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GOVERNMENT OF INDIA
CENTRAL PUBLIC WORKS DEPARTMENT

GENERAL SPECIFICATIONS FOR ELECTRICAL WORKS

PART-I
INTERNAL

2013

CPWD

PUBLISHED UNDER THE AUTHORITY
OF
DIRECTOR GENERAL, CPWD, NEW DELHI

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FOREWORD

This revised and enlarged edition of General Specifications for Electrical Works Part-1 Internal 2013 is of immense importance in view of the need to promote green building norms in Central Government buildings being constructed and maintained by CPWD.

This revision reflects the green initiatives in the field of internal electrical installations, including lighting aspects of GRIHA compliant buildings under construction by CPWD throughout the country. The previous editions were brought out in the year 1972, 1994 and 2005.

These revised specifications incorporate the relevant provisions of ECBC 2007 containing lighting design, lighting control, etc., table of lux requirements and revised life expectancy of various E&M equipments as per latest Maintenance Manual 2012. In addition, a chapter incorporating features of LED lighting has also been added to include latest in the field of energy efficiency. The IS codes mentioned in the specifications were also revised wherever these have undergone change.

Detailed deliberations were conducted between CPWD officers and TERI officials on various aspects of energy efficiency in a building. As a result of these discussions, TERI presented its recommendations to CPWD. These revised specifications were drafted by Shri Mukesh Vij, CE (E), Shri S.K. Chawla, CE (E) and Shri C.K. Varma, CE (E) on the recommendations of TERI (The Energy and Resources Institute) to make these specification ECBC (Energy Conservation Building Code) and GRIHA (Green Rating for Integrated Habitat Assessment) compliant.

I acknowledge the hard work and efforts put in by the Specification Committee under the chairmanship of Shri R.K. Singhal, Spl. DG(NR) in reviewing and finalizing these specifications. I acknowledge the active support of TERI officials whose recommendations have been suitably incorporated in this revision. I also acknowledge the efforts of Shri S.S. Garg, SE (E) TAS, Member Secretary and his team of officers for contributing towards making the publication available in a short period of time.

Suggestions for modifications as well as errors and omissions may be sent to SE (E) TAS, office of Chief Engineer (E) CSQ, CPWD, Vidyut Bhawan, New Delhi.

In case of any discrepancy between English and Hindi versions, the English version shall be held valid.

Place : New Delhi
Dated : 26.02.2013

(Ashok Khurana)
Director General
CPWD, New Delhi

CPWD

राकेश कुमार सिंघल
विशेष महानिदेशक (उत्तरी क्षेत्र)
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PREFACE

1. The Central Public Works Department (CPWD) is a 158 years old institution and is the principal agency of the Government of India responsible for creating assets and providing comprehensive services including planning, designing, construction and maintenance of office and residential buildings as well as other infrastructures of various ministries, departments of Government of India, autonomous bodies and public sector enterprises. Its activities are spread throughout the country.

2. Therefore, the following is the sequence of various editions of CPWD General Specifications for Electrical Works (Internal).
   - 1949
   - 1960
   - 1972
   - 1994
   - 2005
   - 2013 (Present edition)

3. This edition aims to incorporate latest technological trends and green building norms in central government buildings being constructed and maintained by CPWD.

4. The highlight of the present edition are :-
   - Green Building initiatives in the field of internal electrical installations of GRIHA compliant buildings under construction by CPWD.
   - Incorporate the relevant provisions of ECBC-2007 containing lighting design, lighting control etc. suggested by the officials of TERI (The Energy and Resources Institute) New Delhi.
   - Recommended Illuminance levels.
   - Revised life expectancy of various E&M equipments as per latest maintenance manual – 2012.
   - A New chapter incorporating features of LED lighting has been added.
   - Important Indian standards are also updated.

I am grateful to Shri Ashok Khurana, Director General, CPWD for reposing trust in me to undertake this work. I also express my deep appreciation to Sh. Mukesh Vij, CE(E), Sh. S.K. Chawla CE(E) and Sh. C.K. Varma, CE(E), for drafting these specifications in the light of the recommendations of TERI, so as to incorporate green building initiative in the field of internal electrical installation of GRIHA compliant buildings.

I acknowledge the efforts put in by members of the specification committee, in making the present specification technically update, modern & user friendly. I acknowledge the active support of TERI officials whose recommendation have paved the way for this revision.

I complement Shri S.S. Garg, SE(E) TAS, CSQ, Sh. R.R. Meena, EE(E) TAS, Sh. V.K. Yadav, AE(E) TAS, Sh. P.P. Singh, AE(E) TAS, who made their sincere efforts to update and making the publication available in very short time.

Errors or omissions, and suggestions for improvement, if any, may kindly be brought to the notice of the Superintending Engineer (E) TAS, Office of the Chief Engineer (E) CSQ, CPWD, New Delhi -01

Place : New Delhi
Dated : 26.02.2013

(R.K. Singhal)
Spl. Director General (NR), CPWD
and Chairman, Specifications Committee(E&M)

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REFERENCES OF AMENDMENTS

Sl. No.	*Reference under which issued*	*Chapter No.*	*Item No.*	*Page*

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CHAPTER 1

GENERAL COMMERCIAL/ TECHNICAL

1.1 Scope

(i) Electricity has become the lifeline of modern society. Homes, Offices, Industry, Schools, Hospitals, Transportation, Communication, Road Lighting, Markets all depend on reliable Electric Supply. Life comes to a standstill without electricity. Electricity has become an integral and inevitable part of every body's life.

It is also necessary to remember that electricity becomes destructive and dangerous, if not handled with care, safety conforming to laid down safety standards and norms. In case of building fires, which often destroy property and lives causing sufferings to the affected people, the first culprit is often supposed to be 'Electric Short Circuit'.

In the above context, the General Specification for Electrical Works (Internal) aims to lay down General guidelines to ensure safe, efficient, reliable and economical use of electricity.

(ii) While these Specifications serve as general guidelines, appropriate technical sanctioning authority can depart from such guidelines to meet the particular requirements of any work or for other technical reasons.

(iii) This Chapter covers the general commercial and technical requirements applicable to works contract for execution of Internal Electrical Installation works.

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

1.2 Related Documents

Each work has its own particular requirements. Therefore, in addition to the General Specifications, governing BIS, I.E. Rules, Standard Contract Conditions etc. there would be necessity of additional conditions/ specifications for a particular work. In case of any discrepancy such additional conditions/ specifications will override these General Specifications.

1.3 Terminology

1.3.1 The definition of terms shall be in accordance with IS 732 : 1989 (Indian Standard Code of Practice for Electrical Wiring), except for the definitions of point, circuit, and submain wiring, which are defined in this specification. Some of the commonly used terms are indicated in Appendix A.

1.3.2 The conventional signs and symbols for technical work shall be as shown in Appendix B.

1.4 Submission of Tenders

1.4.1 The tender shall be submitted complete with the following:-

(i) Complete tender documents as purchased from CPWD duly filled in and signed. The price part of the tender shall be indicated only on the tender schedule of work.

(ii) Earnest Money deposit in one of the specified forms.

(iii) Any other supplementary details required for the evaluation of the tenders such as drawings, technical literature/ catalogues, data etc.

1.4.2 Where two part tendering system is proposed to be adopted in any particular work, the procedure for submission and opening of tenders shall be indicated in tender documents for that work.

1.5 Rates

1.5.1 The work shall be treated as on works contract basis and the rates tendered shall be for complete items of work (except the materials, if any, stipulated for supply by the department) inclusive of all taxes (including works contract tax, if any), duties, and levies etc. and all charges for items contingent to the work, such as, packing, forwarding, insurance, freight and delivery at site for the materials to the supplied by the contractor, watch and ward of all materials (including those, if any, supplied by the department) for the work at site etc.

1.5.2 Prices quoted shall be firm. Price adjustments shall however be governed by Clause 10C/ 10CC of the Conditions of Contract given in form CPWD 7 or 8 of the tender documents, for works executed under these forms. All relevant documents shall be produced by the contractor to the Engineer-in-charge, whenever called upon by him to do so, for working out such adjustments in rates.

1.6 Taxes and Duties

1.6.1 Being an indivisible works contract, Sales Tax, Excise Duty etc. are not payable separately.

1.6.2 The works contract tax shall be deducted from the bills of the contractor as applicable in the State in which the work is carried out, at the time of payments.

1.6.3 Octroi shall not be paid separately for the materials supplied by the contractor, but the Department, on demand, can furnish octroi exemption certificate. However, the Department is not liable to reimburse the octroi duty in case the concerned authorities do not honor such exemption certificates.

1.7 Mobilization Advance

No mobilization advance shall be paid for the work, unless otherwise stipulated in tender papers for any individual work.

1.8 Completeness of Tender

All sundry fittings, assemblies, accessories, hardware items, foundation bolts, termination lugs for electrical connections as required, and all other sundry items which are useful and necessary for proper assembly and efficient working of the various

components of the work shall be deemed to have been included in the tender, whether such items are specifically mentioned in the tender documents or not.

1.9 Works to be Arranged by the Department

Unless and otherwise specified in the tender documents, the following works shall be arranged by the Department:

(i) Storage space for all equipments, components and materials for the work.

(ii) Supply of materials to the contractor as stipulated in the tender documents.

1.10 Works to be done by the Contractor

Unless and otherwise mentioned in the tender documents, the following works shall be done by the contractor, and therefore their cost shall be deemed to be included in their tendered cost: -

(i) Foundations for equipments and components where required, including foundation bolts.

(ii) Cutting and making good all damages caused during installation and restoring the same to their original finish.

(iii) Sealing of all floor openings provided by him for pipes and cables, from fire safety point of view, after laying of the same.

(iv) Painting at site of all exposed metal surfaces of the installation other than pre-painted items like fittings, fans, switchgear/ distribution gear items, cubicle switchboard etc. Damages to finished surfaces of these items while handling and erection, shall however be rectified to the satisfaction of the Engineer-in-charge.

(v) Testing and commissioning of completed installation.

1.11 Storage and Custody of Materials

Suitable and lockable storage accommodation shall be provided by the Department free of cost to the contractor. However, the watch and ward of the stores and their safe custody shall be his responsibility till the final taking over of the installation by the Department.

1.12 Electric Power Supply and Water Supply

Unless and otherwise specified, power supply and water supply will be arranged by the contractor at the site for installation purpose.

However, for testing purpose, electricity supply will be made available free of cost to the contractor.

Contractor will take due care to ensure safety of electrical installation during execution of work.

1.13 Tools for Handling and Erection

All tools and tackles required for handling of equipments and materials at site of work as well as for their assembly and erection and also necessary test instruments shall be the responsibility of the contractor.

