7.2.1.4 For telecommunication circuits, plastic-insulated and armoured telephone cables may be used.

7.2.1.5 In Zone 0 areas only intrinsically safe circuits shall be installed and its use shall be kept to an unavoidable minimum. Wiring of circuits which have been approved as intrinsically safe may follow the requirements of general electrical wiring except that the following requirements shall be observed:

a) The conditions of use laid down on the test certificate issued by the approving authority shall be observed,
b) The wiring shall be so made as to avoid contact with other circuits,
c) The wiring shall be so made as to avoid electromagnetic or electrostatic induction from other circuit(s).

d) The wiring shall be adequately protected against mechanical damage, and
e) Aluminium armoured or sheathed cable shall not be used in Zone 0 areas.

7.2.2 *Wiring Design*

7.2.2.1 Correctly designed terminations complete with armour clamps shall be provided for armoured cables. The armouring should be carried into the clamps to provide mechanical support to the cable and to ensure electrical continuity. Where such cable is lead covered and armoured, the lead-sheath should be plumbed or mechanically gripped and sealed and the armouring should be carried over the lead joint.

7.2.2.2 Where circuits traverse a hazardous area in passing from one non-hazardous area to another, the wiring in the hazardous area should comply with the requirements of this standard.

7.2.2.3 Where practicable, contact either deliberate or accidental, should be avoided between electrical apparatus, conduit or cables, and any equipment or pipework used for carrying combustible gases, vapours or liquids.

7.2.2.4 Where, owing to particular circumstances, contact between components referred to in **7.2.2.3** is unavoidable, the armouring, conduit or sheathing of the cable should be bonded to the equipment or pipework in such a manner and at such intervals as to ensure that under the worst fault conditions, the passage of any current will not give rise to incendive sparking or bring about a temperature rise approaching the ignition temperature of the combustible gas, vapour or liquid which may be present. Alternatively, in the case of cable, the insulation of the sheath may be sufficient to prevent danger.

7.2.2.5 Where cables or conduits pass through a floor, wall, partition or ceiling, the hole provided for them should be sealed with cement or similar incombustible material to the full thickness of the floor, wall, partition or ceiling, so that no space remains around the cable through which combustible gas liquid or vapour might spread. Alternatively cable glands may be used for this purpose.

7.2.2.6 Where trunking, ducts, pipes or trenches are used to accommodate cables, precautions should be taken to prevent the passage of combustible gases, vapours or liquids from one area to another, and to prevent the collection of combustible gases, vapours or liquids in trenches. Such precautions may involve the sealing of trunking, ducts and pipes, and the adequate ventilation or sand filling of trenches.

7.2.2.7 Where an overhead supply line is used for either power or telecommunication circuits, it should be terminated outside the hazardous area and be fitted at or near the terminal pole with an effective surge-protection apparatus. The cable used to connect the overhead line with the installation in the hazardous area should comply with the recommendations for wiring systems in hazardous areas. Conduit should not be used if it is likely to be subjected to vibration. The casing, armouring or sheathing and armouring should be electrically continuous and the end adjacent to the point of connection with the overhead line should be bonded to the earth electrode of the overhead line. In addition, the casing or sheathing should be independently earthed as near as possible to the junction of the cable, with the installation and bonded to the earthing lead of any lightning protective system associated with the hazardous area. If convenient, a common electrode may be used for this independent earth and for the lightning-protective system of the installation.

Where the overhead line supplying a building forming a hazardous area is supported by the building, and the connecting cable to the installation consequently is short, the earth electrodes for the surge-protection apparatus on the overhead line may be used for earthing the cable sheath or casing and for any lightning protective system associated with the hazardous area.

7.2.2.8 The wiring entry to the apparatus, direct or indirect, should maintain the type of protection used.

7.2.2.9 Unused cable entries in electrical apparatus should be closed with plugs suitable for the type of protection used.

7.2.2.10 Where cable terminals are used in apparatus and accessories with the type of protection 'e' or 'n' they shall be fixed in position so as to ensure maintenance of the creepage and clearance distances as specified in IS/IEC 60079-7 and IS /IEC 60079-15.

7.2.3 *Laying of Conduits*

7.2.3.1 Conduits shall be solid-drawn or seamless, screwed and galvanized.

Conduit, having an external diameter of more than 25 mm, should be fitted with a stopper box at each point of connection with apparatus or fittings, unless a self-contained assembly, independent of external connections, has been certified.

7.2.3.2 Elbows of the solid type may be used for the immediate connection of conduit to apparatus.

7.2.3.3 The lengths of the screwed part of any conduit should be in accordance with the requirements of IS/IEC 60079-1.

7.2.3.4 Where, in a run of conduit, it is necessary to employ a joint other than a screwed coupler, certified unions approved for flame-proof purposes should be used. The use of running couplings is not recommended but where it is impracticable to avoid their use, factory made assemblies should be used and the running coupling should be secured by locknuts.

7.2.3.5 All screwed joints should be pulled up tight and should, in addition, be provided with locknuts.

7.2.3.6 Surface-mounted conduit should be supported by spacing saddles.

7.2.3.7 Elbows or tees, other than those of the inspection type, should not be used except for the immediate connection of conduit to apparatus, and all inspection fittings should be of the flameproof type.

7.2.3.8 All joints in an assembly or conduit should be painted after assembly with moisture-resisting paint to inhibit the development of rust.

NOTE — It is important to ensure efficient earthing and bonding in a flameproof installation. In view of the operating conditions associated with the use of flameproof apparatus, attention is drawn to the necessity of ensuring that the resistance of all joints, including those in or between flameproof enclosures and conduit, or cable sheaths and armour, is such as to prevent a dangerous rise of temperature or voltage from the passage of fault current, and that the total resistance of the earth-fault current path, measured from any point in the installation, is such as to ensure reliable operation of the protection devices in all seasons.

7.2.3.9 Where a run of conduit, irrespective of size, passes from a hazardous area to a non-hazardous area, a stopper or sealing box or appropriate sealing device shall be inserted on the side remote from the hazardous area. There shall be no union, coupling, box or fitting in the conduit between the sealing fittings and point at which the conduit leaves the hazardous locations.

7.2.3.10 Seals shall be provided within 450 mm where conduit run is terminated on the apparatus.

7.2.3.11 Metal conduit containing no unions, couplings, boxes or fittings that passes through a hazardous location with no fittings less than 300 mm beyond each boundary may not be sealed if the termination points of the unbroken conduit are in non-hazardous locations.

7.2.3.12 For canned pumps, process connections for instruments, etc, that depend upon a single seal diaphragm or tube to prevent process fluids from entering the electrical conduit system, an additional approved seal or barrier shall be provided with an adequate drain between the seals in such a manner that leaks would be obvious.

7.2.3.13 Where there is a probability that any vapour or moisture in the air may be condensed into liquid within the conduit runs, boxes or sealing fittings, proper means shall be provided to prevent accumulation of or to permit drainage of such liquid periodically.

7.2.4 *Laying of Cables*

7.2.4.1 Cable systems include cables laid above ground or cables laid underground directly buried, in concrete trenches, or in cable ducts. The types of the cable for use in hazardous areas shall be as specified in this Section.

7.2.4.2 Cable runs should, where practicable, be uninterrupted, that is, continuous and therefore, free from intermediate joints. Where discontinuities cannot be avoided, either during installation or subsequently, the apparatus used for interconnection should be provided with the type of protection appropriate to the zone.

7.2.4.3 All cables shall be provided with adequate mechanical protection. Cables shall be adequately supported throughout their length, care being taken to avoid excessive pressure when clamp supports are used. Horizontal cables may be carried on supports, cable trays or through protective troughs or tubes. Rising cables should be clipped, cleated or otherwise attached to suitable supports which provide adequate mechanical protection.

7.2.4.4 Where paper-insulated armoured cables are used, and particularly where such cables may be exposed to high temperature, preference should be given to non-draining cables. In the case of other types of paper-insulated armoured cables, vertical runs should be avoided.

7.2.4.5 The passage of cables from a hazardous area to a non-hazardous area should, if necessary, be provided with adequate means to prevent the transmission of flammable material into the non-hazardous area consideration should also be given to the treatment of cables against fire transmission.

7.2.4.6 Where trunking, ducts, pipes or trenches are used to accommodate cables, precautions should be taken to prevent the passage of combustible gases, vapours or liquids from one area to another, and to prevent the collection of combustible gases, vapours or liquids in trenches. Such precautions may involve the sealing of trunking, ducts and pipes and the adequate ventilation or sand filling of trenches.

7.2.4.7 Cables capable of transmitting gases or vapours through the core shall be sealed in the hazardous location in such a manner as to prevent passage of gases or vapours into a non-hazardous location.

7.2.4.8 Correctly designed terminations complete with armour clamps shall be provided for armoured cables, the armouring should be carried into the clamps to provide mechanical support to the cable and to ensure electrical continuity. Where such cables are lead covered and armoured, the lead sheath should be plumbed or mechanically gripped and sealed and the armouring should be carried over the lead joint.

7.2.4.9 Cable glands, where used, shall be flameproof type for flameproof enclosure and double-compression type for enclosure having type of protection other than flameproof.

7.2.4.10 Cable fittings for mineral insulated cables shall be suitable for use with the appropriate apparatus to which they are to be attached. Fittings should be arranged for sealing the cable insulation and be provided with means for ensuring adequate earth continuity.

7.2.4.11 Where electrolytic corrosion of copper sheath of mineral insulated cable may result from contact with walls or other surfaces to which the cable is attached, it should be kept clear of such surface or covered with a protective sheath.

7.2.4.12 Where there is risk of mineral-insulated cables being exposed to excessive voltages such as inductive surges; surge suppression devices should be fitted. Where surge suppression devices are installed in hazardous areas, they should be suitably explosion-protected.

7.2.4.13 Aluminium sheathed cables, unless sheathed with a protective covering, should not be installed in contact with walls or floor. Consideration should be given to the avoidance of frictional contact with such cables.

7.2.5 *Plugs and Sockets*

7.2.5.1 Plugs and sockets for installation in Zone 2 areas shall be flameproof type. Those shall be of interlocked switch type.

7.2.5.2 Plugs and sockets shall be of the type that provides for connections to the earthing conductor of the flexible cables. The contacts of the grounding conductor shall be mechanically and electrically of at least the same quality as the main contacts and when the plug is inserted it shall make connection before or at the same time as the main contacts are made.

7.2.6 *Connections to Portable and Transportable Apparatus*

7.2.6.1 Flexible cables of the types specified below may be used for connection between a fixed source of supply and the portable transportable apparatus through flameproof plugs and sockets:

a) Ordinary tough rubber sheathed flexible cables,
b) Ordinary tough polychloroprene sheathed flexible cables,
c) Heavy tough rubber sheathed flexible cables, and
d) Plastic insulated cables equivalent to ordinary tough rubber sheathed flexible cables.

Use of screened cables is also permitted.

All flexible cables shall be provided with braiding for mechanical protection.

7.2.6.2 An effective cable clamping device so designed as not to damage the insulation of the flexible cable, should be provided at the points of entry of the flexible cable to the apparatus and plug. In addition, means should be provided to prevent sharp bending of the cable at both points of entry.

7.2.7 *Protective Measures from Dangerous Sparking*

7.2.7.1 *Dangers from live parts*

In order to avoid the formation of sparks liable to ignite the explosive gas atmosphere, any contact with bare live parts other than intrinsically safe parts shall be prevented.

Where this requirement is not met by construction other precautions shall be taken. In certain cases a warning label such as 'Isolate elsewhere before opening' may be sufficient.

7.2.7.2 *Dangers from exposed and extraneous conductive parts*

It is impracticable to cover all possible systems in this case but the basic principles on which safety depends are the limitation of earth currents (magnitude and potentials on equalizing conductors).

NOTE — The term extraneous conductive parts is defined as a conductive part likely to propagate a potential and not forming part of the electrical installation.

Guidance on permissible power systems is given below:

a) If a power system with an earthed neutral is used, the type TN-S system with separate neutral (N) and protective conductor (PE) throughout the system is preferred.

   The neutral and the protective conductor shall not be connected together, or combined in a single conductor, in a hazardous area.

   A power system of type TN-C (having combined neutral and protective functions in a single conductor throughout the system) is not allowed in hazardous areas.

b) If a type IT power system (separate earths for power system and exposed conductive parts) is used in Zone 1, it shall be protected with a residual current device even if it is a safety extra-low voltage circuit (below 50 V).

   The type TT power system is not permitted in Zone 0.

c) For an IT power system (neutral isolated from earth or earthed through impedance), an insulation monitoring device should be used to indicate the first earth fault. However equipment in Zone 0 shall be disconnected instantaneously in case of the first earth fault, either by the monitoring device or by a residual current operated device.

d) For all power systems installed in Zone 0, irrespective of the voltages, due attention should be paid to the limitation of earth fault currents in magnitude and duration. Instantaneous earth fault protection shall be installed.

NOTE — It may also be necessary to provide instantaneous earth fault protection devices for certain applications in Zone 1.

7.2.7.3 *Potential equalization*

To avoid dangerous sparking between metallic parts of structures, potential equalization is, always required for installations in Zone 0 and Zone 1 areas and may also be necessary for installations in Zone 2 areas. Therefore, all exposed and extraneous conductive parts shall be connected to the main or supplementary equipotential bonding system.

The bonding system may include normal protective conductors, conduits, metal cable sheaths, steel wire armouring and metallic parts of structures but shall not include neutral conductors. The conductance between metallic parts of structures shall correspond to a cross section of at least 10 mm^2 of copper.

Enclosures need not be separately connected to the equipotential bonding system if they are secured to and are in metallic contact with structural parts or piping which are connected to the equipotential bonding system. For additional information, *see* relevant Indian Standards.