1.14 Payment Terms

1.14.1 Unless otherwise specified in the additional conditions of the contract, the payment shall be made as per the relevant clauses of form PWD 7/8 forming a part of the tender documents.

1.14.2 Security deposit shall be deducted in such form and as per provisions contained in CPWD form 7/8 as amended from time to time. The earnest money deposit shall be adjusted against this security deposit. The security deposit shall be released on the expiry of guarantee/ maintenance period stipulated in the contract.

However, the contractor can furnish a bank guarantee in the specified format from a scheduled bank for the full value of the security deposit, in which event no recovery shall be made towards security deposit from his bills. The bank guarantee shall be kept valid till the expiry of the above guarantee/ maintenance period.

1.15 Co-ordination with Other Agencies

The contractor shall co-ordinate with all other agencies involved in the building work so that the building work is not hampered due to delay in his work. Recessed conduit and other works, which directly affect the progress of building work, should be given priority.

1.16 Care of Buildings

Care shall be taken by the contractor to avoid damage to the building during execution of his part of the work. He shall be responsible for repairing all damages and restoring the same to their original finish at his cost. He shall also remove at his cost all unwanted and waste materials arising out of his work from the site.

1.17 Structural Alterations to Buildings

(i) No structural member in the building shall be damaged/altered, without prior approval from the competent authority through the Engineer-in-charge.

(ii) Structural provisions like openings, cutouts, if any, provided by the department for the work, shall be used. Where these require modifications, or where fresh provisions are required to be made, such contingent works shall be carried out by the contractor at his cost.

(iii) All such openings in floors provided by the Department shall be closed by the contractor after installing the cables/ conduits/ rising mains etc. as the case may be, by any suitable means as approved by the Engineer-in-charge without any extra payment.

(iv) All chases required in connection with the electrical works shall be provided and filled by the contractor at his own cost to the original architectural finish of the buildings.

1.18 Addition to an Installation

Any addition temporary or permanent to the existing electrical installation shall not be made without a properly worked out scheme/ design by a qualified Electrical Engineer to ensure that such addition does not lead to overloading, safety violation of the existing system.

1.19 Work in Occupied Buildings

(i) When work is executed in occupied buildings, there would be minimum of inconvenience to the occupants. The work shall be programmed in consultation with the Engineer-in-charge and the occupying department. If so required, the work may have to be done even before and after office hours.

(ii) The contractor shall be responsible to abide by the regulations or restrictions set in regard to entry into, and movement within the premises.

(iii) The contractor shall not tamper with any of the existing installations including their switching operations or connections thereto without specific approval from the Engineer-in-charge.

1.20 Drawings

(i) The work shall be carried out in accordance with the drawings enclosed with the tender documents and also in accordance with modification thereto from time to time as approved by the Engineer-in-charge.

(ii) All wiring diagrams shall be deemed to be 'Drawings' within the meaning of the term as used in Clause 11 of the Conditions of Contract (PWD 7 or PWD 8). They shall indicate the main switch board, the distribution boards (with circuit numbers controlled by them), the runs of various mains and sub-mains and the position of all points with their controls.

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

1.21 Conformity to IE Act, IE Rules, and Standards

1.21.1 All Electrical works shall be carried out in accordance with the provisions of Indian Electricity Act, 2003 and Indian Electricity Rules, 1956 amended up to date (Date of call of tender unless specified otherwise). List of Rules of particular importance to Electrical Installations under these General Specifications is given in Appendix C for reference.

1.22 General Requirements of Components

1.22.1 *Quality of Materials*

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

1.22.2 *Inspection of Materials and Equipments*

(a) Materials and equipments to be used in the work shall be inspected by the Departmental officers. Such inspection will be of following categories:

(i) Inspection of materials/ equipments to be witnessed at the manufacturer's premises in accordance with relevant BIS/ Agreement Inspection Procedure.

(ii) To receive materials at site with Manufacturer's Test Certificate(s).

(iii) To inspect materials at the Authorized Dealer's Godowns to ensure delivery of genuine materials at site.

(iv) To receive materials after physical inspection at site.

(b) The Departmental officers will take adequate care to ensure that only tested and genuine materials of proper quality are used in work.

(c) Similarly, for fabricated equipments, the contractor will first submit dimensional detailed drawings for approval before fabrication is taken up in the factory. Suitable stage inspection at factory also will be made to ensure proper use of materials, workmanship and quality control.

(d) The tender specifications will stipulate the inspection requirements or their waiver for various materials/ equipments including norms of inspection in specific cases.

1.22.3 ***Ratings of Components***

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

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

1.22.4 ***Conformity to Standards***

(a) All components shall conform to relevant Indian Standard Specifications, wherever existing. Materials with ISI certification mark shall be preferred.

(b) A broad list of relevant Indian Standards is given in Appendix D. These Indian Standards, including amendments or revisions thereof upto the date of tender acceptance, shall be applicable in the respective contracts.

1.22.5 ***Interchangeability***

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

1.23 Workmanship

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

1.23.2 ***Proper Supervision/Skilled Workmen***

The contractor shall be a licensed electrical contractor of appropriate class suitable for execution of the electrical work. He shall engage suitably skilled/ licensed workmen of various categories for execution of work supervised by supervisors / Engineer of appropriate qualification and experience to ensure proper execution of work. They will

carry out instructions of Engineer-in-charge and other senior officers of the Department during the progress of work.

1.23.3 ***Use of Quality Materials***

Only quality materials of reputed make as specified in the tender will be used in work.

1.23.4 ***Fabrication in Reputed Workshop***

Switch boards and LT panels shall be fabricated in a factory/ workshop having modern facilities like quality fabrication, seven tank process, powder/ epoxy paint plant, proper testing facilities, manned by qualified technical personnel.

The tender shall specify some quality makes of fabricators with modern facilities of design, fabrication and testing capable of delivering high quality LT panels and switch boards after testing as per relevant specifications.

1.24 Testing

All tests prescribed in these General Specifications, to be done before, during and after installation, shall be carried out, and the test results shall be submitted to the Engineer-in-charge in prescribed Performa, forming part of the Completion Certificate.

1.25 Commissioning on Completion

After the work is completed, it shall be ensured that the installation is tested and commissioned.

1.26 Completion Plan and Completion Certificate

(i) For all works completion certificate after completion of work as given in Appendix E shall be submitted to the Engineer-in-charge.

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

(a) General layout of the building.

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

(c) Position of all points and their controls.

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

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

1.27 Guarantee

The installation will be handed over to the Department after necessary testing and commissioning. The installation will be guaranteed against any defective design/ workman-ship. Similarly, the materials supplied by the contractor will be guaranteed against any manufacturing defect, inferior quality. The guarantee period will be for a period of 12 months from the date of handing over to the Department. Installation/ equipments or components thereof shall be rectified/ repaired to the satisfaction of the Engineer-in-charge.

CHAPTER 2

PLANNING OF ELECTRICAL INSTALLATION

2.1 Planning of Electrical Installation

The design and planning of an electrical installation involve consideration of all prevailing conditions and is usually guided by the requirement of the consumer. A competent Electrical Engineer should take the responsibility of detailed designing and planning to meet the requirement of various functional needs, efficiency, economy, energy conservation, aesthetics, appropriate technology, safety and avoidance of possible fire hazards. Some of the guiding factors are:

(a) Adverse conditions like humidity, high/low ambient temperature, pollution, heat, dust, flame etc. that are likely to affect the installation.

(b) Possible presence of inflammable or explosive vapour, gas, liquid.

(c) The degree of mechanical and electrical protection necessary.

(d) The need of uninterrupted electrical supply, which requires adequate standby system, including generating sets and UPS back up.

(e) Flexibility for future modification or extension.

(f) Energy cost, which requires proper examination of local electrical tariff.

(g) Energy conservation measures.

(h) Need of building management system for efficiency and energy cost saving.

(i) Relative cost of various alternative methods.

(j) Safety aspects including provision of built in safety measures.

(k) Specific measures for avoidance of possible fire hazards.

(l) Use of appropriate technology.

(m) Quality control based on appropriate design and use of quality materials and equipments.

(n) Aesthetics and co-ordination with Architectural and Structural requirement.

(o) Taking into account future growth of load.

(p) Need to provide related space/ conduits/ channels/ cables/ wire for services like: Communication cables, computer cabling, fire alarm cabling, UPS cabling etc. CCTV/ Security system cables etc.

(q) Reducing operation and maintenance cost with appropriate use of automation, sensors, remote control, microprocessor control for controlling various electrical and mechanical activities.

(r) Providing an efficient power distribution system to meet the various power requirements of equipments like:

Computers.

ACs.

Pumps.

Lifts.

Specific equipments.

Ventilation Plant.

AC Plant. etc.

2.2 Coordination

2.2.1 Before planning is started, coordination and collaboration is needed amongst the following:

Client/ user/ users of the building/ Civil/ Structural Engineer/ Architect/ Horticulture.

2.2.2 Based on the specific requirement and projected use of the building, conceptual coordinated detailed planning for the entire building will be finalized. The electrical portion has to fit into such integrated concept of the building.

2.3 Location and Requirement of Sub-station

2.3.1 Electrical sub-station may be required for following reasons:

(a) When electric load is in excess of permitted LT supply limit of 'Electrical Supply Authority', which necessitates setting up of sub-station.

(b) When it is desired to have a sub-station for technical reasons.

2.3.2 ***Ideal Location***

(i) The ideal location for an electric sub-station for a building or group of buildings would be at the load center and shall be located on the ground floor in a separate building. Such building should have direct access through a motorable road to ensure easy access or removal of equipment. The floor level of the sub-station or switch room (in case of LT) shall be above the highest flood level of the locality.

(ii) In case the sub-station has to be located within the main building itself for unavoidable reasons, then it should be located on ground floor with easy access from outside. Location of sub-station in the basement floors should be avoided as far as possible on account of likely flooding and fire hazard. In case it is unavoidable, then foolproof anti-flooding measures have to be taken, which includes provision of automatic dewatering pumping and construction of waterproof basement. Such portion (for sub-station) should be isolated from the rest of basement and should have easy entry and exit arrangement. Also, suitable mechanical ventilation and fire detection/ protection system to be provided to conform to B.I.S. requirements and requirements of local fire authority. Only dry type transformers and switchgear to be provided, unless they are installed in a separate service building separated from the main building.

(iii) Emergency power supply equipment (such as generating sets) shall not be allowed to be installed above ground floor or below first basement level of building.

(iv) Facility for connection from sub-station to adjoining building to feed emergency load shall be permitted.

2.3.3 ***Space for Electric Sub-station***

Reference may be made to "SPACE FOR ELECTRICAL AND MECHANICAL SERVICES IN BUILDINGS" as approved by 38th Specification Committee, October 2002.

2.3.4 ***Co-ordination with Local Supply Authority***

The power requirement should be assessed, in consultation with the owner/ users, and discussion should be held with the Electricity supply authority to decide on location/ space required for Electricity supply equipment/ meter and tariff involved.

2.3.5 ***Provision for Future Growth of Load***

The useful life of the building may be more than 50 years. Experience indicates 5 to 10% growth of electrical load every year. Therefore, building should have adequate space provision for augmentation of electrical supply and associated distribution network.

2.3.6 ***Space for Electrical Services***

Reference may be made to "SPACE FOR ELECTRICAL AND MECHANICAL SERVICES IN BUILDINGS" as approved by 38th Specification Committee, October 2002:

The building has to provide for space for various electrical equipments and service. These include:

(a) Electrical substation to house HT switchgear, Metering, transformers, LT panels, generating sets, essential LT Panel, Voltage correction devices, UPS, Battery Room, Electrical switch rooms, vertical shafts for power, communication, fire alarm, UPS cabling, wet riser, associated doors, cutouts in floors/slabs, cable routes/ trenches/ ducts, cable entry pipes, etc. space for distribution boards etc.

All such provisions are essential to provide an efficient, safe and aesthetic electrical system for the building.

2.3.7 ***Location of Switch Room***

Where, it is not necessary to provide a sub-station, a switch room shall be provided. This shall be preferably near the entrance of the building on the ground floor. This switch room shall receive LT supply for which suitable pipe/ trench provision shall be kept for cable entry. Power distribution shall start with suitable number of rising mains (or rising cables) for vertical distribution. A large building will be divided into suitable number of parts, each part served by a rising main. Suitable provision shall be kept for laying cables/ bus duct from switch room to feed each rising main.

2.3.8 ***Distribution of Supply and Cabling***

A well-designed distribution system will take into account prevailing conditions, various requirement of power so that the installation meets the intended purpose and is safe, and efficient.

2.3.9 ***System of Supply***

(i) All electrical equipments, accessories shall be suitable for voltage and frequency of supply.

(ii) Use of low voltage, medium voltage or high voltage system or combination thereof is a matter of expert calculation, judgement, comparative studies, prevailing tariff, for ensuring better quality of electric supply, better operation, control and economy of use of equipments, better safety etc. Use of high voltage supply entails provision of suitable transformer substation, which demands additional cost and space. However, such additional cost may be justified for following reasons:

(a) Advantage in tariff.

(b) More effective earth fault protection.

(c) Elimination of interference with supplies to other consumers permitting use of large size motors etc.

(d) Better control of voltage.

2.3.10 ***Stand-by Systems***

Whenever reliable power supply is intended, it is essential to plan for stand by systems like:-

(i) Incoming supply from two sources.

(ii) Minimum 2 Nos. Transformers, so that in case of failure of one transformer, there is a standby.

2.3.11 ***Planning for Peak-Non-peak Loads in Office Buildings***

In a typical office building, peak load is between 10 AM to 5 PM. Holidays and after office hours demand is hardly 5% of peak load. Hence, for such period a smaller capacity transformer may be planned to reduce energy losses on account of 'Core Loss' of transformer.

2.4 Quality of Electric Supply

(i) The parameters which decide the quality of electric supply are:-

(a) Voltage.

(b) Frequency.

(c) Absence of harmful harmonics.

(d) Protection against Surge/ Lightning.

(ii) Modern buildings use large number of electro-mechanical, electronic devices, which for their proper operation and protection require quality electric supply.

(iii) Hence, based on specific needs, suitable additional equipments like voltage correctors, filters, surge protectors, UPS etc. may be provided as an integral part of the electric power system.

2.5 Standby Generator Set

2.5.1 In the event of mains power failure, it is necessary to provide standby generating sets to meet the requirement of essential power supply, so that the normal working of

offices and other institutions, which provide service to the public/users, don't suffer. The essential power loads are as below:-

(a) ***Residential***

Water supply pump sets.

Lifts.

Fire protection/ Fire fighting system.

Street lighting.

Essential Community needs.

(b) ***Non-residential***

Water supply pump sets.

Lifts.

Fire protection/ Fire fighting system.

Lights and fans.

Exit lights.

Staircase lights etc.

Other requirements like critical air-conditioning, AHUs, essential power out lets etc.

(c) Therefore, it is necessary to provide for essential power supply system consisting of:

(i) Standby DG Sets.

(ii) Essential LT Power panels.

(iii) Essential rising mains.

(iv) Main boards, DB's, essential wiring etc.

2.6 Power Factor Management

(i) Low power factor results in higher current resulting in higher voltage drop and system losses. In order to have control over these parameters power factor of not less than 0.95 lag to be maintained by the power consumers, at the point of connection.

Percentage reduction of load current and transformer loss due to power factor improvement is given in table below:

Initial Power Factor	*Power Factor Improvement*	*% Reduction in Load Current*	*% Reduction in Transformer Losses*
0.7	0.9	23.7	40
0.7	1.0	30.0	51
0.8	0.9	10.0	21
0.8	1.0	20.0	36
0.9	1.0	10.0	19

(ii) ***Effect of Leading Power Factor***

Leading power factor causes higher voltage; resulting in:

(a) Increase in hysterics and eddy current losses.

(b) Transformer may operate in saturated BH curve, resulting in generation of harmonics, which may lead to heating, and failure of capacitor.

(iii) ***Automatic Power Factor Correction Capacitor Banks***

Properly designed APFC panels shall be provided to maintain power factor automatically at desired level.

2.7 UPS

(a) To meet the requirement of no break power supply for requirements like computer/ communication/ security/ life safety needs etc. it may be necessary to provide for centralized/de-centralized UPS system.

(b) In a centralized UPS system, there will be a third distribution system (besides essential and non-essential power distribution system) consisting of battery room, UPS system, UPS LT Panel, UPS rising main, main boards/ DBs wiring etc.

(c) Such a system requires carefully designed power switchgear and distribution system, so that in case of power failure, the essential/ UPS loads are connected to their respective sources in a safe and reliable manner.

2.8 Allied Services

2.8.1 The modern building, besides electric wiring, has to provide for following services:

(i) Telephone wiring.
(ii) Communication cabling.
(iii) Computer cabling, networking, dedicated earthing.
(iv) Audiovisual systems.
(v) Security systems.
(vi) Sound re-inforcement.
(vii) Stage lighting.
(viii) External lighting.
(ix) Architectural in-built lighting.
(x) Solar Energy system.
(xi) Photo voltaic power system.
(xii) Other specific lighting services etc.
(xiii) Building management system.

2.8.2 It is for the electrical planning engineer to coordinate provision of these services in consultation with the user, Architect, structural engineer and specialized agencies.

2.8.3 Also it is necessary to provide for space/ shafts/ routes and in-built provisions for all these services.

2.8.4 The basic guidelines are:-

(a) Each specialized service will be executed without mixing up with other services.

(b) Wiring of each service will be taken in its own pipe/ channel, except when it is permitted other wise.

(c) Consultation will be made with reputed specialized firms to provide for space and other in-built provision for such services.

(d) Suitable cat-walk shall be provided as an integral part of the building structure, to provide facility for maintenance of systems provided at higher level.

2.9 Lighting Design

2.9.1 *Interior Lighting*

Proper lighting level is to be maintained. NBC 2005 specifies lux levels required for various applications. Lower lux level reduces efficiency of working.

Aged person requires higher lux level. For normal office working a middle-aged man requires 350 lux. A person of 55 to 60 years of age may require 500 lux. Proper designing is required for achieving satisfactory lux levels in conformity with NBC 2005 (see Table 11).

2.9.1.1 *Lighting Power Density*

Lighting Power Density is the ratio of the total lighting load of a space to the total lit space area. The installed interior lighting power for a building shall not exceed the interior lighting power allowance determined in accordance with either Building Area Method or Space Function Method. The installed interior lighting power shall include all power used by the luminaires, including lamps and ballast.

Building Area Method

Determination of interior lighting power allowance (watts) by the building area method shall be in accordance with the following:

- Determine the allowed lighting power density from the table below for each building area type.
- Calculate the gross lighted floor area for each building area type.
- The interior lighting power allowance is the sum of the product of the gross lighted floor area of each building area times the allowed lighting power density for that building area types.

Interior Lighting Power Building Area Method			
Building Area Type	***LPD (W/m²)***	***Building Area Type***	***LPD (W/m²)***
Automotive Facility	9.7	Multifamily Residential	7.5
Convention Centre	12.9	Museum	11.8
Dining : Bar Lounge/ Leisure	14.0	Office	10.8
Dining : Cafeteria/ Fast Food	15.1	Parking Garage	3.2
Dining : Family	17.2	Performing Arts Theatre	17.2
Dormitory/ Hostel	10.8	Police/ Fire Station	10.8
Gymnasium	11.8	Post Office/ Town Hall	11.8
Health care-Clinic	10.8	Religious Building	14.0
Hospital/ Health Care	12.9	Retail/ Mall	16.1
Hotel	10.8	School/ University	12.9
Library	14.0	Sports Arena	11.8
Manufacturing Facility	14.0	Transportation	10.8
Motel	10.8	Warehouse	8.6
Motion Picture Theatre	12.9	Workshop	15.1
In case where both a general building area type and a specific building area type are listed, the specific building area type shall apply.			

Source : Energy Conservation Building Code 2007, Table 7.1

Space Function Method

Determination of interior lighting power allowance (watts) by the space function method shall be in accordance with the following:

- Determine appropriate building type from table below and the allowed lighting power density.
- For each space enclosed by partitions 80% or greater than ceiling height, determine the gross interior floor area by measuring to the center of the partition wall. Include the floor area of balconies or other projections. Retail spaces do not have to comply with the 80% partition height requirements.

  The interior lighting power allowance is the sum of the lighting power allowances for all spaces. The lighting power allowance for a space is the product of the gross lighted floor area of the space times the allowed lighting power density for that space.