However, there are certain pieces of equipment, for example some intrinsically safe apparatus, which are not intended to be connected to the equipotential bonding system.

NOTE — Potential equalization between vehicles and fixed installations may require special means, for example, when insulated flanges in connecting pipelines are used.

7.2.7.4 *Cathodically protected metallic parts*

Cathodically protected metallic parts located in hazardous areas are live extraneous conductive parts which shall be considered potentially dangerous (especially if equipped with the impressed current method) despite their low negative potential. No cathodic protection shall be provided for metallic parts in Zone 0 unless they are specially designed for this application.

7.2.7.5 *Electromagnetic radiation*

Account should be taken of the effects due to strong electromagnetic radiation.

7.3 Selection of Equipment

7.3.1 *General*

7.3.1.1 The selection of electrical apparatus for explosive gas atmospheres is based on the general principle that the likelihood of the simultaneous presence of a hazardous atmosphere and a source of ignition is reduced to an acceptably low level.

7.3.1.2 When the electrical apparatus does not have an internal release of flammable material, the classification of the hazardous area surrounding the electrical equipment decides the selection of an adequate type of protection.

7.3.1.3 When the electrical apparatus has an internal release of flammable material, the actual hazard is a combination of the external and internal hazards and both must be taken into account when selecting an adequate type of protection.

7.3.1.4 The selected apparatus will normally have a recognized type of protection and should also be selected for the appropriate temperature class and the appropriate apparatus group applicable. Where gases of different degrees of hazard exist in the same area, the type of protection appropriate for the highest degree of hazards shall be applicable.

7.3.1.5 The selected electrical apparatus shall be adequately protected against corrosive and solvent agencies, and against water ingress and thermal and mechanical stresses as determined by the environmental conditions. These construction requirements should ensure that the protection against explosion is not reduced when the apparatus is used in the specified conditions of service.

7.3.1.6 Particular consideration shall be given to the location of apparatus which incorporates aluminium or light alloys in the construction of its enclosure. These have been outlined in IS 5571 reference to which should be made (*see also* IS/IEC 60079-1).

7.3.1.7 As electrical apparatus for flammable gas atmospheres requires special safety maintenance after they are installed, the selection of electrical apparatus shall be made with full considerations to the facility and frequency of inspection and maintenance, preparation for spares and repairing materials and the extent of allowable interruption of power supply during maintenance work.

7.3.1.8 It is advisable that the selection of electrical apparatus be made after full considerations have been given not only to the initial cost of installation but also to the expected life and expenses for operation and maintenance of the apparatus.

7.3.1.9 Unless otherwise specified for particular equipment, the guidance provided in Table 2 shall be followed in the selection of equipment for hazardous areas. However, any equipment which in the opinion of the authorised inspector affords a degree of safety not less than that afforded by the equipment specified may be accepted as an alternative.

7.3.1.10 The necessity for equipment with flameproof enclosures or other enclosures may sometimes be eliminated by the adoption of special design, such as pressurised equipment.

7.3.2 *Selection Procedure*

7.3.2.1 In order that electrical apparatus may be selected for use in hazardous area, the following information is necessary:

a) The classification of the area, that is, the zone (*see* **7.2.1.1**).
b) The ignition temperature of the gas or vapour involved, or the lowest values of ignition temperature if more than one combustible material is present.

   This will permit determination of the temperature classification required for the apparatus, or the upper-limit temperature for any unprotected surface according to IS/IEC 60079-0 (*see* **7.3.2.3**).
c) The characteristics of the gas or vapour involved in relation to (*see* **7.3.2.3**).
   1) Ignition current or minimum ignition energy in the case of installations of intrinsically safe apparatus, or
   2) Safe gap data in the case of installations for flameproof enclosures.

Apparatus certified to the constructional and design requirements for a particular group may also be used with compounds of lesser risk and which would be allocated therefore to a lesser group, subject again to consideration of temperature classification and chemical compatibility.

Similarly electrical apparatus which is designed so that it may be used with certain flammable materials in a particular zone may be used with flammable materials in zone of lesser risk without restriction provided it is determined that the flammable materials likely to be present are compatible with the following characteristics of the apparatus:

a) Apparatus grouping (where this is applicable).
b) Temperature classification.
c) Chemical compatibility.

7.3.2.2 *Selection of type of protection*

The selection of type of protection of the equipment for different zone of hazardous areas shall be made in accordance with Tables 2, 3 and 4 as applicable.

7.3.2.3 *Temperature classes*

Besides the danger of explosion caused by an electric spark or arc, there is also a danger of ignition at a hot surface exposed to a flammable atmosphere. The maximum surface temperature of any unprotected surface of electrical equipment should not exceed the ignition temperature of the gas or vapour.

Flammable gases and vapours fall into fairly well-defined groups when classified with reference to their ignition temperature. To simplify the manufacture of apparatus, therefore, the permitted maximum surface temperatures have been classified in IS/IEC 60079-0 as follows:

Temperature Class Required by the Area Classification	*Ignition Temperature of Gas or Vapour (°C)*	*Allowable Temperature Classes of Equipment*
T1	>450	T1-T6
T2	>300	T2-T6
T3	>200	T3-T6
T4	>135	T4-T6
T5	>100	T5-T6
T6	>85	T6

If the marking of the electrical equipment does not include an ambient temperature range, the equipment shall be used only within the temperature range –20 °C to +40 °C. If the marking of the electrical equipment includes an ambient temperature range, the equipment shall only be used within this range.

If there is an influence from an ambient temperature outside the temperature range, the process temperature or exposure to sun light, the effect on the equipment shall be verified as suitable for the application and documented.

Ambient temperatures do not consider solar radiation. Where applicable, additional factors should be applied.

Junction boxes and switches in intrinsically safe circuits, however, can be assumed to have a temperature classification of T6 because, by their nature, they do not contain heat dissipating components. Simple apparatus used within an intrinsically safe circuit shall

Table 2 Types of Protection for Different Hazardous Areas
(*Clauses* 7.3.1.9 *and* 7.3.2.2)

Sl No.	Area Classification	Type of Protection	Description
(1)	(2)	(3)	(4)
i)	Zone 0	Electrical equipment and circuits can be used in Zone 0, if they are constructed in accordance with following:	
		a) Intrinsic safety (category "i_a") according to IS 5780	*Intrinsic Safety* (Ex-i) A circuit or part of a circuit is intrinsically safe when any spark or thermal effect produced normally (that is, by breaking or closing the circuit) or accidentally (for example by short-circuit or earth fault) is incapable, under prescribed test conditions, of causing ignition of a prescribed gas or vapour.
		b) EPL "Ga"	*EPL "Ga"* Equipment for explosive gas atmospheres, having a "very high" level of protection, which is not a source of ignition in normal operation, expected malfunction or when subject to rare malfunction. Such equipment will have a form of protection which will remain effective even in the presence of two potential faults (for example, intrinsic safety, level of protection i_a), or will have two independent means of protection (for example, Ex-e and Ex-d acting independently of each other).
ii)	Zone 1	Electrical equipment can be used in Zone 1 if it is constructed in accordance with the requirements for Zone 0 or one or more of the following types of protection:	
		a) EPL "Gb"	*EPL "Gb"* Equipment for explosive gas atmospheres, having a "high" level of protection, which is not a source of ignition in normal operation or when subject to faults that may be expected, though not necessarily on a regular basis
		b) Flameproof enclosures "d" according to IS/IEC 60079-1	*Flameproof enclosures* (Ex-d) An enclosure for electrical apparatus that will withstand when the covers or other access doors are properly secured, an internal explosion of the flammable gas or vapour which may enter it or which may originate inside the enclosure, without suffering damage and without communicating the internal flammation to the external flammable gas or vapour for which it is designed, through any joints or structural openings in the enclosure.
		c) Pressurized enclosures "p" according to IS 7389	*Pressurized Enclosure* (Ex-p) An enclosure for electrical apparatus in which the entry of flammable gas or vapour is prevented by maintaining the air (or other non-flammable gas) within the enclosure at a pressure above that of the external atmosphere. This type of protection has the following categories (for choice *see* Table 3): 1) Pressurization with air and alarm in case of loss of air pressure [Ex-p (1)]. 2) Pressurization with air and automatic switching off from electric supply in case of loss of air pressure [Ex-p (2)]. 3) Pressurization with inert gas and alarm in case of loss of inert gas pressure [Ex-p (3)]. 4) Pressurization with inert gas and automatic switching off from electric supply in case of less of inert gas pressure [Ex-p (4)]. 5) Dilution with air and alarm in case of loss of air supply [Ex-p (5)]. 6) Dilution with air and automatic switching off from electric supply in case of loss of air supply [Ex-p (6)].
		d) Powder filling "q" according to IS 7724	*Sand-filled apparatus* (Ex-q) Electrical apparatus which has all its live parts entirely embedded in a mass of powdery material, in such a way that under the conditions of use for which the apparatus has been designed no arc occurs within the outer explosive atmosphere either by the transmission of flame or by the overheating of the walls of the enclosure.
		e) Oil immersion "o" according to IS 7693	*Oil Immersed Apparatus* (Ex-o) Electrical apparatus in which all parts in which an arc may occur in normal service are immersed in oil to a sufficient depth to prevent ignition of an explosive gas mixture that may be present above the surface of the oil, and all live parts in which arcs do not occur in normal service are either immersed in oil or protected by some other recognised techniques (*see* Notes 3 and 5).

Table 2 — (*Concluded*)

Sl No. (1)	Area Classification (2)	Type of Protection (3)	Description (4)
		f) Intrinsic safety "i_b" according to IS 5780	*Intrinsically Safe Apparatus* (Ex-i_b) Electrical apparatus in which all the circuits are intrinsically safe.
		g) Encapsulation "m" according to IS/IEC 60079-18	*Encapsulation "m"* (Ex-m) Type of protection whereby parts that are capable of igniting an explosive atmosphere by either sparking or heating are enclosed in a compound in such a way that the explosive atmosphere cannot be ignited under operating or installation conditions.
		h) Electrical Heat Tracers and equipment which are certified for use in Zone 1 areas	
iii)	Zone 2	a) Electrical equipment can be used in Zone 2 if it is constructed in accordance with the requirements for Zone 0/ Zone 1 or one or more of the following types of protection: EPL "Gc"	*EPL "Gc"* Equipment for explosive gas atmospheres, having a "enhanced" level of protection, which is not a source of ignition in normal operation and which may have some additional protection to ensure that it remains inactive as an ignition source in the case of regular expected occurrences (for example failure of a lamp).
		b) Non-sparking "n" according to IS/IEC 60079-15 (*see* Note 2)	*Non-sparking Apparatus* (Ex-n) Apparatus which in normal operation is not capable of igniting a surrounding explosive atmosphere, and a fault capable of causing ignition is not likely to occur.
		c) Intrinsic safety "i_c" according to IS/IEC 60079-11	*Intrinsically Safe Apparatus* (Ex-i_c) Electrical apparatus in which all the circuits are intrinsically safe.
		d) Increased safety "e" according to IS/IEC 60079-7 (*see* Note 2)	*Increased Safety* (Ex-e) A method of protection in which measures additional to those adopted in ordinary industrial practice are applied, so as to give increased security against the possibility of excessive temperatures and the occurrence of arcs or sparks in electrical apparatus which does not produce arcs or sparks in normal service.
		e) Electrical Heat Tracers and equipment, which are certified for use in Zone 2	

NOTES

1 Special protection category is reserved for those types of protection that cannot be classified as belonging wholly to anyone of the above types. It may be that a combination of several types of protection is incorporated within one piece of apparatus.

2 For outdoor installation, the apparatus with type of protection 'e' and 'n' should be used with enclosures providing at least the following degree of protection:

a) IP 55 where there are uninsulated conducting parts internally, and

b) IP 44 for insulated parts.

3 Oil-immersed apparatus may be used only in case its security will not be impaired by tilting or vibration of the apparatus.

4 For apparatus with type of protection 'p', 'c', 'n' and where applicable, 'q' only area classification and ignition temperature are required. However, where apparatus is protected by Ex-'i' or Ex-'d' in addition to one of these types of protection, it is necessary to determine the appropriate apparatus grouping according to IS/IEC 60079-11 and IS/IEC 60079-1 respectively.

5 Type "o" equipment shall not be used in Zone 1 area in Oil mines.

6 Even though, in general, use of increased safety equipment in Zone 1 area is not permitted, certain equipment having a combination of Ex-i, Ex-e and Ex-d protection may be used in Zone 1 areas, provided the Ex-e protection is limited to the termination of cables / wires only.

7 Various Indian standards for electrical equipment for hazardous areas have been aligned with IEC Standards to facilitate manufacturers and testing bodies. However selection and installation of these equipment in hazardous areas shall follow IS 5571.

8 Requirements of diesel engines for hazardous areas are covered in Annex D.

Table 3 Minimum Actions on Failure of Protective Gas for Type of Protection 'p'

(*Clause* 7.3.2.1)

Sl. No (1)	Area Classification (2)	Enclosure Does not Contain Ignition-Capable Apparatus (3)	Enclosure Contains Ignition-Capable Apparatus (4)
i)	Zone 1	Alarm	Alarm and switch off
ii)	Zone 2	No action required	Alarm

Table 4 Adequate Types of Protection for Electrical Apparatus with an Internal Source of Release
(*Clause* 7.3.2.1)

Sl No.	Internal Release		Area Classification	Type of Protection										
	Normal	Abnormal		d	e	i_a	i_b	n	P(1)	P(2)	P(3)	P(4)	P(5)	P(6)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
i)	None	Restricted	NH, Zone 2	2	✓	✓	✓	✓	2	2	✓	✓	✓	✓
			Zone 1	2	—	✓	✓	—	2	2	2	✓	2	✓
		Unrestricted	NH, Zone 2	2	✓	✓	✓	✓	2	2	✓	✓	2	2
			Zone 1	2	—	✓	✓	—	2	2	2	✓	2	2
ii)	Restricted	Restricted	NH, Zone 2	1	—	✓	—	—	—	—	✓	✓	✓	✓
			Zone 1	1	—	✓	—	—	—	—	2	✓	2	✓
		Unrestricted	NH, Zone 2	1	—	✓	—	—	—	—	✓	✓	2	2
			Zone 1	1	—	✓	—	—	—	—	2	✓	2	2
iii)	Unrestricted	Not relevant	NH, Zone 2	1	—	✓	—	—	—	—	✓	✓	—	—
			Zone 1	1	—	✓	—	—	—	—	2	✓	—	—
iv)	Not relevant	Not relevant	Zone 0	—	—	✓	—	—	—	—	—	—	—	—

NOTE
NH : Non-hazardous area.
✓ : Adequate.
1 : Adequate, if the internal components of circuits have type of protection adequate for Zone-1.
2 : Adequate, if the internal components of circuits are not ignition-capable during normal operation.
— : Not adequate

be temperature classified in accordance with IS 5571.

Cable glands in normal service do not create a heat source and therefore do not have a temperature class or ambient operating temperature range marked on them. In general cable glands will be marked with service temperature. If no marking exists it is assumed that the service temperature is –20°C to +80°C.

NOTE — Consideration of the capability of the equipment and cables to operate in the required temperature range should include normal operating limits as well as temperature rise.

7.3.2.4 *Apparatus groups*

For the purpose of flameproof enclosures and intrinsic safety, gases and vapours have been classified according to the groups or sub-groups of apparatus required for use in the particular gas or vapour atmosphere. The groups of the apparatus are:

a) Group I — for mining applications, susceptible to fire damp

b) Group II — applications in industries with an explosive gas atmosphere, other than mines susceptible to firedamp

c) Group II — apparatus is sub-divided according to the requirements appropriate to the nature of the flammable atmosphere for which the apparatus is intended. These sub-groups with a representative gas and the design parameters are as follows:

Apparatus Sub-group	*Representative Gas*	*Maximum Experimental Safe Gap*	*Minimum Ignition Current Ratio*
(1)	(2)	(3)	(4)
IIA	Propane	≥0.9 mm	Above 0.8
IIB	Ethylene	Greater than 0.5 mm less than 0.9 mm	Between 0.45 and 0.8
IIC	Hydrogen	≤ 0.5 mm	Below 0.45

Various gases and vapours, for which a particular group of enclosure is suitable are listed in IS 9570.

NOTE — For flameproof enclosures, gases and vapours are classified according to their maximum experimental safe gap (MESG). For intrinsic safety, gases and vapours are classified according to the ratio of their minimum igniting currents (MIC) with that of laboratory methane (*see also* IS 9735).

7.3.3 *Individual Features of Electrical Equipment for Hazardous Areas*

The essential features of individual equipment for installation in hazardous areas are indicated in Table 5.

7.4 Miscellaneous Requirements

7.4.1 *Exceptional Circumstances*

7.4.1.1 In exceptional circumstances (for example, research, development or repair-work, and in emergency situations) apparatus may be used which is not specially designed for use in Zone 1 or Zone 2 hazardous areas, provided that adequate measures have been taken to ensure an adequate level of safety.

7.4.1.2 Apparatus which is intended to be used for short periods only may be of normal industrial design but only when operating in Zone 2, it is either regularly supervized by trained personnel or gas-free conditions are regularly monitored.

7.4.2 *Static Electricity* (*See* IS 7689)

7.4.3 *Pressurized Rooms*

7.4.3.1 Where unavoidable, electrical switchgear and equipment may be located in a pressurized room within a hazardous area meeting the following requirements:

a) The pressurized room shall be situated in such area within a hazardous location, which is least hazardous and from which the operators working in the room can easily evacuate in the event of an accident.
b) Main structural parts such as wells, pillars, ceiling, floor, doors and the like shall be on non-combustible materials and shall be sufficiently resistant to explosion blasts or other mechanical effects.
c) Structural materials and construction of the room shall be such as not to allow gases or vapours to penetrate easily through them.
d) More than one doorway shall be provided, and at least one of them shall face the direction of no source of hazard as for as practicable.
e) The design of the doorway facing the hazardous area shall be such that the doors can only be opened outwards from the interior and they shall be double doors.
f) In case it is necessary to provide a window facing the hazardous area, the window shall have enough strength to resist an explosion blast, blowout of gases or other possible mechanical effects.
g) The source of air shall be free of hazardous concentrations of flammable gases and vapours contaminants and any other foreign matter. It shall be determined from the nature of the process and the physical layout.
h) The volume and pressure of supply air shall be such that the air pressure in the vicinity of doorways is maintained higher than the atmospheric pressure outside the room.
j) An alarm or other device shall be provided so that any disorder in the pressurization system may be assuredly noticed.
k) Openings to lead wirings or pipings from the hazardous locations into the room shall be so constructed as not to admit explosive gases into the room, by filling tightly the space around conduits or pipes with cement or similar incombustible materials.

NOTE — Elevated ambient temperatures can be expected in pressurized rooms. Accordingly, it is advisable that due account be taken while selecting electrical equipment for installation in pressurized rooms.

7.4.3.2 Prior to commissioning apparatus protected by pressurization or continuous dilution, it shall be verified by competent personnel that the installation of the equipment fulfils the requirements of relevant Indian Standards, either by inspection of the reference documents, or by tests if necessary.

The following shall be considered:

a) the protective gas supply is suitable, that is, impurities in the protective gas will not reduce the level of safety such as by attacking the enclosure or ducting material or introducing flammable material into the enclosure.
b) The apparatus design and safety provisions are such that purging can be completed satisfactorily.
c) The minimum pressure required is maintained with the minimum protective gas supply stated by the manufacturer.
d) The maximum temperature limits stated are not exceeded.

NOTE — Satisfactory completion of purging would include passing a volume of protective gas of at least five times the free internal volume of the protected enclosure and associated ducting, prior to energizing the electrical apparatus.

With regard to installation practices, the following shall be considered:

a) For wiring systems:
    1) When cable wiring systems are used, the cable entries shall prevent excess leakage of the protective gas and ensure that sparks or incandescent particles do not escape from the enclosure.
    2) When conduit wiring systems are used, it is recommended that all conduit entrances to an enclosure be sealed to prevent excess leakage of protective gas unless the conduit system is being used as a duct for supplying the protective gas.
b) The point at which the protective gas enters the supply duct or ducts should be situated in a non-hazardous area.
c) Ducting should, as far as possible, be located in a non-hazardous area. If ducting passes through a hazardous area, it shall be checked

Table 5 Features of Electrical Equipment

(*Clause* 7.3.3)

Sl No.	Equipment	Zone 0	Zone 1	Zone 2
(1)	(2)	(3)	(4)	(5)
i)	Motors	No motor shall be used in this area	a) Motor with type of protection 'd' b) Motors with type of protection 'p'	a) Motor suitable for Zone-1 area. b) Motors with type of protection 'n' and 'e'. However, all normally sparking parts such as slip-rings and brushes shall be provided with type of protection 'd' or 'p'. Motors provided with a combination of the above forms of protection. For example, slip-ring motors in which the main enclosures and windings are of type 'e' but the normally sparking parts of type 'd' protection
ii)	Transformers and capacitors	No transformer or capacitor shall be used in this area	a) All power and distribution transformers and capacitors with type 'd' protection. b) Type 'i' protection for control and instrumentation, with transformers and capacitors forming part of flameproof or intrinsically safe equipment.	Transformers and capacitors suitable for Zone 1 area. Transformers and capacitors that are dry type or containing liquids need not have any special enclosure provided that the following requirements are satisfied: a) Cable boxes shall be suitable for specified level of current and fault clearing time. b) Only off-circuit manually operated tap changers shall be allowed with provision for locking the operating handle in position. c) Auxiliary devices shall be intrinsically safe or if they have sparking contacts, these shall be: 1) Type 'd' 2) Under adequate head of oil. 3) of mercury in glass type with adequate mechanical protection. 4) of enclosed break type or, alternatively, auxiliary devices may be deleted or installed in a safe zone. d) Any other sparking accessories or switches shall comply with the requirements for Zone 1 area. Where oil filled transformers are used, necessary precautions against spread of fire (*see* IS 1646) shall be complied with.
iii)	Lighting fittings (*see* Notes 1 and 2)	No lighting fitting shall be used	All switches, circuit breakers, fuses and other equipment shall be housed in an enclosure with type 'd' protection.	a) Lighting fittings for Zone 1. b) Lighting fittings with type of protection 'e' or 'n'.
iv)	Switchgear and control gear	No switchgear and control gear shall be used. When not practicable use type 'i' protection	All switches circuit breakers, fuses and other equipment, the enclosure together with the enclosed apparatus shall be type 'd' protection.	All equipment where arcing may occur under normal conditions of operating shall be of type 'd', unless the current interrupting contacts are oil-immersed, or the switches are enclosed break type with flameproof breaking chamber or having mercury in glass switches or enclosed break micro switches.
v)	Generators	No generator shall be used	Generators with Type 'd' and 'p' protection	Equipment suitable for Zone 1 areas. Generators with type 'n' protection or 'e' and having brushless excitation system and sparking parts, if provided shall comply with Zone 1 requirements.
vi)	Diesel engines	Unacceptable	The use of permanently installed diesel engines to be avoided. Where necessary, they shall satisfy the requirements as given in Annex D.	a) The use of permanently installed diesel engines to be avoided. b) Equipment suitable in Zone 1 areas.
vii)	Storage batteries	Shall not be used	Storage batteries shall not be installed in Zone 1 areas, except those in portable torches where the enclosures housing the bulb, switch and battery shall be flameproof type.	Storage batteries shall be of type 'e' protection (*see also* Annex E).

NOTES

1 Low-pressure sodium lamps shall not be used in a hazardous area owing to the risk of ignition from the free sodium from a broken lamp.

2 If luminaires with fluorescent lamps are used in a hazardous area, then the area should be confirmed to be free from group IIC gas/vapour before lamps are transported through the area or changed, unless suitable precautions are taken to prevent tubes being broken.

for leaks prior to start-up of the electrical apparatus to ensure that the requirements of **7.4.3.2** (a) are met.

d) Exhaust ducting shall vent to a non-hazardous area or otherwise be designed to prevent the emission of sparks or hot particles such as by the use of spark arrestors or baffles. Care should be taken to ensure that the exhaust does not result in a secondary hazardous source in an otherwise non-hazardous area.

7.4.4 *Intrinsically Safe Installations*

A fundamentally different installation philosophy has to be recognized in the installation of intrinsically safe circuits. In comparison with all other types of installations, where care is taken to confine electrical energy to the installed system as designed so that a hazardous environment cannot be ignited, the integrity of an intrinsically safe circuit has to be electrically protected from the environment in order that the safe energy limitation in the circuit is not exceeded, even when breaking, shorting or earthing of the circuit occurs.

As a consequence of this principle the aim of the installation rules for intrinsically safe circuits is to maintain separation from other circuits.

7.4.4.1 Intrinsically safe circuits may be installed either;

a) isolated from earth, or
b) connected at one point to the potential equalization conductor if this exists in the whole area of the installation of the intrinsically safe circuits, or
c) connected to earth at one point only, if earthing is required for functional or protective purposes.

The installation method shall be chosen with regard to the functional requirements of the circuits according to the manufacturers' instructions.

If the circuit is isolated from earth, particular attention should be given to any possible danger due to static charges.

More than one earth connection is permitted on a network provided that the network is galvanically separated into circuits each of which has only one earth point.

7.4.4.2 Where a safety barrier is used, the maximum fault voltage in apparatus connected to the barrier input terminals shall not exceed the fault voltage rating of the barrier, for example, 250 V. Where a safety barrier requires a connection to earth, the connecting load to the earthing terminal of the safety barrier should be as short as possible. The cross-section of the connecting load shall take account of the short circuit current to be expected, and shall have a minimum value of 1.5 m^2 copper.

Consideration should be given to the need for earthing of the supply system connected to the barrier input terminals.

7.4.4.3 In installations with intrinsically safe circuits, for example, in measuring and control cabinets, the terminals shall be reliably separated from the non-intrinsically safe circuits (for example, by a separating panel, or a gap of at least 50 mm). The terminals of the intrinsically safe circuits shall be marked as such. All terminals shall satisfy the requirements of relevant Indian Standards.

Where terminals are arranged to provide separation of circuits by spacing alone, care shall be taken in the layout of terminals and the wiring method used, to prevent contact between circuits should a wire become disconnected.

7.4.4.4 Enclosures and wiring of intrinsically safe circuits should meet the requirements which would be applied to similar types of equipment which are intended to be installed in non-hazardous areas otherwise having the same environmental conditions. If an enclosure contains both intrinsically safe circuits and non-intrinsically safe circuits, the intrinsically safe circuits shall be clearly identified.

In installation containing both intrinsically safe apparatus and apparatus having another type of protection, the intrinsically safe circuits shall be clearly marked.

7.4.4.5 Marking may be achieved by labelling or colour coding of enclosure, terminals and cables. Where a colour is used for this purpose it shall be light blue.

7.4.4.6 Where intrinsically safe circuits may be exposed to disturbing magnetic or electric fields, suitable attention shall be given to transposition or shielding to ensure that these fields do not adversely affect the intrinsic safety of the circuit.

7.4.4.7 Unless specifically permitted, conductors of intrinsically safe circuits and conductors of non-intrinsically safe circuits shall not be run together in cables, cords, conduits, or bundles. In cable ducts and trays, intrinsically safe cables shall be separated from non-intrinsically safe cables by a mechanical barrier. Such a barrier is not required if all cables are provided with additional protective sheathing or sleeves which provide equivalent separation, or if the cables are securely fastened to ensure that physical separation is maintained.