Interior Lighting Power Space Function Method			
Space Function	*LPD (W/m²)*	*Space Function*	*LPD (W/m²)*
Office-enclosed	11.8	Workshop	20.5
Office-open plan	11.8	Convention Centre - Exhibit Space	14.0
Conference/ Meeting/ Multipurpose	14.0	Library	
Classroom/Lecture/ Training	15.1	• For Card File & Cataloguing	11.8
Lobby	14.0	• For Stacks	18.3
• For Hotel	11.8	• For Reading Area	12.9
• For Performing Arts Theatre	35.5	Hospital	
• For Motion Picture Theatre	11.8	• For Emergency	29.1
Audience/ Seating Area	9.7	• For Recovery	8.6
• For Gymnasium	4.3	• For Nurse Station	10.8
• For Convention Centre	7.5	• For Exam Treatment	16.1
• For Religious Buildings	18.3	• For Pharmacy	12.9
• For Sports Arena	4.3	• For Patient Room	7.5
• For Performing Arts Theatre	28.0	• For Operating Room	23.7
• For Motion Picture Theatre	12.9	• For Nursery	6.5
• For Transportation	5.4	• For Medical Supply	15.1
Atrium-first three floors	6.5	• For Physical Therapy	9.7
Atrium-each additional floor	2.2	• For Radiology	4.3
Lounge/ Recreation	12.9	• For Laundry - Washing	6.5
• For Hospital	8.6	Automotive - Service Repair	7.5
Dining Area	9.7	Manufacturing Facility	
• For Hotel	14.0	• For Low Bay (<8m ceiling)	12.9
• For Motel	12.9	• For High Bay (>8m ceiling)	18.3
• For Bar Lounge/ Leisure Dining	15.1	• For Detailed Manufacturing	22.6
• For Family Dining	22.6	• For Equipment Room	12.9
• Food Preparation	12.9	• For Control Room	5.4
Laboratory	15.1	Hotel/ Motel Guest Rooms	11.8
Restrooms	9.7	Dormitory - Living Quarters	11.8
Dressing/ Lockers/ Fitting Room	6.5	Museum	
Corridor/ Transition	5.4	• For General Exhibition	10.8
• For Hospital	10.8	• For Restoration	18.3
• For Manufacturing facility	5.4	Bank Office - Banking Activity Area	16.1
Stairs-active	6.5	Retail	
Active Storage	8.6	• For Sales Area	18.3
• For Hospital	9.7	• For Mall Concourse	18.3
Inactive Storage	3.2	Sports Arena	
• For Museum	8.6	• For Rising Sports Area	29.1
Electrical/ Mechanical Facility	16.1	• For Court Sports Area	24.8

Space Function	*LPD (W/m²)*	*Space Function*	*LPD (W/m²)*
• For Indoor Field Area	15.1	Parking Garage - Garage Area	2.2
Warehouse		Transportation	
• For Fine Material Storage	15.1	• For Airport - Concourse	6.5
• For Medium/ Bulky Material		• For Air/ Train/ Bus-Baggage Area	10.8
Storage	9.7	• For Ticket Counter Terminal	16.1

Source : Energy Conservation Building Code 2007, Table 7.3.2

2.10 False Ceiling Coordination

False ceiling electrical layout will be coordinated with the Architect and the Civil Engineer so that reflected drawing provides for symmetrical and aesthetic layout of the following:

Fans

Light fittings

A/C Diffuser

Fire detectors

Sprinklers

Speakers etc.

2.11 Functional Areas like Auditorium, Conference Hall, Computer Rooms, and Library

Special attention to be paid for functional areas to meet the client's requirements, and functional requirements in coordination with the Architect and to provide for specialized services like Audio visual system, P.A. System, Sound reinforcement, Stage lighting, Conference system, Security needs, etc. It may be noted that provision of such services at a latter stage will not only mar the aesthetics of the building, also will compromise with efficiency of such services for want of proper space etc.

2.12 Areas like Hospitals, Stadia

Planning of such buildings require high degree of professionalism, for application of latest technology to provide efficient and effective installation.

2.13 Outdoor Lighting, High Mast Lighting, Road Lighting, Security Lighting, Garden Lighting, Illuminated Fountains

Present day modern buildings require highly aesthetic lighting making use of a variety of lighting design, themes and fixtures available. For proper aesthetic effect, high level of professional approach is needed based on computer aided design and calculations.

2.13.1 *Luminous Efficacy*

Luminous efficacy of the outdoor lighting assemblies used in the outdoor lighting system should be equal to or more than the luminous efficacy mentioned in the table below. The lighting assembly includes luminaire, lamp and ballast.

Luminous efficacy is defined as the ratio of lamp lumen output divided by the total input power which includes the lamp losses and power losses in ballast.

Luminous efficacy (lm/W) = {lamp lumen output (lm)}/{lamp wattage (W) + ballast power loss (W)}

Minimum luminous efficacy required to be maintained in lighting assemblies used in outdoor application	
Type of lamp lighting system	*Luminous efficacy (lm/W)*
CFL	65
T-5 Tubular fluorescent lamp	100
Metal halide lamp	75
High Pressure Sodium Vapour lamp	90
LED Warm Day Light	80
LED Cool Day Light	70

2.13.2 ***Lighting Power Density***

The installed lighting power density for building exterior lighting applications mentioned in the table below shall not exceed the limits specified in the table below.

Exterior Lighting Applications	*Power Limits*
Building entrance (with canopy)	13 W/m^2 (1.3 W/ft^2) of canopied area
Building entrance (without canopy)	90 W/lin m (30 W/lin f) of door width
Building exit	60 W/lin m (20 W/lin f) of door width
Building facades	2 W/m^2 (0.2 W/ft^2) of vertical facade area

2.13.3 ***Night Sky Pollution & Light Tresspass***

All exterior lighting should be designed to minimize night sky pollution. Only those areas shall be lighted that are required for safety and comfort. Installation of luminaires on site and building shall be such that no light tresspassing occurs on the neighbouring site and buildings.

For Interior Lighting

The angle of maximum candela from each interior luminaire as located in the building shall intersect opaque building interior surfaces and not exit out through windows.

For Exterior Lighting

All projects defined under the following zones shall follow the requirements for that specific zone as given below:

- ***Dark (Park and Rural Settings)***

  Design exterior lighting so that all site and building mounted luminaires produce a maximum initial illuminance value no greater than 0.01 horizontal and vertical footcandles at the site boundary and beyond.

  Lighting Fixture: 0% of the total initial fixture lumens are emitted at an angle of 90 degree or higher from nadir.

- ***Low (Residential Areas)***

  Design exterior lighting so that all site and building mounted luminaires produce a maximum initial illuminance value no greater than 0.10 horizontal and vertical footcandles at the site boundary and no greater than 0.01 horizontal footcandles 10 feet beyond the site boundary.

  Lighting Fixture: 2% of the total initial fixture lumens are emitted at an angle of 90 degree or higher from nadir.

- ***Medium (Commercial/ Industrial, High Density Residential)***

  Design exterior lighting so that all site and building mounted luminaires produce a maximum initial illuminance value no greater than 0.20 horizontal and vertical footcandles at the site boundary and no greater than 0.01 horizontal footcandles 15 feet beyond the site boundary.

  Lighting Fixture: 5% of the total initial fixture lumens are emitted at an angle of 90 degree or higher from nadir.

- ***High (Major City Centre, Entertainment Districts)***

  Design exterior lighting so that all site and building mounted luminaires produce a maximum initial illuminance value no greater than 0.60 horizontal and vertical footcandles at the site boundary and no greater than 0.01 horizontal footcandles 15 feet beyond the site boundary.

  Lighting Fixture: 10% of the total initial fixture lumens are emitted at an angle of 90 degree or higher from nadir.

2.13.4 ***LED Lighting***

2.13.4.1 *Features of LED Lighting:*

(i) Energy saving
(ii) Long Life
(iii) Rugged and Durable
(iv) Smaller lighting Fixture
(v) Environment friendly – no mercury
(vi) Instant starting
(vii) Dimmable for automation
(viii) Available in different colours

2.13.4.2 *Challenges of LED Lightings:*

(i) LEDs are not manufactured in India.

(ii) Quality control.

(iii) Expensive.

(iv) Still in development stage. Efficiency of LED luminaries is continuously being upgraded.

(v) No. of electronic items in LED luminaries like driver, PCB, power supply etc. affect LED life.

(vi) Quality of phosphor coating on LED.

(vii) Diffuser used in LED luminaries, reduces its lumen output.

(viii) Heat Management.

(ix) Junction temperature v/s lumen output.

2.13.4.3 Design Parameter for selecting source of lighting while designing lighting of building/ campus :

Following important parameters be kept in view while deciding the suitable light source for indoor lighting:-

(i) CRI of the source.

(ii) Usable lumen per watt of fitting

(iii) Glaring index of fixture

(iv) Life of the lamp

2.13.4.4 The present practice in CPWD while designing indoor lighting is to use T5 lamp in rooms and CFL lamp in corridors and other common areas due to keeping good CRI and to maximize usable lumen per watt. HPSV lamp and Metal Halide lamp are being used for outdoor lighting.

2.13.4.5 Following technical parameters of LED,T5, CFL, HPSV and Metal halide lamp are brought out:-

	LED (Warm White)	*LED (Cool White)*	*T5 Lamp*	*CFL Lamp*	*HPSV Lamp*	*Metal Halide Lamp*
CRI	80-85	75	85	85	22	60-90
Efficacy in lm/w	80	132	90	70	95-110	65-70
Usable lm/w	55-65	>100	75-85	50-60	55-65	35-40
Life (Hrs.)	50k+	50k+	30k	8-10k	24k	10k-20k

2.13.4.5.1 LED lighting has become efficient (luminous efficacy) and with good CRI over HPSV lamp as well as metal halide lamp, hence it can be used for outdoor lighting applications which are being done by HPSV and Metal halide lamps.

2.13.4.5.2 In indoor applications for down lighters, task lighting etc. where CFL luminaires are being used, the luminous efficacy of the LED luminaires is comparable and due to higher life can be used for such applications.

2.13.4.5.3 Since light output and life of LED is dependent on the driver current and junction temperature, Indian standards for the LED are now available and luminaires efficacy and life cycle of T5 lamp selectively for indoor applications in business/ institutional building only with prior approval of Chief Engineer concerned as consideration of CRI in these areas is of prime importance. Chief Engineer may approve the type and make of LED fittings keeping in view of the specific applications and IS.