7.4.4.8 A flexible cable may contain more than one intrinsically safe circuit if the cable installation is such as to minimize the risk of damage which could cause interconnection between different circuits.

7.4.4.9 The installation of intrinsically safe circuits shall be such that the extreme permitted values, such as capacitance, inductance and inductance to resistance ratio, are not exceeded. The permissible values shall be taken from the certificate, the nameplate of the apparatus, or from the installation instructions.

7.4.4.10 Where intrinsically safe circuits are interconnected to form a system, due account shall be taken by calculation or by measurement of the resultant combination of electrical parameters, such as inductance, and capacitance, which may affect the intrinsic safety of the system as a whole.

NOTE — In addition to electrical sparking due account should be taken of thermal effects particularly where non-certified apparatus is used.

7.4.4.11 The following equipment is considered to be intrinsically safe without certification:

Devices whose electrical parameters, according to the manufacturer's specification, do not exceed any of the values 1.2 V, 0.1 A, 20 J or 25 mW need not be certified or marked. They will be subject, however, to the requirements of relevant Indian Standard, if they are connected to a device which contains a source of energy which could cause the circuit to exceed these parameters.

8 TESTING OF INSTALLATION

8.0 All equipment intended for use in hazardous areas shall be approved by a recognized, testing and certifying authority (*see* **4.2**).

8.1 Installation tests should include insulation resistance and earth continuity resistance and the checking of fused ratings and other protection devices, settings and operation.

8.2 For periodical electrical testing, the following precautions shall be followed:

a) Insulation tests should, in general, be carried out with certified intrinsically safe insulation tester for use in hazardous areas.
b) Earth continuity tests, in general, be carried out with certified intrinsically safe earth tester embodying a hand-driven generator suitable for use in hazardous areas.
c) The rating of fuses and the settings of protective devices, where practicable, and the operation of other protective devices should be checked.

ANNEX A

(*Clause* 1.4)

EXAMPLE OF INDUSTRIES AND THEIR WORKING PLACES WHICH REQUIRE CONSIDERATIONS IN REGARD TO HAZARDOUS LOCATIONS

A-1 Though it is difficult to determine hazardous locations merely according to kind of industries or kind of working places, typical industries and working places, which require considerations in regard to hazardous locations are listed below:

1) *Ammonium sulphate manufacturing industry* — Places where gaseous raw materials are produced, electrolysis of water is conducted or synthesis of ammonia is carried out.
2) *Soda manufacturing industry* — Working places of electrolysis, synthetic hydrochloric acid manufacturing and liquid chlorine handling.
3) *Electric furnace industry* — Working places where calcium carbide is pulverised and storage of it.
4) *Compressed or liquefied flammable gas industry* — Working places where flammable gases are produced, compressed or filled. Storage of containers filled with flammable gases.
5) *Coal tar products industry* — Working places where coal tar is fractionally distilled or light oil extracted from coal is refined or fractionally distilled. Places where benzene or the other volatile flammable liquids are filled or stored.
6) *Dyestuffs and their intermediates manufacturing industry* — Working places where flammable gases or volatile flammable liquids are handled in large quantity.
7) *Fermentation industry* — Working places where volatile flammable liquids are distilled or filled. Storage of volatile flammable liquids.
8) *Acetylene*, *ethylene or methanol derivative manufacturing industries* — Working places where gaseous raw materials or volatile flammable liquids are produced, refined reacted, distilled, filled, or stored.
9) *Synthetic resin and plastic manufacturing industry* — Working places where flammable gases or volatile flammable liquids are handled in large quantity.
10) *Synthetic fibres manufacturing industry* — Working places where flammable gases or volatile flammable liquids are added, reacted, produced, recovered or stored.
11) *Vegetable oil industry*, *solvent extraction plants* — Working places where extraction or recovery is conducted using volatile flammable liquids. Storage of volatile flammable liquids. Hydrogeneration plants.
12) *Fatty acids*, *hardened oil and glycerin manufacturing industry* — Working places where hydrogen is produced or added. Other working places where flammable gases or volatile flammable liquids are used in large quantity.
13) *Wood dry distillation industry* — Working places where dry distillation or rectification is conducted. Places where volatile flammable liquids are filled or stored.
14) *Drugs and medicine manufacturing industry* — Working places where flammable gases or volatile flammable liquids are handled in large quantity. Storage of the gases and liquids.
15) *Paints manufacturing industry* — Working places where volatile flammable paints or thinners are produced. Places where volatile flammable raw materials or finished products are stored.
16) *Insecticides and germicides manufacturing industry* — Working places where flammable gases or volatile flammable liquids are handled in large quantity.
17) *Perfumes and cosmetics manufacturing industry* — Working places where volatile flammable liquids are added, prepared, distilled or extracted. Storage of these liquids.
18) *Photographic sensitive materials manufacturing industry* — Working places where volatile flammable liquids are added, prepared, applied, recovered or distilled. Storage of these liquids.
19) *Oil refining and petrochemical industry* — Working places where various refining processes or chemical reactions are conducted. Places where volatile flammable liquids are transported, filled or stored.
20) *Gum products industry* — Working places where gum arabic is produced or applied. Storage of volatile flammable liquids.
21) *Brewing industry* — Places where alcohol is distilled, added or stored.
22) *Processed paper or coated cloth manufacturing industry* — Working places

where volatile flammable liquids are added, applied or recovered.

23) *Dry-cleaning industry* — Working places where washing using flammable liquids and recovery of the said liquids are conducted. Storage of the said liquids.

24) *Finishing processes* — Working places where preparation of volatile flammable paints, locations where paints, lacquers or other flammable finishers are regularly or frequently applied by spraying, dipping, brushing or by other means, where flammable thinners are used, and where readily ignitable deposits or residues from such paints, lacquers finishers may occur.

25) *Printing industry* — Working places where printing is done using inks with addition of volatile flammable liquids.

26) *Aircraft hangars* — Location used for storage or servicing of aircraft in which gasoline, jet fuels or other volatile flammable liquid or flammable gases are used.

27) *Petrol bunks and service stations* — Location where petrol or other volatile flammable liquids, or liquefied flammable gases are transferred to the fuel tanks of vehicles.

ANNEX B

(*Clause* 2)

INDIAN STANDARDS FOR ELECTRICAL EQUIPMENT FOR USE IN EXPLOSIVE ATMOSPHERES

IS No.	*Title*
1554 (Part 1) : 1988	PVC insulated (heavy duty) electric cables: Part 1 For working voltages upto and including 1 100 V
1646 : 1997	Code of practice for fire safety of buildings (general): Electrical installations
2309 : 1989	Code of practice for the protection of buildings and allied structures against lightning
5571 : 2009	Guide for selection and installation of electrical equipment for hazardous areas
5572 : 2009	Classification of hazardous areas (other than mines) having flammable gases and vapours for electrical installation
7689 : 1989	Guide for the control of undesirable static electricity
7724 : 2004/ IEC 60079-5	Electrical apparatus for explosive gas atmoshperes — Powder filling "q"
7820 : 2004/ IEC 60079-4	Electrical apparatus for explosive gas atmospheres — Method of test for ignition temperature
9570 : 1980/ IEC 60079-12 : 1978	Classification of flammable gases or vapours with air according to their maximum experimental safe gaps and minimum igniting currents
9735 : 2003/ IEC 60079-1-1 : 2002	Electrical apparatus for explosive gas atmospheres — Flameproof enclosures "d" — Method of test for ascertainment of maximum experimental safe gap
IS/IEC 60079-0 : 2004	Explosive atmospheres: Part 0 General requirements
IS/IEC 60079-1 : 2007	Explosive atmospheres: Part 1 Equipment protection by flameproof enclosures "d"
IS/IEC 60079-2 : 2007	Explosive atmoshperes: Part 2 Equipment protection by pressurized enclosures "p"
IS/IEC 60079-6 : 2007	Explosive atmospheres : Part 6 Equipment protection by oil-immersed "o"
IS/IEC 60079-7 : 2006	Explosive atmoshpheres : Part 7 Equipment protection by increased safety 'e'
IS/IEC 60079-11: 2006	Explosive atmospheres : Part 11 Equipment protection by intrinsic safety "i"
IS/IEC 60079-15 : 2005	Explosive atmospheres: Part 15 Construction, test and marking of type of protection "n" electrical apparatus
IS/IEC 60079-18 : 2004	Explosive atmospheres: Part 18 Construction, test and marking of type of protection encapsulation "m" electrical apparatus

ANNEX C

(*Clause* 7.1.2.2)

LIGHTNING PROTECTION OF STRUCTURES WITH EXPLOSIVE OR HIGHLY FLAMMABLE CONTENTS

C-0 The presence of explosives or highly flammable materials in a structure may increase the risk to persons or to the structure and the vicinity in the event of a lightning stroke. For this reason higher degree of protection is essential for these structures. Protection of a different degree may be secured in the case of both inherently self-protecting and other structures by installation of various types of protection equipment, such as vertical and horizontal air terminations and other means. The recommendations given in **C-1** to **C-5.4** should be followed for structures in which explosive or highly flammable solids, liquids, gases, vapours or dusts are manufactured, stored or used or in which highly flammable or explosive gases, vapours or dusts may accumulate.

C-1 PRECAUTIONS

C-1.1 Following precautions should be taken for the protection of structures and their contents from lightning.

a) Storage of flammable liquids and gases in all-metal structures, essentially gas-tight,
b) Closure or protection of vapour or gas openings against entrance of flames,
c) Maintenance of containers in good condition, so far as potential hazards are concerned,
d) Avoidance, so far as possible, of the accumulation of flammable air-vapour mixtures about such structures,
e) Avoidance of spark gaps between metallic conductors at points where there may be an escape or accumulation of flammable vapours or gases.
f) Location of structures not inherently self-protecting in positions of lesser exposure with regard to lightning, and
g) For structures not inherently self-protecting, the establishment of zones of protection through use of earthed rods, masts, or the equivalent.

C-2 GENERAL PRINCIPLES OF PROTECTION

C-2.1 For the protection of structures with explosives or highly flammable contents the general principles are given below. In case of doubt, expert advice should be sought.

C-2.2 An air termination network should be suspended at an adequate height above the area to be protected. If one horizontal conductor only is used, the protective angle adopted should not exceed 30°. If two or more parallel horizontal conductors are installed, the protective angle to be applied may be as much as 45° within the space bonded by the conductors, but it should not exceed 30° outside that space. The height of the horizontal conductor should be sufficient to avoid all risk of flashover from the protective system to the structure to be protected. The supports of the network should be adequately earthed.

C-2.3 Where the expense of the method given in **C-2.2** is unjustified, and where no risk is involved in discharging the lightning current over the surfaces of the structure to be protected, a network of horizontal conductors with a spacing of 3 m to 7.5. m, according to the risk, should be fixed to the roof of the structure.

C-2.4 If the vertical conductor is separate from the structure to be protected, the minimum clearance between it and the protected structure shall be not less than 2 m; this clearance should be increased by 1 m for every 10 m of structure height above 15 m to prevent side flashes. Also the minimum clearance between the suspended horizontal air termination and the highest projection on the protected structure shall be 2 m.

C-2.5 A structure which is wholly below ground and which is not connected to any services above ground may be protected by an air termination network in accordance with **C-2.2** by virtue of the fact that soil has an impulse breakdown strength which can be taken into account when determining the risk of flashover from the protective system to the structure to be protected, including its services. Where the depth of burying is adequate, the air termination network may be replaced by a network of earthing strips arranged on the surface in accordance with expert advice. Where this method is adopted, the recommendations for bonding between metal in the structure, or metal conductors entering the structure given in **C-4**, should be ignored.

C-3 TYPES OF LIGHTNING PROTECTION SYSTEM

C-3.1 These should generally be of the integral mounted system with the horizontal air terminals running along the perimeter of the roof in all cases except for buildings containing highly sensitive explosives and very small buildings. The following types of protection are recommended:

Type of Building (1)	*Recommended Type of Protection* (2)
Building with explosives dust or flammable vapour risk	Integrally mounted system with vertical air terminals 1.5 m high and horizontal air terminals spaced 3 to 7.5 m from each other depending on the type of storage and processes involved
Explosives storage building and explosives workshops	Integrally mounted system with vertical air terminals 0.3 m high and horizontal air terminals spaced 7.5 m.
Small explosives storage buildings	Vertical pole type.
Buildings storing more dangerous types of explosives, for example, nitroglycerine (NG) and for initiatory explosives manufacturing	Suspended horizontal air terminations at least 2 m higher than the structure and with a spacing of 3 m.

C-3.2 Each separate structure protected in accordance with **C-2.3** should be equipped with twice the number of down conductors recommended in Part 1/Section 15 of this Code.

C-3.3 The earth terminations of each protective system should be interconnected by a ring conductor. This ring conductor should preferably be buried to a depth of at least 0.5 m unless other considerations, such as the need for bonding other objects to it, testing, or risk of corrosion make it desirable to leave it exposed in which case it should be protected against mechanical damage. The resistance value of the earth termination network should be maintained permanently at 10 Ω or less. If this value proves to be unobtainable, the methods recommended in IS 2309 should be adopted, or the ring conductor should be connected to the ring conductors of one or more neighbouring structures until the above value is obtained.

C-4 BONDING

C-4.1 All major members of the metallic structure, including continuous metal reinforcement and services, should be bonded together and connected to the lightning protective system. Such connections should be made at least in two places and should, so far as is possible, be equally spaced round the perimeter of the structure at intervals not exceeding 15 m.

C-4.2 Major metalwork inside the structure should be bonded to the lightning protective system.

C-4.3 Electrical conductors entering a structure of this category should be metal-cased. This metal casing should be electrically continuous within the structure. It should be earthed at the point of entry outside the structure on the supply side of the service and bonded directly to the lightning protective system.

C-4.4 Where the electrical conductors are connected to an overhead electric supply line, a length of buried cable with metal sheath or armouring should be inserted between the overhead line and the point of entry to the structure and a surge protective device, for example, of the type containing voltage-dependent resistors, should be provided at the termination of the overhead line. The earth terminal of this protective device should be bonded direct to the cable sheath or armouring. The spark over voltage of the lightning protective device should not exceed one-half the breakdown withstand voltage of the electrical equipment in the structure. On account of the low impulse strength of mineral-insulated metal-sheathed cable, such cables are not recommended for the above purpose.

C-4.5 Metallic pipes, electrical cable sheaths, steel ropes, rails or guides not in continuous electrical contact with the earth, which enter a structure of this kind, should be bonded to the lightning protective system. They should be about 75 m away and the other a further 75 m away.

C-5 MISCELLANEOUS REQUIREMENTS

C-5.1 For a buried structure or underground excavation to which access is obtained by an adit or shaft, the recommendation in **C-4.5** as regards extra earthing should be followed for the adit or shaft at intervals not exceeding 75 m.

C-5.2 The metal uprights, components and wires of all fences, and of retaining walls in close proximity to the structure, should be connected in such a way as to provide continuous metallic connection between themselves and the lightning protective system. Discontinuous metal wire fencing on non-conducting supports or wire coated with insulating material should not be employed.

C-5.3 The vents of any tanks containing flammable gas or liquid and exhaust stacks from process plants emitting flammable vapours or dusts should either be constructed of non-conducting material or be filled with flame traps.

C-5.4 Structures of this category should not be equipped with a tall component, such as spire or flagstaff or radio aerials on the structure or within 15 m of the structure. This clearance applies also to the planting of new trees, but structures near existing trees should be treated in accordance with IS 2309.

ANNEX D

[*Table* 5, *Sl No.* (vi)]

RECOMMENDATIONS FOR THE PROTECTION OF DIESEL ENGINE FOR PERMANENT INSTALLATION IN HAZARDOUS AREAS

D-0 To ensure a maximum degree of safety in the event of a permanently installed diesel engine being necessary in Zone 1 or Zone 2 it is recommended that it should have the following protection.

D-1 The starter shall be either of flameproof electrical type (usually operated from the mains supply) or of the following non-electric types:

a) Pneumatic,
b) Hydraulic,
c) Spring recoil,
d) Inertia, or
e) Hand start.

Any other electrical equipment associated with the engine shall be flameproof, Electrical equipment shall be effectively earthed and bonded.

D-2 Cooling fan blades shall be made from non-metallic materials, which do not accumulate electrostatic charge.

D-3 All belts shall be of antistatic fire resistant type.

D-4 In order to contain discharge of sparks or flames from the exhaust system; a gas conditioner box and a flame trap shall be installed. Alternatively, the exhaust should be designed to discharge to a location within a safe area.

D-5 To prevent flash back through induction system, wherever possible, air intakes for engines shall be located in a safe area. Alternatively, a flame trap should be installed.

D-6 The surface temperature of the engine and exhaust system shall not exceed 250°C, when tested under full load conditions. In some situations cooling of the exhaust manifold and piping may be necessary, using water-jacketing or finned coolers and/or high temperature cut outs or alarms should be provided.

However, when either the free movement of air is restricted by thermal or acoustic shielding or the ignition temperature of the surrounding flammable atmosphere is below 200°C, exposed surface temperature of engine shall not exceed the minimum ignition temperature of the gases involved.

D-7 To prevent over speeding of the engine due to induction of flammable gases or vapours, means shall be provided to stop the engine. It can be either:

a) a valve to close the air intake, or
b) a system to inject carbon dioxide into the air intake.

D-8 Alarms or automatic shutdown devices shall be provided, activated by excessive water temperature and low lube oil pressure

D-9 A system using an alarm or trip device to protect the engine from excessive vibration should be considered.

D-10 An engine having a crankcase volume of over 0.5 m^3 shall be provided with relief devices. Relief valves or breathers on engines shall be fitted with flame traps or discharge into the induction system downstream of the flame trap, if fitted, and upstream of the shut-off valve, if fitted, as specified in **D-7**. Dipsticks and/or filler caps should be screwed or effectively secured by other means.

D-11 Intake and exhaust system design shall meet the following minimum requirements:

a) The length of the flame path through or across any joint shall be not less than 13 mm;
b) Suitable metal-clad or other acceptable jointing material shall be interposed between all joint faces to ensure that leakage does not occur;
c) Where valve spindles pass through the walls of any component of the induction system. The diametrical clearance shall not exceed 0.13 mm for an axial length of not less than 25 mm unless end caps are fitted; and
d) No screw, stud or bolt hole shall pass through the wall of any component of the system.

D-12 Decompression system should not normally be provided. However, if they are essential, then the decompression parts should be provided with flame traps and ducted away to safe area.

D-13 The fuel injection pump land governor, where fitted, should be so designed that reverse running of the engine is not possible.

ANNEX E

[*Table* 5, *Item* (vii)]

RECOMMENDATIONS FOR STORAGE BATTERIES FOR USE IN ZONE 2 AREAS

E-0 Storage batteries for use in Zone 2 areas shall be of increased safety type. These shall meet the following requirements.

E-1 Celluloid and similar combustibles shall not be used as constructional materials.

E-2 Battery containers as well as fittings and insulating parts outside the enclosed cells shall not consist of porous materials, for example, wood or other flammable materials and shall be resistant to flame and the action of electrolytes.

E-3 Openings of cells necessary for the escape of the gases given off shall be so constructed as to prevent splashing of the electrolyte.

E-4 The exterior of the cells shall be so constructed as to resist impact, and the cell cases shall be firmly fixed.

E-5 The cells shall be so built into the containers that working loose of connection of the cells with one another is impossible and normally a discharge voltage exceeding 24 V shall not appear between adjacent rows of cells.

The creepage distance between two poles of adjacent cells shall not be less than 35 mm. Where the discharge voltage exceeds 24 V, the creepage distance shall be correspondingly increased by 1 mm/2 V.

Where voltage of batteries is not less than 50 V either the battery case shall be sub-divided by partitions or the batteries shall be grouped into containers so that in no grouping does a voltage exceeding 50 V occur. In these cases, the partitions or the containers shall have heights at least half that of the battery case.

E-6 The battery case shall be so constructed as to ensure sufficient ventilation in order to prevent accumulation of gases given off from the battery, and the free space within the case shall be as small as possible.

E-7 The metallic cover of the battery case shall be lined with materials resistant to electrolyte.

E-8 The cover of the battery case shall have special fastenings.

E-9 Exposed live parts of battery contained in a case shall be protected with rubber or equivalent insulating materials. However, the opening for checking voltage may be provided.

NOTE — Charging of storage batteries shall be conducted in non-hazardous location, while the cover of the battery enclosure is kept open.

NATIONAL ELECTRICAL CODE

PART 8

PART 8 SOLAR PHOTOVOLTAIC (PV) POWER SUPPLY SYSTEMS

0 FOREWORD

Solar energy is a natural resource which is, for practical purposes, free, renewable and inexhaustible and can supplement/augment the depleting fossil fuel resources. Greenhouse gases and pollutant emissions which result from fossil fuel generation can be offset by solar photovoltaic power generation. It can be used in decentralized/distributed mode. The energy converter (namely, solar photovoltaic cells which convert solar energy directly in dc electric power) does not have moving parts and has a comparatively long lifetime. It is expected that such advantages would lead to further growth of solar photovoltaic power supply systems.

This Part 8 of the Code is primarily intended to cover the requirements relating to electrical installations of power supply system based on the solar photovoltaic energy.

1 SCOPE

This Part 8 of the Code covers essential requirements for electrical installations for power supply system based on the solar photovoltaic energy including systems with ac modules.

2 REFERENCES

This Part 8 of the code should be read in conjunction with the following Indian Standards:

IS No.	*Title*
2309 : 1989	Code of practice for the protection of buildings and allied structures against lightning
3034 : 1993	Fire safety of industrial buildings: Electrical generating and distribution stations — Code of practice
3043 : 1987	Code of practice for earthing
8623 (Part 1) : 1993	Specification for low voltage switchgear and controlgear assemblies: Part 1 Requirements for type-tested and partially type tested assemblies
8623 (Part 2) : 1993	Specification for low voltage switchgear and controlgear assemblies: Part 2 Particular requirements for busbar trunking systems (busways)
8623 (Part 3) : 1993	Specification for low voltage switchgear and controlgear assemblies: Part 3 Particular requirements for equipment where unskilled persons have access for their use
IS 14153 : 1994	Guide for general description of photovoltaic(PV) power generating systems

3 TERMINOLOGY

The following terminology related to solar photovoltaic energy systems will apply.

3.1 PV Cell — Basic PV device which can generate emf by the absorption of photons from source such as solar radiation.

3.2 PV Module — Smallest complete environmentally protected assembly of interconnected PV cells.

3.3 PV String — Circuit in which PV modules are connected in series, in order for a PV array to generate the required output voltage.

3.4 PV Array — Mechanically integrated assembly of PV modules, together with support structure, but exclusive of foundation, tracking apparatus, thermal control and other such components, to form a dc power producing unit.

3.5 PV Array Junction Box — Enclosure where all PV strings of any PV array are electrically connected and where protection devices can be located if necessary.

3.6 PV Generator — Assembly of PV arrays.

3.7 PV Generator Junction Box — Enclosure where all PV arrays are electrically connected and where protection devices can be located if necessary.

3.8 PV String Cable — Cable connecting PV modules to form a PV string.

3.9 PV Array Cable — Output cable of a PV array.

3.10 PV dc. Main Cable — Cable connecting the PV generator junction box to the dc terminals of the PV inverter.

3.11 PV Inverter — Device which changes dc input into an ac output.

3.12 PV Supply Cable — Cable connecting the ac terminals of the PV inverter to a distribution circuit of the electrical installation.

3.13 PV ac Module — Integrated module/inverter assembly where the electrical interface terminals are ac only. No access is provided to the dc side.

3.14 PV Installation — Erected equipment of a PV power supply system.

3.15 Standard Test Conditions (STC) — Reference testing values of cell temperature (35 °C), in-plane irradiance (1 000 W/m^3), air mass solar reference spectrum (AM = 1.5) for a PV module or PV cell testing.

3.16 Open-Circuit Voltage under Standard Test Conditions U_{OCSTC} — Voltage under standard test conditions across an unloaded (open) PV module, PV string, PV array, PV generator or on the dc side of the PV inverter.

3.17 Short-circuit Current under Standard Test Conditions I_{SCSTC} — Short-circuit current of a PV module, PV string, PV array or PV generator under standard test conditions.

3.18 dc Side — Part of a PV installation from a PV cell to the dc terminals of the PV inverter.

3.19 ac Side — Part of a PV installation from the ac terminals of the PV inverter to the point of connection of the PV supply cable to the electrical installation.

3.20 Simple Separation — Separation between circuits or between a circuit and earth by means of basic insulation.

NOTE — The abbreviation 'PV' is used for 'solar photovoltaic'.

4 CLASSIFICATION

The major PV power-generating configurations are as follows:

a) *Stand alone system* — an independent power-producing system that is not connected to utility.
b) *Utility connected system* — a power producing system interconnected with an electric power utility.

NOTE — The term 'utility' is also referred to as the 'grid'.

5 GENERAL CHARACTERISTICS OF INSTALLATIONS

General guidelines on the assessment of characteristics of installations in buildings are given in Part 1/Sec 8 of the Code. An overview of PV power-generating systems including functional description of major components and interfaces and also possible configurations is given in IS 14153. PV modules shall comply with the requirements of the relevant equipment standard where such standards exist. PV modules of class II construction or with equivalent insulation are recommended if $U_{\text{OC STC}}$ of the PV strings exceeds 120 V dc. The PV array junction box, PV generator junction box and switchgear assemblies shall be in compliance with IS 8623.

NOTE — General information on solar photovoltaics is given at Annex A.

6 OPERATIONAL CONDITIONS AND EXTERNAL INFLUENCES

6.1 Electrical equipment on the dc side shall be suitable for direct voltage and direct current. PV modules may be connected in series up to the maximum allowed operating voltage of the PV modules and the PV inverter, whichever is lower. Specifications for this equipment shall be obtained from the equipment manufacturer

6.2 As specified by the manufacturer, the PV modules shall be installed in such a way that there is adequate heat dissipation under conditions of maximum solar radiation for the site.

7 WIRING

7.1 All cabling and electrical wiring of the installation shall be done in accordance with the practice recommended in Part 1/Sec 9 of this Code.

7.2 Selection and Erection in Relation to External Influences

7.2.1 PV string cables, PV array cables and PV dc main cables shall be selected and erected so as to minimize the risk of earth faults and short-circuits.

NOTE — This may be achieved for example by reinforcing the protection of the wiring against external influences by the use of single-core sheathed cables.

7.2.2 Wiring systems shall withstand the expected external influences such as wind, ice formation, temperature and solar radiation.

8 EARTHING

8.1 The provision of **17** of IS 3043 shall apply (*see also* Part 1/Section 14 of the Code). Earthing of one of the live conductors of the dc side is permitted, if there is at least simple separation between the ac side and the dc side.

NOTE — Any connections with earth on the dc side should be electrically connected so as to avoid corrosion

8.2 Earthing Arrangements, Protective Conductors and Protective Bonding Conductors

Where protective equipotential bonding conductors are installed, they shall be parallel to and in close contact as possible with dc cables and ac cables and accessories.