2.14 Street Light Poles

Hot dipped galvanized poles with integrated in-built control box and lighting brackets is a preferred option to ensure long life of poles and to delay effect of corrosion. The height and spacing of poles should be designed with the aid of computers for ensuring proper lux level. Similarly the wattage and type of luminaires should be decided based on proper design. But in keeping view of energy efficiency, the street and area lighting should be designed to keep lux level at lower limit specified in the standards. Having an external control box fixed to the pole is not a preferred option for aesthetic/ technical reasons. If it is decided to go for this option, it is better to go for non-metallic enclosures (like polycarbonate/ engineering plastic) with IP: 65 protections, to avoid corrosion effect. Similarly street light fittings fixed to the wall of the building should be generally avoided. Also for feeder pillars application, enclosures made of non-corrosive materials like fibre glass/ engineering plastic manufactured by reputed firm can be used after suitable technical evaluation. (See Fig. 1 for typical road lighting & Fig. 2 for typical feeder pillar)

2.15 Renewable Energy System

Based on the source of renewable energy, renewable energy systems can be categorized as:

- Systems using direct forms of solar energy (solar thermal and solar photovoltaic systems),
- Systems using indirect forms of solar energy (wind, hydro, bio-energy, and wave energy systems),
- Non-solar based renewable energy systems (geothermal energy systems, tidal energy systems, and hydrogen and fuel cells).

2.15.1 *Use of Solar PV System for Outdoor Lighting*

Solar PV system for outdoor lighting should be installed such that a minimum of 25% of the total number or 15% of the total connected load of outdoor lighting fixtures (whichever is higher) should be powered by solar energy.

2.15.2 ***Renewable Energy Generation System Capacity***

A renewable energy system shall be installed in the building and its rated capacity shall be equal to or more than 1% of internal lighting and space-conditioning connected loads.

It is recommended that the installed renewable energy system meets the annual energy requirements of equal to or more than 30% of internal lighting connected loads or its equivalent in the building.

2.15.3 ***Renewable Energy Based Water Heating System Capacity***

Residential facilities, hotels and hospitals with a centralized system shall have solar water heating for at least one-fifth of the design capacity.

It is recommended that the capacity of the hot water system is such that the annual energy saved by proposed renewable energy system is more than 70% of annual energy required for water heating to meet the hot water requirements of the occupants in the building.

Exception to above:

If the hot water requirement is less than 500 litres per day.

System Efficiency

Solar water heater shall meet the performance/ minimum efficiency level mentioned in IS 13129 Part 1& 2.

CHAPTER 3

ELECTRIC POWER DISTRIBUTION AND WIRING

3.1 Introduction

The electric power will be received and distributed in a building, through following means:-

(i) Cabling and switchgear to receive power.

The building is divided into convenient number of parts, each part served by a rising main system to distribute power vertically/horizontally.

(ii) Power flows from rising main through tap-off box to floor main board to final DBs and then to wiring.

(iii) Dedicated circuit for different loads such as lighting, HVAC, power plug loads shall be provided, wherever possible.

(iv) Rising main, which takes care of general lighting and power outlet load of the building, should have independent cables for lighting as well as power, wherever possible. Other loads like lifts, water pump sets, other motor loads are fed by independent cables of suitable capacity fed from properly designed essential/ non-essential LT power panels with suitably designed switchgear having necessary control and safely features.

(v) Therefore the distribution/wiring system essentially consists of provision of cables, switchgear, rising main, bus-ducting, earthing, laying of pipes/ conduits etc. (in surface or recess) based on proper detailed designing to decide on various sizes/ capacities of these components and various controls and safeties involved, to provide an efficient, reliable, safe and adequate electrical distribution and wiring system.

(vi) A typical schematic diagram of power distribution of a building is enclosed. (See Fig. 3)

3.2 System of Distribution and Wiring

(i) The wiring shall be done from a distribution system through main and/or branch distribution boards. The system design and location of boards will be properly worked out.

(ii) Each main distribution board and branch distribution board shall be controlled by an incoming circuit breaker/linked switch with fuse. Each outgoing circuit shall be controlled by a circuit breaker/switch with fuse.

(iii) For non-residential and residential buildings as far as possible DBs shall be separate for light and power.

(iv) Only MCCB/MCB/HRC fuse type DBs shall be used. Rewirable type fuses shall not be used.

(v) Three phase DBs shall not be used for final circuit distribution as far as possible.

(vi) 'Power' wiring shall be kept separate and distinct from light wiring, from the level of circuits, i.e., beyond the branch distribution boards. Conduits for light/power wiring shall be separate.

(vii) Essential/non-essential/UPS distribution each will have a completely independent and separate distribution system starting from the main, switchboard upto final wiring for each system. As for example, conduit carrying non-essential wiring shall not have essential or UPS wiring. Wiring for essential and UPS supply will have their own conduit system. No mixing of wiring is allowed.

(viii) Generally, no switchboard will have more than one source of incoming supply. More than one incoming supply will be allowed only at main board with proper safety and interlocking so that only one source can be switched on at a time.

(ix) Each MDB/DB/Switch Board will have reasonable spare outgoing ways for future expansion.

(x) Balancing of 3-phase circuit shall be done.

3.3 Wiring

3.3.1 *Submain & Circuit Wiring*

(a) *Submain Wiring*

Submain wiring shall mean the wiring from one main/distribution switchboard to another.

(b) *Circuit Wiring*

Circuit wiring shall mean the wiring from the distribution board to the 1st tapping point inside the switch box, from where point wiring starts.

3.3.2 *Measurement of Submain and Circuit Wiring*

(i) Circuit and submain wiring shall be measured on linear basis along the run of the wiring. The measurement shall include all lengths from end to end of conduit or channel as the case may be, exclusive of interconnections inside the switchboard etc. The increase on account of diversion or slackness shall not be included in the measurement.

(ii) The length of circuit wiring with two wires shall be measured from the distribution board to the nearest switch box from which the point wiring starts. Looping of switch boxes also will be counted towards circuit wiring, measured along the length of conduit/channel.

(iii) When wires of different circuits are grouped in a single conduit/ channel, the same shall be measured on linear basis depending on the actual number and sizes of wires run.

(iv) Protective (loop earthing) conductors, which are run along the circuit wiring and the submain wiring, shall be measured on linear basis and paid for separately.

Note: Conduit carrying submain will not carry circuit/point wiring. Similarly conduit carrying circuit wiring will not carry submain/point wiring. Conduit carrying point wiring will not carry submain/circuit wiring.

3.3.3 ***Measurement of Other Wiring Work***

Except as specified above for point wiring, circuit wiring and submain wiring, other types of wiring shall be measured separately on linear basis along the run of wiring depending on the actual number and sizes of wires run.

3.4 Point Wiring

3.4.1 ***Definition***

A point (other than socket outlet point) shall include all work necessary in complete wiring to the following outlets from the controlling switch or MCB.

(a) Ceiling rose or connector (in the case of points for ceiling/exhaust fan points, prewired light fittings, and call bells).

(b) Ceiling rose (in case of pendants except stiff pendants).

(c) Back plate (in the case of stiff pendants).

(d) Lamp holder (in the case of goose neck type wall brackets, batten holders and fittings which are not prewired).

3.4.2 ***Scope***

Following shall be deemed to be included in point wiring:

(a) Conduit/channel as the case may be, accessories for the same and wiring cables between the switch box and the point outlet, loop protective earthing of each fan/ light fixture.

(b) All fixing accessories such as clips, screws, Phil plug, rawl plug etc. as required.

(c) Metal or PVC switch boxes for control switches, regulators, sockets etc, recessed or surface type, and phenolic laminated sheet covers over the same.

(d) Outlet boxes, junction boxes, pull-through boxes etc. but excluding metal boxes if any, provided with switchboards for loose wires/conduit terminations.

(e) Control switch or MCB, as specified.

(f) 3 pin or 6 pin socket, ceiling rose or connector as required. (2 pin and 5 pin socket outlet shall not be permitted.)

(g) Connections to ceiling rose, connector, socket outlet, lamp holder, switch etc.

(h) Bushed conduit or porcelain tubing where wiring cables pass through wall etc.

(**Note*:*** In areas where false ceiling are provided, termination of wires should be at the fittings. Flexible conduits from ceiling junction box to the fittings shall be provided duly coupled at both ends. This shall be included within the scope of point wiring.)

(i) Interconnecting wiring between switches within the switch box on the same circuit.

3.4.3 ***Measurement***

(a) *Point Wiring (other than socket outlet points)*

(i) Unless and otherwise specified, there shall be no linear measurement for point wiring for light points, fan points, exhaust fan points and call bell points. These shall be measured on unit basis by counting, and classified as laid down in 3.4.4.

3.4.4 ***Classification***

Points measured under 3.4.3 on unit basis shall be classified as under according to the type of building:

(a) *Residential Buildings*

(i) Group 'A', for point wiring for type I, type II and type III residential quarters and hostels.

(ii) Group 'B', for point wiring for type IV and above type of residential quarters and barracks.

(b) *Non-residential Buildings*

Group 'C' for all types of non-residential buildings such as offices, hospitals, laboratories, educational institutions, libraries etc.

(c) *For any Other Type of Building*

The group under which the points are to be classified shall be decided by the concerned Chief Engineer (Elect.).

3.4.5 ***Point Wiring for Socket Outlet Points***

(i) The light plug (6 A) point and power (16 A) point wiring shall be measured on linear basis, from the respective tapping point of live cable, namely, switch box, another socket outlet point, or the sub-distribution board as the case may be, up to the socket outlet.

(ii) The metal/PVC box with cover, switch/MCB, socket outlet and other accessories shall be measured and paid as a separate item.

Note: There shall normally be no "on the board" light plug point.

(iii) The power point outlet may be 16 A/6 A six pin socket outlet, where so specified in the tender documents.

3.4.6 ***Group Control Point Wiring***

(i) In the case of points with more than one point controlled by the same switch, such points shall be measured in parts i.e. (a) from the switch to the first point outlet as one point and classified according to 3.4.4, and (b) for the subsequent points, the distance from that outlet to the next one and so on, shall be treated as separate point(s) and classified according to 3.4.4.

(ii) No recovery shall be made for non-provision of more than one switch in such cases.

3.4.7 ***Twin Control Light Point Wiring***

(i) A light point controlled by two numbers of two way switches shall be measured as two points from the fitting to the switches on either side and classified according to 3.4.4.

(ii) No recovery shall be made for non-provision of more than one ceiling rose or connector in such cases.

3.4.8 ***Multiple Controlled Call Bell Point Wiring***

(i) In the case of call bell points with a single call bell outlet, controlled from more than one place, the points shall be measured in parts i.e.

(a) from the call bell outlet to one of the nearest ceiling roses meant for connection to bell push, treated as one point and classified according to 3.4.4, and

(b) from that ceiling rose to the next one and so on, shall be treated as separate point(s) and classified according to 3.4.4.

(ii) No recovery shall be made for non-provision of more than one ceiling rose or connector for connection to call bell in such cases.

3.5 Wiring System

(i) Wiring shall be done only by the looping system. Phase/live conductors shall be looped at the switch box. For point wiring, neutral wire/earth wire looping for the 1st point shall be done in the switch box; and neutral/earth looping of subsequent points will be made from point outlets.