9 PROTECTION FOR SAFETY

9.1 Protection Against Electric Shock

PV equipment on the dc side shall be considered to be energized, even when the system is disconnected from the ac side. The selection and erection of equipment shall facilitate safe maintenance and shall not adversely affect provisions made by the manufacturer of the PV equipment to enable maintenance or service work to be carried out safely.

9.2 Protection Against Both Direct and Indirect Contact

9.2.1 *Protection by Extra-low Voltage: SELV and PELV*

For SELV and PELV systems, $U_{\text{OC STC}}$ replaces U_{n} and shall not exceed 120 V dc.

9.3 Fault Protection

9.3.1 *Protection by Automatic Disconnection of Supply*

On the ac side, the PV supply cable shall be connected to the supply side of the protective device for automatic disconnection of circuits supplying current-using equipment.

Where an electrical installation includes a PV power supply system without at least simple separation between the ac side and the dc side, a Residual Current Device (RCD) installed to provide fault protection by automatic disconnection of supply shall be Type B according to Indian Standards.

9.4 Protection Against Overload on the dc Sides

9.4.1 Overload protection may be omitted to PV string and PV array cables when the continuous current-carrying capacity of the cable is equal to or greater than 1.25 times $I_{SC\ STC}$ at any location.

9.4.2 Overload protection may be omitted to the PV main cable if the continuous current-carrying capacity is equal to or greater than 1.25 times $I_{SC\ STC}$ of the PV generator.

9.5 Protection Against Short-circuit Currents

9.5.1 The PV supply cable on the ac side shall be protected by a short circuit or an overcurrent protective device installed at the connection to the ac mains.

9.6 Protection Against Electromagnetic Interference (EMI) in Buildings

9.6.1 To minimize voltages induced by lightning, the area of all wiring loops shall be as small as possible.

9.7 Lightning Protection

9.7.1 The provisions of IS 2309 shall apply.

10 ISOLATION, SWITCHING AND CONTROL

10.1 To allow maintenance of the PV inverter, means of isolating the PV inverter from the dc side and the ac side shall be provided.

10.2 Devices for isolation and Switching

10.2.1 In the selection and erection of devices for isolation and switching to be installed between the PV installation and the public supply, the public supply shall be considered the source and the PV installation shall be considered the load.

10.2.2 A switch disconnector shall be provided on the dc side of the PV inverter.

10.2.3 All junction boxes (PV generator and PV array boxes) shall carry a warning label indicating that active parts inside the boxes may still be live after isolation from the PV inverter.

11 FIRE-SAFETY REQUIREMENTS

The provisions of IS 3034 shall apply.

ANNEX A

(*Clause* 5)

GENERAL INFORMATION ON SOLAR PHOTOVOLTAICS

A-1 SUN AS AN ENERGY SOURCE

A-1.1 The sun is a spherical mass of hot gases, with a diameter of about 1.39×10^9 m and at an average distance of 1.5×10^{11} m from the earth. Energy is being continuously produced in the sun through various nuclear fusion reactions, the most important one being where four protons combine to form a helium nucleus.

$$H_2 + H_2 \rightarrow He + 15\ MeV$$

The mass lost in the process is converted into energy. These reactions occur in the innermost core of the sun, where the temperature is estimated to be $(8\text{-}40) \times 10^6$ K. The various layers of differing temperatures and densities emit and absorb different wavelengths making the solar spectrum quite composite. However, the sun essentially acts as a black body having a temperature of 5 800 K. The spectral distribution of solar radiation at the earth's mean distance is shown in Fig. 1.

A-1.2 Photon is a particle of light that acts as an individual unit of energy. Its energy depends on wavelength. Solar radiation is in the form of photons.

A-1.3 Solar photovoltaic effect is the phenomenon that occurs when photons, the 'particles' in a beam of solar radiation (light), knock electrons loose from the atoms they strike. When this property of solar radiation (light) is combined with the properties of semiconductors, electrons flow in one direction across a junction, setting up a voltage. With the addition of circuitry, current will flow and electric power will be available.

A-2 SOLAR RADIATION AT THE EARTH'S SURFACE

A-2.1 Solar Constant (G_0)

It is the radiant flux density incident on a plane normal to the sun's rays at a distance of 1.49×10^8 km from the sun and is given by the area under the curve in Fig. 1. It has a value of 1 367 W/m^2 in space and about 1 000 W/m^2 at sea level at the equator at solar noon.

NOTE — The received flux density varies by ±1.5 percent during the day's course due to variations in the sun's output, and by about ± 4 percent over the year due to the earth's elliptic orbit.

Irradiance is the solar power incident on a surface. It

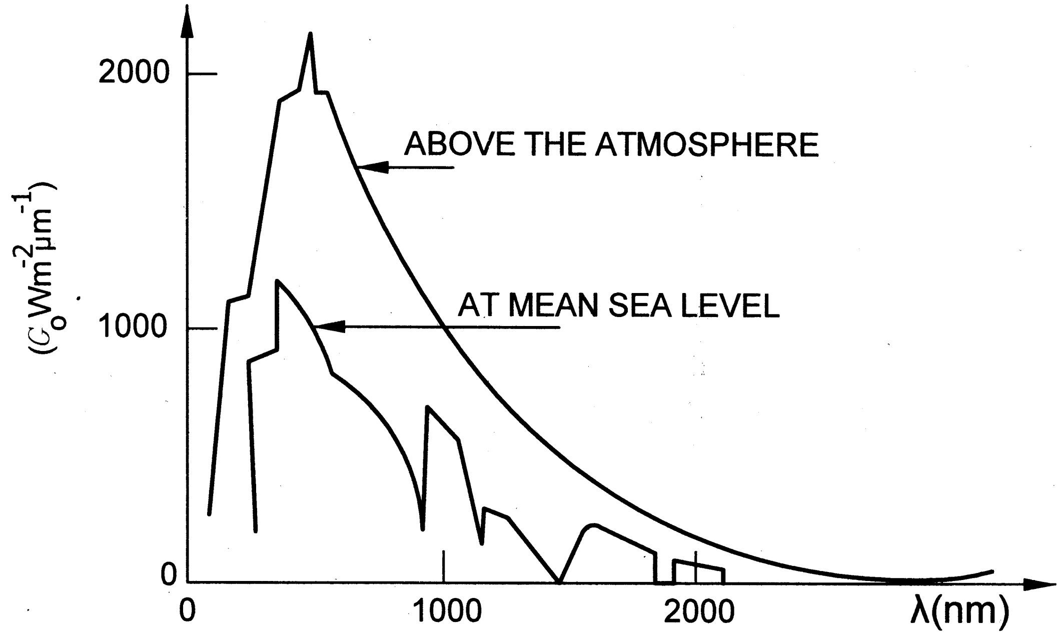


FIG. 1 SPECTRAL DISTRIBUTION OF THE SUN'S RADIATION

is usually expressed in kW/m^2. The product of irradiance and time equals insolation.

A-3 CLASSIFICATION OF SOLAR SPECTRUM

The solar spectrum can be classified based on spectral distribution; the basis of type of radiation or the energy received.

A-3.1 Classification Based on Spectral Distribution

The solar spectrum can be divided into three main regions:

a) Ultraviolet region : ($\lambda < 400$ µm) — 9 percent

b) Visible region : (400 nm $< \lambda <$ 700 nm) — 45 percent

c) Infrared region : ($\lambda >$ 700 nm) — 46 percent

The radiation in the wavelengths above 2 500 nm are negligible.

The earth's atmosphere absorbs various components of the radiation to different levels. The short wave UV and X-ray regions are almost completely absorbed by oxygen and nitrogen gases and irons; the ozone absorbs UV rays. The atmosphere unaffected by dust or clouds acts as an open window for the visible region. Up to 20 percent of the IR (Infrared) radiation is absorbed by the water vapour and CO_2. The carbon dioxide concentration in the atmosphere is about 0.03 percent by volume and is beginning to rise with pollutants being let off into the atmosphere. The water vapour concentration can very greatly (up to 4 percent by volume). Dust, water droplets and other molecules scatter the sun's radiation.

A-3.2 Classification Based on Beam and Diffuse Radiation

A-3.2.1 The sun's radiation at the earth's surface is composed of two components: beam radiation and diffuse radiation. Beam or direct radiation consists of radiation along the line connecting the sun and the receiver as shown in Fig. 2A. Diffuse radiation is the radiation scattered by the atmosphere without any unique direction as in Fig. 2B. There is also a reflected component due to terrestrial surface. Total radiation is shown in Fig. 2C.

It follows from these figures that

$$G_{bc} = G_b * \cos \theta$$

For a horizontal surface, the relation becomes

$$G_{bh} = G_b * \cos \theta_z$$

Here Q_z (called the Zenith angle) is the angle of incidence of beam component of solar radiation for a horizontal surface. Zenith Angle is the angle between directly overhead and the line intersecting the sun. (90°-zenith) is the elevation angle of the sun above the horizon.

G_b* is intensity of beam component of normally

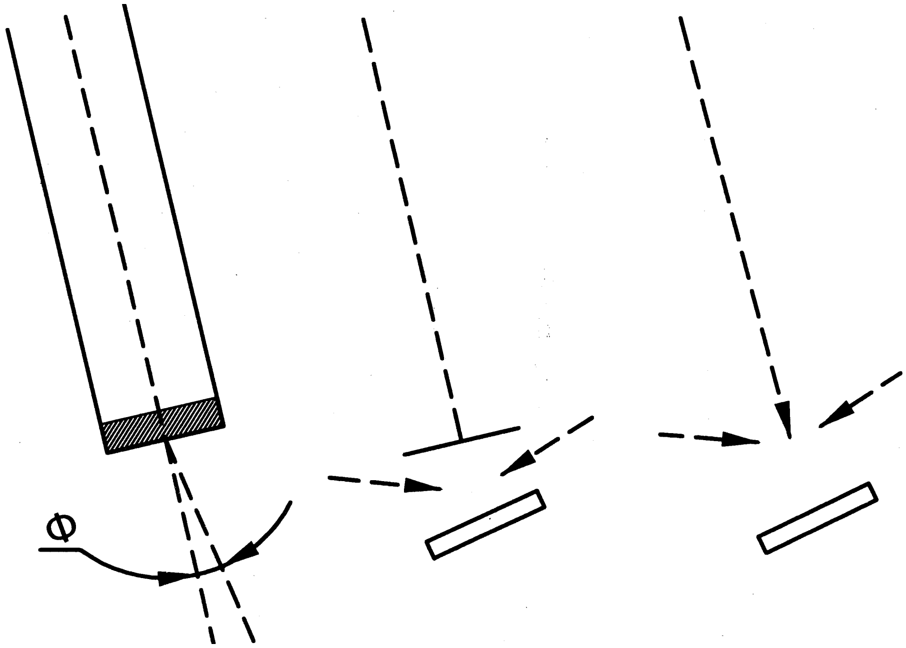


FIG. 2 COMPONENTS OF SOLAR REACTING EARTH

incident solar radiation on a surface. Adding the beam of the diffuse components,

$$G = G_{tc} = G_{bc} + G_{dc}$$

A-3.2.2 *Equation Used to Determine Monthly Average Daily Global Radiation*:

$$\frac{\bar{H}_g}{\bar{H}_0} = a + b\left(\frac{S}{\bar{S}_{Max}}\right)$$

where

$\bar{H}_g$ = monthly average daily global radiation, in kWh/m²day;

$\bar{H}_0$ = monthly average daily extraterrestrial radiation, in kWh/m²day; and

$\bar{S}$ = the monthly average sunshine h and $\bar{S}_{Max}$ is the monthly average maximum sunshine h.

A-3.2.2.1 *Monthly average daily diffuse radiation*

For Indian cities linear equation used to compute monthly average daily diffuse radiation is.

$$\frac{\bar{H}_d}{\bar{H}_g} = 1.411 - 1.696 \times \frac{\bar{H}_g}{\bar{H}_0} \text{ and is valid for } 0.3 < \frac{\bar{H}_g}{\bar{H}_0} < 0.7$$

A-3.2.2.2 *Monthly average total radiation on tilted surface*

The tilt angle or slope of collector governs the amount of energy intercepted by the flat plate collector and is hence an important specification for design of fixed or non-tracking collectors. The following relation is used to calculate the optimum tilt using the available solar radiation data,

$$\beta_{opt} = \tan^{-1}\left\{\left[\sum_{i=1}^{12}\left(\bar{H}_b \times \tan(\Phi - \delta)\right)\right] \Big/ \left[\sum_{i=1}^{12}\bar{H}_b\right]\right\}$$

where Φ is the latitude of the location and δ is the angle of tilt of the beam. Optimum tilt for the entire year typically for Bangalore is $\beta_{opt} = 11.7°$.

The optimum tilt for any location for the whole year is almost equal to 0.9Φ and is equal to 11.7° and it is also nearly equal to latitude of the location Φ. For practical considerations the optimal tilt is taken as latitude +15°.

The following relation is used to calculate monthly average total radiation on tilted surface:

$$\frac{\bar{H}_t}{\bar{H}_g} = \left[1 - \frac{\bar{H}_d}{\bar{H}_g}\right] \times R_b + \frac{\bar{H}_d}{\bar{H}_g} \times R_d + R_r$$

$\bar{H}_t$ = monthly average daily global radiation on tilted surface,

$\bar{H}_g$ = monthly average daily global radiation on horizontal surface,

$\bar{H}_d$ = monthly average daily diffused radiation on horizontal surface, and

R_b = conversion factor for beam solar radiation.

A-3.3 Classification by Energy

A-3.3.1 Solar energy as an energy source has the following characteristics:

a) The peak global (beam + diffuse) solar radiation received in India is ~ 1 kW/m^2.
b) The power output follows a parabolic trend with the maximum value at noon.
c) The maximum daily load factor ($P_{Average}/P_{Max}$) is 33 percent. This implies that if the capacity of the SPV panel is 100 kW the maximum average power input over the day (12 h) cannot exceed 33 kW. The maximum annual load factor ($\Sigma P_{Average}/\Sigma P_{Max}$) is 25 percent. This implies that if the capacity of the SPV panel is 100 kW the maximum average power input over the year (12 h/day × 365 days/year) cannot exceed 25 kW.
d) The total annual global energy input (beam + diffuse radiation) in India is typically 1970-2 100 kWh/year.
e) An average of 0.5 kWh/m^2 day of energy available for over 300 days per annum.

Even the hottest regions on earth, have solar radiation flux rarely to exceed 1 kW/m^2 amounting to 7 kWh/m^2/day. Typical solar radiation profile for Bangalore is given at Annex B. Annex C gives typical daily, monthly and annual data for Bangalore. Typical daily solar radiation is in the range of 5-6 kWh/ m^2/day. The measured solar radiation data is recorded by mainly by the Indian Meteorological Department using Thermo-electric Pyraonometer with sensor placed at a distance of 19.2 m from ground level.

A Pyranometer is an instrument used for measuring global solar irradiance. A Pyrheliometer is an instrument used for measuring direct beam solar irradiance. It has an aperture of 5.7° to transcribe the solar disc.

Peak sun hours is the equivalent number of h per day when solar irradiance averages 1 000 W/m^2. For example, six peak sun hours means that the energy received during total daylight *h* equals the energy that would have been received had the irradiance for 6 h been 1 000 W/m^2.

A-3.3.2 *Effect of Cloud Cover*

Cloud cover is measured in Okta [0 Okta: clear sky; 8 Okta:fully covered sky]. Cloud cover directly reduces solar radiation. There are between 20 and 100 cloudy days in an year in different Indian locations.

A-3.3.3 *Effect of Rainfall, Relative Humidity and Dry Bulb Temperature*

Rainfall is normally associated with cloud cover and with increase in cloud cover the global solar radiation is reduced. Relative humidity (0-100 percent) and dry bulb temperature (-2 to 45 ºC) do not affect the solar radiation significantly but affects the performance of SPV cells negatively.

A-3.3.4 *Effect of Latitude and Longitude*

The effect of location on the optimal collector tilt angle is already given above.

A-3.3.5 *Effect of Altitude*

The effect of altitude on solar radiation is not very significant.

A-3.3.6 *Effect of Wind Velocity*

Average wind velocities range between 0 and 20 m/s. Wind does not directly affect solar radiation but affects the performance of SPV cells in a positive way by increasing the heat removal from the top cover.

A-4 CLASSIFICATION OF CELLS

a) In terms of materials: non-crystalline silicon, polycrystalline silicon, amorphous silicon, gallium arsenide, cadmium telluride, cadmium sulphide, idium arsenide, etc.
b) In terms of technology for fabrication: single crystal bonds (or cylinders), ribbon growth, thin-film, etc.

A-4.1 Some of the definitions under this section are as follows:

a) *Amorphous Semiconductor* — A non-crystalline semiconductor material that has no long-range order.
b) *Amorphous Silicon* — A thin-film PV silicon cell having no crystalline structure. Manufactured by depositing layers of doped silicon on a substrate.
c) *Cadmium Telluride (CdTe)* — A polycrystalline thin-film photovoltaic material.
d) *CIS (Copper-Indium-Diselelide)* — A base material for SPV cells.
e) *Crystalline Silicon* — A type of PV cell made from a single crystal or polycrystalline slice of silicon.
f) *Czochralski Process* — A method of growing large size, high quality semiconductor crystal by slowly lifting a seed crystal from a molten bath of the material under careful cooling conditions.
g) *EFG (Edge defined Film Growth)* — A method for making sheets of polycrystalline silicon in which molten silicon is drawn upward by capillary action through a mold.

h) *EVA (Ethylene-Vinyl-Acetate Foil)* — It is a material to be used by module production for covering the cells.

j) *GaAs (Gallium Arsenide)* — A crystalline, high-efficiency semiconductor/ photovoltaic material.

k) *MOS-FET (Metal-Oxide-Silicon Field Effect Transistor)* — used as semiconductor power switch in charge regulators, inverters etc.

m) *N-Type Silicon* — Silicon material that has been doped with a material that has more electrons in its atomic structure than does silicon.

n) *Polycrystalline Silicon* — A material used to make PV cells which consist of many crystals as contrasted with single crystal silicon.

p) *Single Crystal Silicon* — Material with a single crystalline formation. Many PV cells are made from single crystal silicon.

q) *Silicon (Si)* — A chemical element, atomic number 14, semi-metallic in nature, dark gray, a semiconductor material. A common constituent of sand and quartz (as the oxide). Crystallizes in face-centered cubic lattice like a diamond. This is the most common semiconductor material used in making photovoltaic cells.

r) *Thin Film PV Module* — A PV module constructed with sequential layers of thin film semiconductor materials.

s) *Wafer* — A thin sheet of semiconductor material made by mechanically sawing it from a single-crystal or multi-crystal ingot or casting.

Some of the important characteristics of various types of SPV cells, measured at normal temperature (25 °C) and under illumination level of 1.0 kW/m^2, are listed in Table 1.

A-5 BASIC STRUCTURE OF PV CELL

A-5.1 The basic structure of typical PV cell is shown in Fig. 3A and 3B. Various layers from top to bottom and their function are as follows:

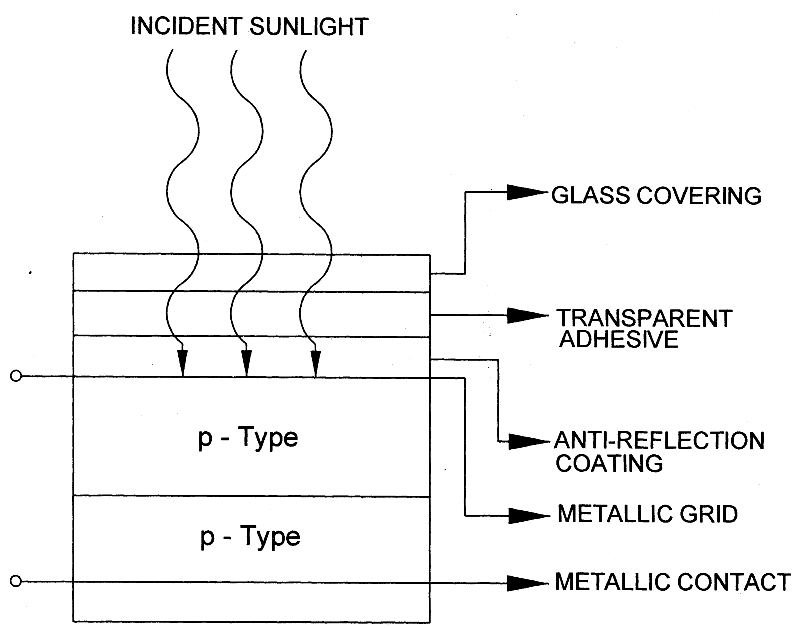
a) Top layer is glass cover, transparency 90-95 percent. Its purpose is to protect the cell from dust, moisture, etc.

b) The next is a transparent adhesive layer which holds the glass cover.

c) Underneath the adhesive is an antireflection coating (ARC) to reduce the reflected sunlight to below 5 percent.

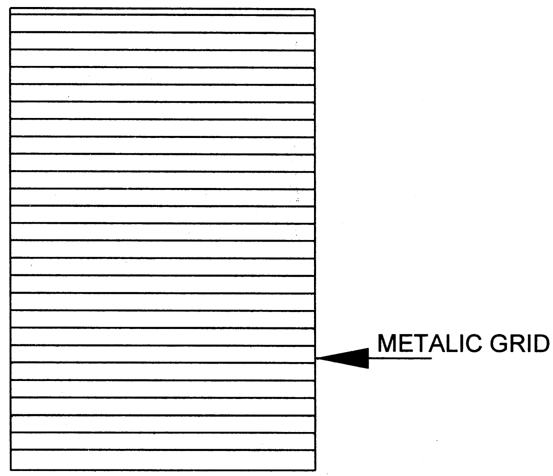
d) Then follows a current carrier bus (aluminium or silver) Fig. 3B which collects the charge carriers, generated by the cell under incidence of sunlight, for circulating to outside load.

e) Under the lower side of the metallic grid lies a *p*-layer followed by *n*-layer forming a *pn*-junction at their interface. The thickness of the top p-layer is so chosen that enough photons cross the junction to reach the lower *n*-layer.



3A Cross Sectional View

FIG. 3 BASIC STRUCTURE OF TYPICAL PV CELL — (*Continued*)



3B Top View

Fig. 3 Basic Structure of Typical PV Cell

f) The follows another bus in contact with the lower n-layer. This forms the second terminal of the cell.

Table 1 Characteristics of SPV Cells
(*Clause* A-4.1)

Sl No.	SPV Cell	Fill Factor	Conversion Efficiency (percent)
(1)	(2)	(3)	(4)
i)	Mono-crystalline silicon	0.85	13-14
ii)	Polycrystalline silicon	0.85	9-12
iii)	Amorphous silicon	0.66	5-6
iv)	Gallium arsenide	0.87	20-25

A-5.2 Operation and Circuit Model for Analysis

The incidence of photons (sunlight) causes the generation of electron-hole pairs in both p and n-layers. Photons generated minority carriers (electrons in p-layer and hole in n-layer) freely cross the junction. This increases the minority carrier flow manifolds. Its major component is the light generated current I_G (when load is connected across the cell terminals). There is also the thermally generated small reverse saturation current I_s (minority carrier flow in same direction as I_G) also called dark current as it flows even in absence of light. I_G flows in opposite direction to I_D, the forward diode current of the junction. The cell feeds current I_L to load with a terminal voltage V.

The above operation suggests the circuit model of a PV cell as drawn in Fig. 4. The following can be written from the circuit model and the well-known expression for:

$$I_D = I_s\,(e^{\lambda V} - 1);\ \lambda = \frac{e}{kT}$$

where

k = Boltsman constant,

e = electronic change and

T = cell temperature in K.

$$I_L = I_G - I_D = I_G - I_s\,(e^{\lambda V} - 1)$$

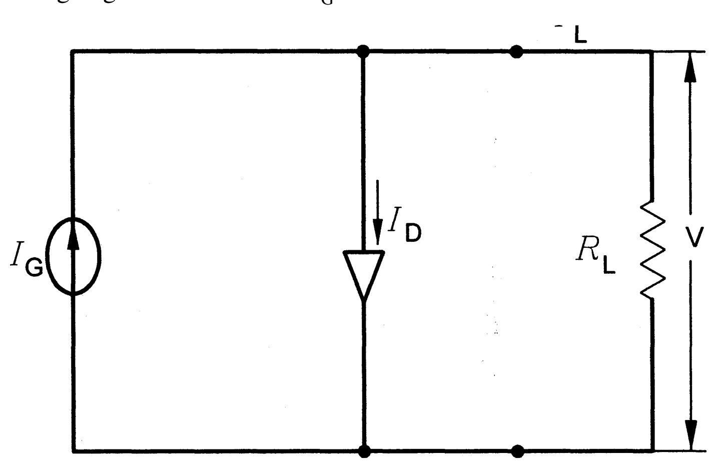


Fig. 4 Circuit Model of PV Cell

Hence,

$$V_{OC}\ (I_L = 0) = \frac{1}{\lambda}\ln\left(\frac{I_G}{I_S}+1\right)$$

and $I_{SC}\ (V = 0) = I_G$

where V_{oc} is the open circuit voltage and I_{sc} is the short circuit current.

Solar radiation generated current I_G is dependent on the intensity of light. The I-V characteristics of the cell are drawn in Fig. 5A for various values of intensity of solar radiation. One typical I-V characteristic of the cell is drawn in Fig. 5B. Each point on this curve belongs to a particular power output. The point Q indicated on the curve pertains to the maximum power output at which the cell should be operated. At this point.

$$P_{Max} = V_{P, Max}\, I_{P, Max}$$

The fill-factor (ff) of a cell is defined as:

$$FF = \frac{P_{Max}}{I_{SC}V_{SC}}$$

The cell efficiency is given as:

$$\eta = \frac{P_{out}}{P_{in}}$$

where P_{out} is the power delivered to load (W) and P_{in} is the solar power incident on the cell (W).

A-5.3 Effect of Temperature on Solar Cell Efficiency

As the temperature increases, the diffusion of electrons and holes in the length of Si (or GaAs) increases causing an increase in the dark current and decrease in $V_{OC.}$ The overall effect causes a reduction in the efficiency of solar cell as the temperature increases. The practical efficiency of Si solar cell is about 12 percent and that of GaAs solar cell is 25 percent at the normal temperature of 300 K. With each degree rise in temperature, the efficiency decreases by a factor of K = 0.004 2 percent.

$$\Delta\eta = -\ 0.0042\Delta T$$

where ΔT is the rise in temperature above 300 K and $\Delta\eta$ is the change in efficiency. The factor K may vary depending on the type of cell.

A-5.4 Spectral Response

It is seen from the spectral response curves of Fig. 6 that the Selenium cell response curve nearly matches that of the eye. The spectral response of the human eye is 550 nm. Because of this, Se cell has a widespread application in photographic equipment such as exposure meters and automatic exposure diaphragm. Silicon response also overlaps the visible spectrum but has its peak at the 0.8 µm (8 000 Å) wavelength, which is in the infrared region. In general, silicon has higher conversion efficiency and greater stability and is less subject to fatigue. It is therefore widely used for present day commercial solar cells.