(ii) In wiring, no joints in wiring will be permitted any where, except in switch box or point outlets, where jointing of wires will be allowed with use of suitable connector.

(iii) The wiring throughout the installation shall be such that there is no break in the neutral wire except in the form of linked switchgear.

(iv) Light, fans and call bells shall be wired in the ‘lighting’ circuits. 15A/16A socket outlets and other power outlets shall be wired in the ‘power’ circuits. 5A/6A socket outlets shall also be wired in the ‘power’ circuit both in residential as well as non-residential buildings.

(v) *Colour Coding*

Following colour coding shall be followed in wiring:

Phase	:	Red/Yellow/Blue.(Three phase wiring)
Live	:	Red (Single phase wiring)
Neutral	:	Black
Earth	:	Yellow/Green.

(vi) *Termination of Circuit into Switchboard*

Circuit will consist of phase/neutral/earth wire. Circuit will terminate in a switch board (first tapping point, where from point wiring starts) in following manner:

Phase wire terminated in phase connector.

Neutral wire terminated in neutral connector.

Earth wire terminated in earth connector.

The switchboard will have phase, neutral and earth terminal connector blocks to receive phase/ neutral/ earth wire.

See Fig 4.

3.6 Run of Wiring

(i) The type of wiring shall be as specified in the tender documents namely, surface conduit/recessed conduit, steel/PVC, channel.

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

(iii) Above false ceiling, in no case, open wiring shall be allowed. Wiring will be done in recessed conduit or surface steel conduit.

(iv) In recessed conduit system, routes of conduit will be planned, so that various inspection boxes provided don't present a shabby look. Such boxes can be provided 5 mm above plaster level, and they can be covered with plaster of paris with marking of junction boxes.

(v) Where number of electrical services like electrical wiring, telephone wiring, computer cabling, pass through corridors, it may be proper to plan such service with properly designed aluminium/PVC channels duly covered by a false ceiling, so that subsequently such service can be maintained and additional cables can be provided.

(vi) Generally conduits for wiring will not be taken in floor slabs. When it is unavoidable special precaution to be taken to provide floor channels with provision for safety and maintenance. Alternatively false flooring can be provided.

3.7 Passing through Walls or Floors

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

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

3.8 Joints in Wiring

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

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

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

3.9 Ratings of Outlets

(to be adopted for design).

(i) Incandescent lamps in residential and non-residential buildings shall be rated at 60W and 100W respectively.

(ii) Ceiling fans shall be rated at 60W. Exhaust fans, fluorescent tubes, compact fluorescent tubes, HPMV lamps, HPSV lamps etc. shall be rated according to their capacity. Control gear loses shall be also considered as applicable.

(iii) 6A and 16A socket outlet points shall be rated at 100W and 1000W respectively, unless the actual values of loads are specified.

3.10 Capacity of Circuits

(i) Lighting circuit shall feed light/fan/ call bell points. Each circuit shall not have more than 800 Watt connected load or more than 10 points whichever is less. However, in case of CFL points where load per point may be less, number of points may be suitably increased.

(ii) Power circuit in non-residential building will have only one outlet per circuit.

(iii) Each power circuit in residential building can feed following outlets:

(a) Not more than 2 Nos. 16A outlets.

(b) Not more than 3 Nos. 6A outlets.

(c) Not more than 1 No.16A and 2 Nos. 6A outlets.

(iv) Load more than 1 KW shall be controlled by suitably rated MCB and cable size shall be decided as per calculations.

(v) *Power Wiring with Bus Trunking*

It is permitted to meet large-scale power requirement in a hall, or floor, with use of single phase or 3 phase bus bars running inside a metal enclosure. This will be provided with careful design and use of factory fabricated bus-trunking of reputed make, conforming to relevant BIS standards and with standard accessories like End feed unit, tap off with necessary safety features like over current, short-circuit and earth fault protection. Such trunking will be of specified breaking KA rating.

3.11 Socket Outlets

(i) Socket outlets modular type shall be 6A 3 pin, 16 Amp 3 pin or 16/6 Amp 6 pin. 5 pin socket outlets will not be permitted.

The third pin shall be connected to earth through protective (loop earthing) conductor. 2 pin or 5 pin sockets shall not be permitted to be used.

(ii) Conductors connecting electrical appliances with socket outlets shall be of flexible type with an earthing conductor for connection to the earth terminal of plug and the metallic body of the electrical appliance.

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

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

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

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

(a) *Non-residential buildings* – 23 cm above floor level.

(b) *Kitchen* – 23 cm above working platform and away from the likely positions of stove and sink.

(c) *Bathroom* – No socket outlet is permitted for connecting a portable appliance thereto. MCB/IC switch may be provided above 2 m for fixed appliances, and at least 1 m away from shower.

(d) *Rooms in residences* – 23 cm above floor level, or any other level in special cases as desired by the Engineer-in-charge.

(vii) Unless and otherwise specified, the control switches for the 6A and 16A socket outlets shall be kept along with the socket outlets.

3.12 Cables

(i) Copper conductor cable only will be used for submain/ circuit/ point wiring.

(ii) Minimum size of wiring:

Light Wiring	:	1.5 sq.mm.
Power Wiring	:	4.0 sq.mm.
Power circuit rated	:	More than 1 KW, Size as per calculation.
(iii) Insulation	:	Copper conductor cable shall be PVC insulated conforming to BIS Specification.
(iv) Multi stranded	:	Cables are permitted to be used.

3.13 Flexible Cable

(i) Conductor of flexible cables shall be of copper. The cross sectional area of conductor for flexible cable shall be as per design.

(ii) Only 3 core flexible cables shall be used for connecting single-phase appliances.

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

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

3.14 Wiring Accessories

(a) ***Control Switches for Point***

(i) Control switches (single pole switch) carrying not more than 16A shall be modular type. The switch shall be 'On' when the knob is down.

(ii) (a) In type I, II & III quarters, Barracks & school buildings (except principal's & staff rooms) etc. Piano type switches shall be provided (unless specifically asked for by the user department / Architect.)

(b) Modular type switches to be provided for remaining types of buildings i.e. in all types of remaining non-residential buildings & residential buildings of type IV & above & Transit hostel or as may be decided by the Architect/ user department. (**Note**: Provision is meant for new constructions and in existing buildings during rewiring if the building work renovation is also in progress in the area. Otherwise existing type of piano switches will be continued.)

(iii) It is recommended to provide double pole MCB in proper enclosure as power outlet for window type AC units, geysers etc.

(b) ***Switch Box***

(i) Switch box shall be hot dip galvanized, factory fabricated, suitable in size for surface/ recess mounting and suitable in size for accommodating the required number of switches and accessories (where required to be used for applications other then modular switches/ sockets).

(ii) Switch box also can be of non-metallic material. The technical sanctioning authority will approve specified makes of reputed quality and specifications.

(c) ***Switch Box Covers (for application other than modular type)***

Phenolic laminated sheets of approved shade shall be used for switch box covers. These shall be of 3 mm thick synthetic phenolic resin bonded laminated sheet as base material and conforming to grade P- I of IS 2036 : 1974.

Note: Specification for switch boxes is covered in the chapters on the various types of wiring.

(d) ***Ceiling Rose***

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

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

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

(e) ***Lamp Holders***

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

(ii) Lamp holders for use on brackets and the like shall have not less than 1.3 cm nipple, and all those for use with flexible pendant shall be provided with cord grips.

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

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

(f) ***Fittings***

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

Indoor Type Fittings

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

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

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

(iv) Fittings shall be installed such that the lamp is at a height of 2.4m above floor level, unless otherwise directed by the Engineer-in-charge.

(v) Fittings made of CRCA shall be phosphatized and powder/epoxy painted. For coastal areas and humid area like toilets, kitchen, for prolonging the life of such fittings, corrosion free materials like engineering plastic, aluminium, stainless steel etc. should be used.

Outdoor Fittings

Outdoor fittings shall have suitable IP protection. It is preferable that street light

fittings are of cast aluminium body of IP 65, for reducing recurring maintenance cost and improved performance. Where required IP 66 fittings also can be provided for reducing maintenance frequency and cost.

Other fittings, which are not available with tested IP 65/54 protection, can be properly fabricated with weatherproof features, proper gasketing etc. As far as possible corrosion free material like cast aluminium, stainless steel, engineering plastics may be used for fabrication of such fittings, to prolong life of such fittings. There should not be any exposed wiring in such outdoor fittings.

3.15 Attachment of Fittings and Accessories

(a) ***Conduit Wiring System***

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

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

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

(b) ***Fixing to Walls and Ceiling***

(i) Wooden plugs for fixing to wall/ceiling will not be allowed. Fixing will be done with the help of PVC sleeves/Rowel plugs/ dash fasteners as required.

(ii) Drilling of holes shall be done by drilling machines only. No manual drilling of hole will be allowed.

3.16 Fans, Regulators and Clamps

(a) ***Ceiling Fans***

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

(ii) The capacity of a ceiling fan to meet the requirement of a room with the longer dimension D meters should be about 55 D m^3/min.

(iii) The height of fan blades above the floor should be (3H + W)/4, where H is the height of the room, and W is the height of the work plane.

(iv) The minimum distance between fan blades and the ceiling should be about 0.3 meters.

(v) When actual ventilated zone does not cover the entire room area, then optimum size of ceiling fan should be chosen based on the actual usable area of the room, rather than the total floor area of the room.

(vi) The number of fans and the optimum sizes for rooms of different dimensions are given in the following table:

Optimum Size/Number of Fans for Rooms of Different Sizes

Room Width	*Room Length*										
m	*4m*	*5m*	*6m*	*7m*	*8m*	*9m*	*10m*	*11m*	*12m*	*14m*	*16m*
(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*	*(11)*	*(12)*
3	1200/1	1400/1	1500/1	1050/2	1200/2	1400/2	1400/2	1400/2	1200/3	1400/3	1400/3
4	1200/1	1400/1	1200/2	1200/2	1200/2	1400/2	1400/2	1500/2	1200/3	1400/3	1500/3
5	1400/1	1400/1	1400/2	1400/2	1400/2	1400/2	1400/2	1500/2	1400/3	1400/3	1500/3
6	1200/2	1400/2	900/4	1050/4	1200/4	1400/4	1400/4	1500/4	1200/6	1400/6	1500/6
7	1200/2	1400/2	1050/4	1050/4	1200/4	1400/4	1400/4	1500/4	1200/6	1400/6	1500/6
8	1200/2	1400/2	1200/4	1200/4	1200/4	1400/4	1400/4	1500/4	1200/6	1400/6	1500/6
9	1400/2	1400/2	1400/4	1400/4	1400/4	1400/4	1400/4	1500/4	1400/6	1400/6	1500/6
10	1400/2	1400/2	1400/4	1400/4	1400/4	1400/4	1400/4	1500/4	1400/6	1400/6	1500/6
11	1500/2	1500/2	1500/4	1500/4	1500/4	1500/4	1500/4	1500/4	1500/6	1500/6	1500/6
12	1200/3	1400/3	1200/6	1200/6	1200/6	1400/6	1400/6	1500/6	1200/7	1400/9	1400/9
13	1400/3	1400/3	1200/6	1200/6	1200/6	1400/6	1400/6	1500/6	1400/9	1400/9	1500/9
14	1400/3	1400/3	1400/6	1400/6	1400/6	1400/6	1400/6	1500/6	1400/9	1400/9	1500/9

Note : This table is indicative only. Case specific design should be done by field officers based on site conditions & constraints.