A-5.5 Fabricating Silicon PV Cell

The most commonly used methods of manufacturing silicon PV cell from purified silicon feedstock are as follows:

a) Single crystal silicon with a uniform chemical structure.
b) Polycrystalline silicon-series of crystalline structures within a PV cell.
c) Amorphous silicon with a random atomic chemical structure.

Most PV power uses flat-plate modules of cut and polished wafer like cells of crystalline silicon, which are now have an efficiency of about 12 percent.

A-5.5.1 *Thin-film technologies*

There are two main reasons why thin film offers promise of significant cost reduction. These are as follows:

a) Thin-film cells use only a few microns of direct material, instead of tens of mills used by crystalline, polycrystalline or ribbon silicon modules.
b) Construction of monolithic thin-film modules can be done at the same time that the cells are formatted, thus eliminating most of the cost of module fabrication. These two aspects of thin-film technology are further explained below:

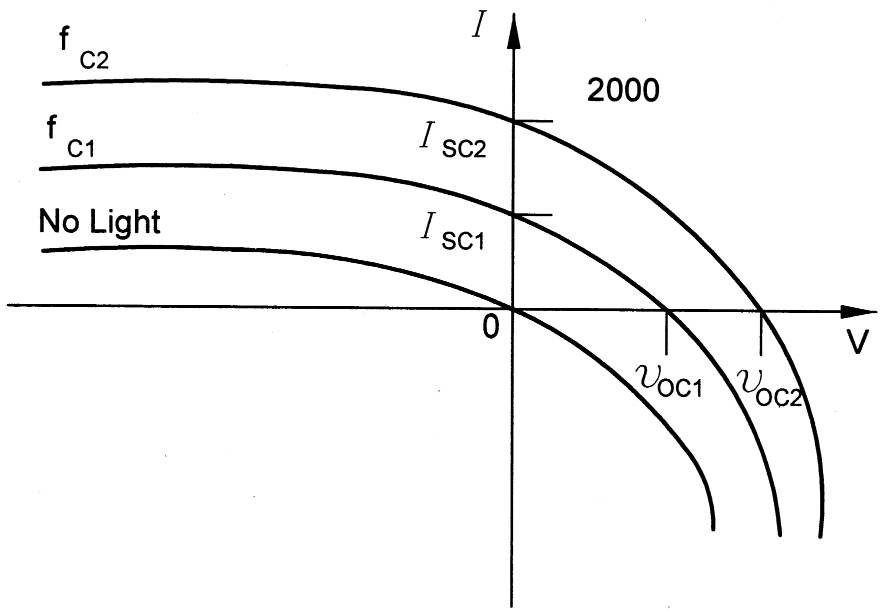
   Cadmium telluride can absorb 99 percent of the sun's energy in less than 0.5 µm thickness as opposed to the 0.2 mm requirement for crystalline silicon. In conventional technologies, cells cut into individual parts are then circuited back together as discrete elements. Monolithic interconnection during cell fabrication eliminates labour and in addition produces a superior looking product because of its uniform finish.

A-6 TESTING OF SPV CELLS

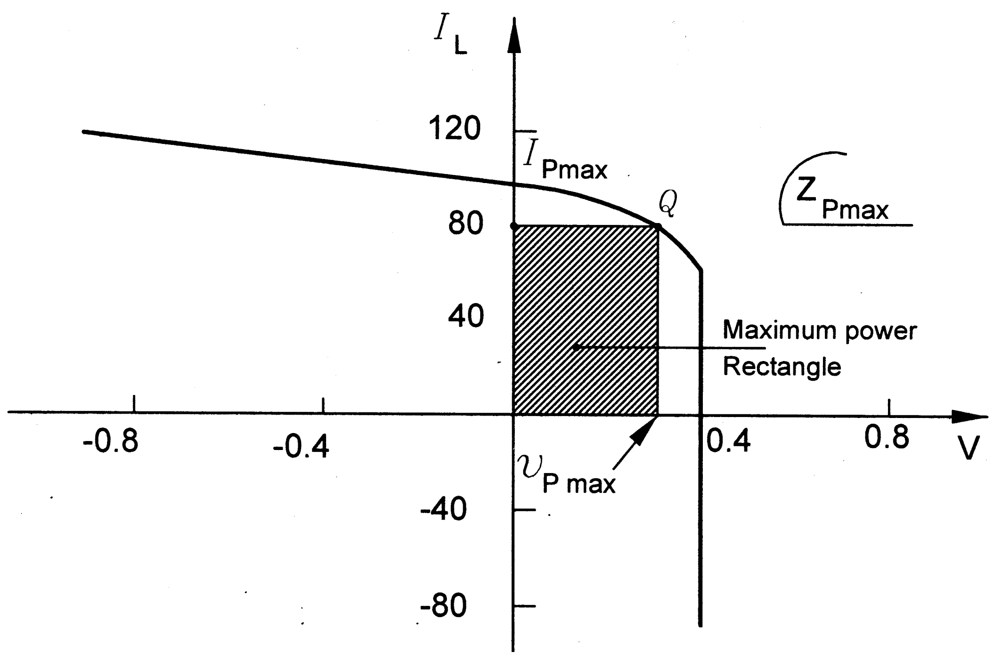
A-6.1 Typical Procedure for Testing of SPV Cells

Some of the definitions under this section are as follows:

a) *NOCT (Nominal Operating Cell Temperature)* — It is the estimated temperature of a SPV



5A



5B

FIG. 5 CURRENT-VOLTAGE CHARACTERISTICS OF A PV CELL

module when operating under 800 W/m^2 irradiance, 20°C ambient temperature and wind speed of 1.0 m/s. NOCT is used to estimate the nominal operating temperature of a module in its working environment.

b) *Standard test conditions* — Conditions under which a module is typically tested in a laboratory:

1) Irradiance intensity of 1 000 W/m^2,
2) AM 1.5 solar reference spectrum; and

3) Cell (module) temperature of 25°C, ± 2°C.

c) *System operating voltage* — The array output voltage under load. The system operating voltage is dependent on the load or batteries connected to the output terminals.

d) *Rated module current* — The current output of a PV module measured at standard test conditions of radiation level of 1 000 W/m^2 and a cell temperature of 25°C.

e) *Short circuit current* — The current produced by an illuminated PV cell, module, or array when its output terminals are shorted.

f) *Full sun* — The full sun condition is the amount of power density received at the surface of the earth at noon on a clear day — about 1 000 W/m^2. Lower levels of sunlight are often expressed as 0.5 sun or 0.1 sun. A figure of 0.5 sun means that the power density of the sunlight is one-half of that of a full sun (that is 500 W/m^2).

The procedure for testing of SPV panels is as follows:

a) Soaking in natural sunlight for 7 days.

b) Measurement of the following parameters under condition of 1 Sun (1000 W/m^2) from a solar simulator (with a non-uniformity of light source within ± 3 percent) at 25°C:

1) V_{oc}, $I_{sc;}$
2) $V_{maximum}$ power point, $I_{maximum}$ power point;
3) R_{series}, R_{shunt}; and
4) V_{load}, $I_{load.}$

c) Calculation of parameters from the above measured data:

1) $P_{Max,}$
2) Fill factor,
3) Cell efficiency, and
4) Module efficiency.

A-7 APPLICATION OF SPV PANELS FOR BULK ENERGY CONVERSION

SPV cell produces dc power which is maximum at a particular point on its I-V characteristics (which responds to solar radiation input). There are several; ways in which this power can be used:

a) Direct use for applications such as lighting, pumping, mechanical power, conversion to ac for ac loads, etc.

b) Conditioning of power**:** SPV power is used as ac after conditioning. The process of conversion and re-conversion into ac with solid stage devices like SCR (Silicon Controlled Rectifier), IGBT (Insulated Gate Bi-polar Transistor) is called power conditioning.

c) Storage in batteries and used for mobile power plants.

d) Hybrid system which is a SPV system that includes other sources of electricity generation, such as wind or diesel generators.

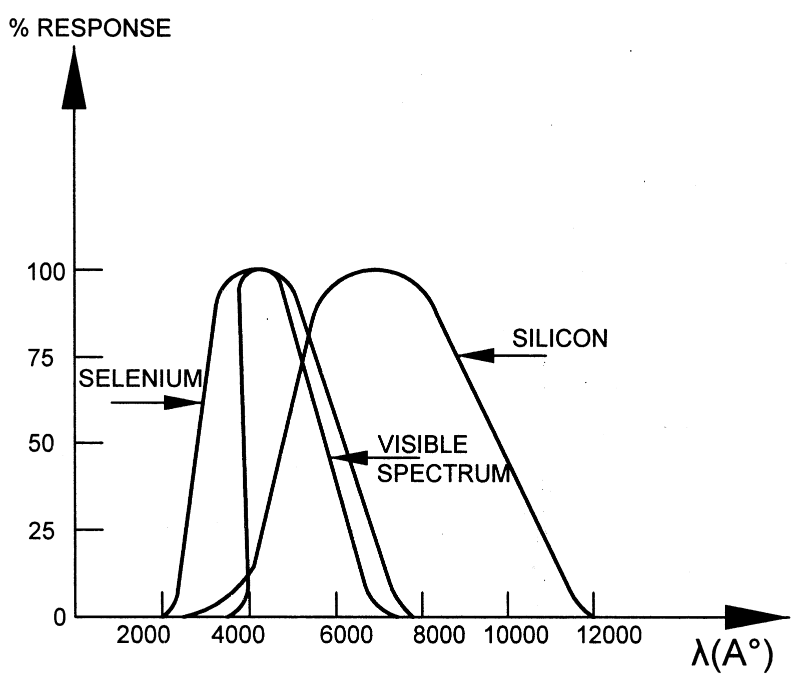


FIG. 6 SPECTRAL RESPONSE OF Si, Se AND THE NAKED EYE

e) Combination of stationary plants with battery storage which can be of two types:

   1) *Minigrids*:

      i) dc bus (because many renewable sources generate dc power).

      ii) ac bus

      iii) ac and dc bus

   2) Generalized ac and dc bus based system can also be connected to conventional power grid at the LT (0.415 kV) or HT (11 kV) level.

f) BIPV (Building integrated SPV) — It is the design and integration of PV into the building envelope, typically replacing conventional building materials. This integration may be in vertical facades, replacing view glass, spandrel glass, or other facade material; into semi-transparent skylight systems; into roofing systems, into shading "eyebrows" over windows; or other building envelope systems.

Usually the SPV panel is the costliest element in the SPV system. Balance of system (BOS) which is composed of the parts or components of a SPV system other than the photovoltaic array usually const only a small fraction of the total cost. Hence it is economical to install the most efficient sub-systems (inverters, battery bank, etc.) in the BOP.

ANNEX B

(*Clause* A-3.3.1)

TYPICAL PROFILE OF SOLAR RADIATION DATA (kW/m^2) FOR BANGALORE

Sl No.	*Time (h)* → *Month* ↓	06:00	07:00	08:00	09:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
i)	January	0.00	0.03	0.20	0.43	0.64	0.78	0.85	0.85	0.76	0.62	0.43	0.23	0.04
ii)	February	0.00	0.05	0.24	0.46	0.64	0.80	0.84	0.85	0.78	0.65	0.45	0.23	0.05
iii)	March	0.00	0.07	0.29	0.53	0.73	0.87	0.94	0.92	0.83	0.69	0.49	0.27	0.07
iv)	April	0.00	0.08	0.30	0.53	0.73	0.86	0.92	0.90	0.83	0.67	0.48	0.25	0.07
v)	May	0.00	0.09	0.28	0.49	0.68	0.82	0.87	0.85	0.78	0.64	0.46	0.26	0.09
vi)	June	0.00	0.10	0.25	0.44	0.59	0.70	0.74	0.74	0.67	0.55	0.42	0.24	0.09
vii)	July	0.00	0.07	0.21	0.36	0.47	0.55	0.60	0.60	0.56	0.48	0.34	0.19	0.07
viii)	August	0.00	0.06	0.19	0.35	0.46	0.55	0.61	0.62	0.57	0.47	0.33	0.19	0.06
ix)	September	0.00	0.05	0.19	0.37	0.54	0.63	0.68	0.67	0.62	0.50	0.35	0.19	0.06
x)	October	0.00	0.04	0.20	0.41	0.54	0.71	0.76	0.76	0.67	0.54	0.37	0.16	0.04
xi)	November	0.00	0.03	0.16	0.34	0.52	0.64	0.70	0.69	0.61	0.52	0.36	0.18	0.04
xii)	December	0.00	0.02	0.15	0.33	0.50	0.61	0.66	0.66	0.60	0.48	0.32	0.17	0.03
	Average	**0.00**	**0.06**	**0.22**	**0.42**	**0.59**	**0.71**	**0.76**	**0.76**	**0.69**	**0.57**	**0.40**	**0.21**	**0.06**

ANNEX C

(*Clause* A-3.3.1)

TYPICAL PROFILE OF DAILY, MONTHLY AND ANNUAL SOLAR RADIATION DATA (kW/m^2) FOR BANGALORE

Sl No. (1)	*Month* (2)	*Days in a Month* (3)	*Total Daily kWh/Day* (4)	*Total Monthly kWh/Month* (5)
i)	January	31	5.860 5	181.674 6
ii)	February	27	6.045 1	163.216 5
iii)	March	31	6.717 0	208.227 9
iv)	April	30	6.630 4	198.911 7
v)	May	31	6.322 9	196.009 6
vi)	June	30	5.548 4	166.450 8
vii)	July	31	4.503 7	139.613 7
viii)	August	31	4.457 0	138.166 1
ix)	September	30	4.852 3	145.570 0
x)	October	31	5.189 6	160.876 2
xi)	November	30	4.765 1	142.954 2
xii)	December	31	4.539 9	140.738 3
	Average	**Total annual**	**5.452 7**	**1 982.409 53**

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