(vii) Energy Efficient fans with BEE 3-5 star rating or complying with IS 374: 1979, shall be used. The minimum service value of fans shall be 3.5 m^3/min/W and air delivery 200 m^3/min.

The values of service factor and air delivery for ceiling fans with 1200 mm sweep are given in the table below:

Star Rating Index Calculation for Ceiling Fans (1200 mm sweep)

Star Rating	*Service Value for Ceiling Fans**
1 Star	≥ 3.2 to < 3.4
2 Star	≥ 3.4 to < 3.6
3 Star	≥ 3.6 to < 3.8
4 Star	≥ 3.8 to < 4.0
5 Star	≥ 4.0

* Where x is the base service value as per IS 374 : 1979. BEE has proposed a base service value of 3.2 at present and would upgrade it to higher value once the BIS value is finalised.

* The BIS has proposed from the year 2010 the service value of 3.5.

* All ceiling fans covered under this standard shall comply with minimum air Delivery of 210 m^3/min.

For other fan size (mm) the following table may be considered

Standard Power with Air Delivery of Fan as per the IS 374 Code

Fan Size	*Type*		*Minimum Air Delivery*	*Minimum Service Value*	*Maximum Power Input*
(mm)			*m^3/min*	*m^3/min/W*	*W*
900	Capacitor	AC	130	3.1	42
		DC	130	3.4	38
1050	Capacitor	AC	150	3.1	48
		DC	150	3.4	44
1200	Capacitor	AC	200	4	50
		DC	200	4.6	44
1400	Capacitor	AC	245	4.1	60
		DC	245	4.8	51
1500	Capacitor	AC	270	4.3	63
		DC	270	5.1	53

Note: Air delivery values are on the basis of air velocity measurements up to 15m/min.

(viii) Step Type Electronic regulators should be used instead of resistance type regulators for controlling speed of fans.

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

(x) For wooden or steel joists and beams, the suspension shall consist of GI flat of size not less than 40 mm x 6 mm, secured on the sides of the joists or beams by means of two coach screws of size not less than 5 cm for each flat. Where there is space above the beam, a through-bolt of size not less than 1.5 cm dia, shall be placed above the beam from which the flats are suspended. In the latter case, the flats shall be secured from movements by means of another bolt and nut at the bottom of the beam. A hook consisting of MS rod of size not less than 1.5 cm dia shall be inserted between the MS flat through oval holes on their sides. Alternatively, the flats may be bent inwards to hold tightly between them by means of a bolt and nut, a hook of 'S' form.

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

(xii) For concrete roofs, a 12 mm dia. MS rod in the shape of 'U' with their vertical legs bent horizontally at the top at least 19 cm on either side, and bound to the top reinforcement of the roof shall be used, as shown in Fig. 5.

(xiii) In buildings with concrete roofs having a low ceiling height, where the fan clamp mentioned under sub-clause (v) above cannot be used, or wherever specified, recessed type fan clamp inside metallic box, as shown in Fig. 6 shall be used.

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

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

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

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

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

(b) ***Exhaust Fans***

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

(ii) Exhaust fans shall be erected at the places indicated by the Engineer-in-charge. For fixing an exhaust fan, a circular opening shall be provided in the wall to suit the size of the frame, which shall be fixed by means of rag bolts embedded in the wall. The hole shall be neatly plastered to the original finish of the wall. The exhaust fan shall be connected to the exhaust fan point, which shall be wired as near to the opening as possible, by means of a flexible cord, care being taken to see that the blades rotate in the proper direction.

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

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

(c) ***Regulators***

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

3.17 Marking of Switch Boards

(i) ***Schematic Diagram***

First a comprehensive schematic diagram for each building is to be prepared, starting from Main LT Panel, rising main, submain boards, DBs, etc. and the

manner in which they are connected. This will include essential, non-essential and UPS systems. Sizes of interconnecting main/submain cables shall be indicated.

(ii) ***Marking of each Main Board***

Each main board/submain board shall be marked indicating rating of each incoming/ outgoing switch and the details of load/area it feeds. Detail/size of incoming and outgoing cable also shall be marked indicating from where the incoming cable has originated.

(iii) ***Marking of Distribution Board***

Each Distribution Board shall be marked indicating detail of incoming switch (Size of cable and from where it is fed) and marking of each outgoing MCB indicating the area it feeds. Suitable marking sticker will be suitably fixed to indicate such details.

(iv) ***Marking of Power/Light DBs***

Power/light DBs shall be marked 'P' and 'L' respectively.

(v) ***Marking for Non-essential/Essential/UPS/Switch Boards***

Each switchboard shall be marked essential/non-essential/UPS to indicate the nature of such switchboards.

(vi) ***Marking of Main Earthing Terminal***

Main arthing terminals in main/submain switchboard shall be permanently marked, as "Safety Earth – Don't Remove".

3.18 LT Distribution Switchgear

Only following type switchboards will be used:

(a) Main/Submain switchboard of cubicle type.

(b) DBs – Conventional DBs of reputed makes can also be used with the approval of technical sanctioning authority in addition to prewired DB.

(c) Specially designed switchboards.

Also specially designed switchboards can be used with detailed specification and fabrication drawings approved by the technical sanctioning authority.

(d) Specifications of cubicle panel and pre-wired DB are given in Clause 7.1.2 of Chapter 7.

3.19 Location of Switchboards

(i) Switchboards are to be located in common areas like corridors, lobby etc. and not to be located in locked room.

(ii) Switchboard shall be located only in dry situation and in well-ventilated space. They shall not be placed in the vicinity of storage battery or exposed to chemical fume.

(iii) Switchboards shall not be erected above gas stove, or sinks or within 2.5 meter of any washing unit in washing rooms of launderings or in the bath rooms, toilets, or kitchen.

(iv) As far as possible main boards shall not be located in basement. Such main boards can be located in ground floor.

(v) It is preferable to locate floor main boards in rising main shafts of adequate size, with steel doors (having ventilation) or in suitable room.

(vi) Similarly DBs can be in suitable nitches in corridor walls having doors.

(vii) Locating main boards under staircase or standing open in corridor is not a desirable practice, besides being highly unaesthetic.

(viii) The main switchboard, which receives power to the building, should be invariably located in a switch room, having round the clock access, for emergency attendance to the switchboard.

3.20 Guidelines for Planning Residential Areas

(i) ***U.G. System of Power Distribution, Street Lighting, Telephone Cabling and TV Cabling***

For long-term economical maintenance, better reliability of service, safety, protection against heavy rains, storm, wind etc. and aesthetics, under ground cable system will be generally followed. Also considering the high cost of land, under ground system results in better economic utilization of land area, otherwise substantial land route has to be earmarked for overhead lines.

(ii) Efficient working of street lights and staircase lighting is required for security of the colony and safety and convenience of the residents. Therefore adequate street lighting, staircase lighting is to be provided. Generally back lanes of residential blocks remain dark. Such areas are also to be covered by basic street lighting for security.

(iii) ***Kitchen***

(i) Exhaust fans opening with one point outlet to be provided irrespective of yardstick of provision of exhaust fans.

(ii) In addition to one 16 A 6-pin power outlet for kitchen, one 3 pin 6 Amp. outlet to be provided for water filter.

(iv) ***Washing Machine***

Location to be finalized in consultation with the Architect. A power outlet plus water supply/drainage to be coordinated with Architect/Civil Engineer.

(v) ***Meter Board***

(For a Block of Quarters)

Generally for a block of quarters of 2/3/4 storied, electric supply for each block is received in a meter board, where a cubicle meter panel is provided with system of power distribution to each quarter.

(See Fig. 7)

At present such meter boards are invariably located under staircase. This is not a desirable practice from technical/aesthetic viewpoint.

It is technically desirable to coordinate with Architect to provide separate meter room for each block of quarters or a number of blocks.

(vi) ***Stair Case Lighting***

Stair case lighting is to be treated as an extension of street lighting, for security and convenience of the residents. CFL (1 x 11 Watt) type stair case lighting may be provided to reduce load. As for example, need of 200 quarters can be met with 100 CFL fitting (each of 11 watt), with connected load of 1.5 KW only. Incandescent stair case lighting and bulk head fittings should not be provided, in view of excessive energy consumption and low burning hours.

(vii) ***Emergency Electric Supply***

For ensuring essential water supply and security lighting, a D.G. set to be provided for each colony to take care of water supply pump set, street lighting and essential load requirement of buildings like CGHS Dispensary, Community Center etc.

(viii) ***Fittings***

Subject to limit of yardstick of fittings for various types of quarters following guidelines to be provided:

(i) Every room to be provided with one fluorescent fitting for energy saving.

(ii) Kitchen to be provided with a fluorescent fitting, tapped from a batten holder (through an adopter), so that in case of need batten holder can be used with bulbs.

(iii) Incandescent bulkhead fittings not to be used.

(iv) Quality fittings of reputed make to be used.

(ix) ***Main Board of Each Quarter***

It shall be MCB type with provision of ELCB with the incoming MCB. It shall be located in a nitch with ventilated door cover, in the room connecting to the entry of the quarter. MCB DB shall be pre-wired type, for trouble free service.

(x) ***Corrosion Free Fittings***

Coastal areas and humid areas like kitchen, toilet are subject to corrosion, which substantially reduces the useful life of such fittings, besides giving an ugly look on account of rusting.

Therefore for coastal areas, and other humid areas corrosion free type of fittings (like aluminium, stainless steel, engineering plastic) should be used, for ensuring long life of such fittings and to achieve life cycle economy, after taking into account recurring expenditure on account of painting of fittings.

(xi) ***Telephone Wiring***

Telephone wiring is to be provided for each quarter. One outlet up to type III quarters,

two outlets up to type IV quarters and three outlets above type IV quarters. Such telephone wiring to be brought to a tag-block at a suitable point in ground floor. Provisions shall be kept for suitable entry-pipe for laying incoming telephone cable.

(xii) ***TV Cabling***

Internal TV cabling shall be provided, with two outlets up to type III quarters and three outlets for type IV quarters and above. Similarly, from suitable point at ground floor, TV cabling shall be provided. With use of suitable splitters, such TV cabling to be connected to each quarter.

(xiii) ***Lighting for Parks***

Colonies are provided with parks. Such parks should be provided with adequate lights to include area lights, pathway lights etc. so that the parks can be effectively used by the residents and they remain secure during night time.

(xiv) ***External Pipe Network for Laying Telephone and TV Cabling for the Colony***

Starting from a suitable room, pipe network may be provided to lay telephones/TV cables for the colony. Suitable road cross pipe and manholes to be provided for drawing such cables and their maintenance.

(xv) ***Preliminary Estimate to Take Care of Telephone/TV Cabling in a Colony***

At present, such services are provided in a very crude manner making use of existing poles and hanging cables. Apart from making colonies shabby, such services are subject to damages and unsatisfactory service. Therefore preliminary estimate should provide for such TV/Telephone cabling for the colony.

(xvi) ***Other Allied Services***

Modern residential colonies require support services like CCTV (for Gate and house security), intercom system, basic security system etc. for the safety and convenience of the residents. Therefore, preliminary estimate should provide for basic provisions for such safety/security systems. Most of these services pay for themselves within 3 / 4 years of installation, besides providing security, which sometimes amount to life saving instances.

3.21 Guidelines for Planning Office Buildings

(i) The main objective is to avoid possible fire hazards, which calls for sound detailed designing and use of quality equipments and materials executed with sound workmanship and supervision.

(ii) All control LT Panels, controlling power supply to the entire building will be located in a centralized room, from where centralized control and monitoring of the entire power supply system can be made.

(iii) Earth fault protection shall be provided for each individual building at the LT receiving point i.e. Main LT Panel. ELCB shall not be provided as a matter of routine in distribution boards. These can be provided, if required, by the Chief Engineer (E), in charge.

(iv) Office buildings are prone to fire hazard during night hours. Therefore, after office hours, all the LT Panels should be switched off. Based on need of the building, only the specified LT panel to be kept 'ON' which feed the loads during night hours. Such panel, called common service panel, may feed following loads, which are normally used after office hours:-

(a) Some specified lifts.

(b) Staircase/ Corridor/ Compound light.

(c) Fire protection loads.

(d) Pump Sets.

(e) Other loads which are kept 'ON' after office hours.

(v) ***Reliability of Power Supply***

Minimum two transformers to be provided to provide certain redundancy. Also a smaller size transformer may be provided to take care of reduced load during 'after office' hours to have energy saving of transformer, after proper technical evaluation.

(vi) It is preferable to plan for a separate service building, to combine all electrical and mechanical services of the building, so that the services can be maintained comprehensively at a lower cost and also reducing the overall area requirement. Such service building can combine electric sub-station, DG Sets, UPS, Air-conditioning Plant, water supply pump sets, etc.

(vii) While planning, maintainability of various services to be ensured, like providing facilities like access, approachability of various equipments, maintenance space etc.

CHAPTER 4

METALLIC CONDUIT WIRING SYSTEM

4.0 Scope

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

4.1 Application

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

(ii) Flexible conduits may only be permitted for interconnections between switchgear, DBs and conduit terminations in wall.

4.2 Material

4.2.1 *Conduits*

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

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

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

4.2.2 *Conduit Accessories*

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

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

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

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

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

4.2.3 ***Outlets***

(i) The switch box or regulator box shall be made of metal on all sides, except on the front. In the case of cast boxes, the wall thickness shall be at least 3 mm and in case of welded mild steel sheet boxes, the wall thickness shall not be less than 1.2 mm (18 gauge) for boxes upto a size of 20 cm x 30 cm, and above this size 1.6 mm (16 gauge) thick MS boxes shall be used. The metallic boxes shall be duly painted with anticorrosive paint before erection as per chapter 15 of these Specifications.

(ii) (a) Outlet boxes shall be of one of the size, covered in the Schedule of Rates (Elect.), 2012

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

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

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

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

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

(vii) Except where otherwise stated, 3 mm thick phenolic laminated sheets as per clause 3.14(c) shall be fixed on the front with brass screws, or aluminium alloy/ cadmium plated iron screws as approved by the Engineer-in-charge.

4.3 Installation

4.3.1 ***Common Aspects for Recessed and Surface Conduit Works***

(i) *Conduit Joints*

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

(b) Conduit pipes shall be joined by means of screwed couplers and screwed accessories only. Threads on conduit pipes in all cases shall be between

13 mm to 19 mm long, sufficient to accommodate pipes to full threaded portion of couplers or accessories.

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

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

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

(ii) *Bends in Conduit*

(a) All necessary bends in the system, including diversion, shall be done either by neatly bending the pipes without cracking with a bending radius of not less than 7.5 cm, or alternatively, by inserting suitable solid or inspection type normal bends, elbows or similar fittings, or by fixing cast iron inspection boxes, whichever is most suitable.

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

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

(iii) *Outlets*

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

(b) All switches (except piano type switches), socket outlets and fan regulators shall be fixed on metal strips which shall be screwed / welded to the box. Piano type switches and accessories shall be fixed on the phenolic laminated sheet covers in flush pattern.

(iv) *Painting after Erection*

After installation, all accessible surfaces of conduit pipes, fittings, switch and regulator boxes etc. shall be painted in compliance with the clauses under Chapter 15 “Painting”.

4.3.2 ***Additional Requirements for Surface Conduit Work***

(i) *Painting before Erection*

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

(ii) *Fixing Conduit on Surface*

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

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

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

(iii) *Fixing Outlet Boxes*

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

4.3.3 ***Additional Requirements for Recessed Conduit Work***

(i) *Making Chase*

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

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

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

(ii) *Fixing Conduits in Chase*

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

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

(iii) *Fixing Conduits in RCC Work*

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

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

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

(iv) *Fixing Inspection Boxes*

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

(b) These shall be mounted flush with the wall or ceiling concrete. Minimum 65 mm depth junction boxes shall be used in roof slabs and the depth of the boxes in other places shall be as per IS 2667 : 1988.

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

(v) *Fixing Switch Boxes and Accessories*

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

(vi) *Fish Wire*

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

(vii) *Bunching of Cables*

(a) Cables carrying Direct Current may, if desired, be bunched whatever their polarity, but cables carrying alternating current, if installed in metal conduit shall always be bunched so that the outgoing and return cables are drawn into the same conduit.

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

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

4.3.4 ***Earthing Requirements***

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

(ii) A protective (loop earthing) conductor(s) shall be laid inside the conduit between the metallic switch boxes and distribution switch boards and terminated with proper earth lugs/ terminals. Only PVC insulated copper conductor cable of specified size green in colour shall be allowed.

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

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

TABLE I

Maximum Number of PVC Insulated 650/1100 V grade Aluminium / Copper Conductor Cable conforming to IS 694 : 1990

[Clause 4.2.1 (ii)]

Nominal cross sectional area of conductor in sq.mm	*20 mm*		*25 mm*		*32 mm*		*38 mm*		*51 mm*		*64 mm*	
	S	*B*	*S*	*B*	*S*	*B*	*S*	*B*	*S*	*B*	*S*	*B*
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*
1.50	5	4	10	8	18	12	–	–	–	–	–	–
2.50	5	3	8	6	12	10	–	–	–	–	–	–
4	3	2	6	5	10	8	–	–	–	–	–	–
6	2	–	5	4	8	7	–	–	–	–	–	–
10	2	–	4	3	6	5	8	6	–	–	–	–
16	–	–	2	2	3	3	6	5	10	7	12	8
25	–	–	–	–	3	2	5	3	8	6	9	7
35	–	–	–	–	–	–	3	2	6	5	8	6
50	–	–	–	–	–	–	–	–	5	3	6	5
70	–	–	–	–	–	–	–	–	4	3	5	4

Note:

(1) The above table shows the maximum capacity of conduits for a simultaneous drawing in of cables.

(2) The columns headed ‘S’ apply to runs of conduits which have distance not exceeding 4.25 m between draw in boxes and which do not deflect from the straight by an angle of more than 15 degrees. The columns headed ‘B’ apply to runs of conduit, which deflect from the straight by an angle of more than 15 degrees.

(3) Conduit sizes are the nominal external diameters.

TABLE II

Girder Clips or Clamps

[Clause 4.2.2 (iv) b]

Size of Conduit	*Width*	*Thickness*
(i) 20 mm	19 mm	0.9 mm (20 SWG)
(ii) 25 mm	19 mm	0.9 mm (20 SWG)
(iii) 32 mm & above	25 mm	1.2 mm (18 SWG)

CHAPTER 5

NON-METALLIC CONDUIT WIRING SYSTEM

5.0 Scope

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

5.1 Application

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

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

5.1.3 ***Special Precautions***

(i) If the pipes are liable to mechanical damages, they should be adequately protected.

(ii) Non-metallic conduit shall not be used for the following applications:-

(a) In concealed/inaccessible places of combustible construction where ambient temperature exceeds 60 degrees C.

(b) In places where ambient temperature is less than 5 degrees C.

(c) For suspension of fluorescent fittings and other fixtures.

(d) In areas exposed to sunlight.

5.2 Materials

5.2.1 ***Conduits***

(i) All non-metallic conduit pipes and accessories shall be of suitable material complying with IS 2509 : 1973 and IS 3419 : 1989 for rigid conduits and IS 9537 (Part 5) : 2000 for flexible conduits. The interior of the conduits shall be free from obstructions. The rigid conduit pipes shall be ISI marked.

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

(iii) No non-metallic conduit less than 20 mm in diameter shall be used.

(iv) *Wiring Capacity*

The maximum number of PVC insulated aluminium/copper conductor cables of 650/1100 V grade conforming to IS 694 : 1990 that can be drawn in one conduit of various sizes is given in Table I under clause 4.2.1 (ii). Conduit sizes shall be selected accordingly.

5.2.2 ***Conduit Accessories***

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

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

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

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

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

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

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

5.2.3 ***Outlets***

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

(ii) PVC boxes shall comply with the requirements laid down in IS 14772 : 2000. These boxes shall be free from burrs, fins and internal roughness.

The thickness of the walls and base of PVC boxes shall not be less than 2 mm. The clear depth of PVC boxes shall not be less than 60 m.

(iii) The specifications for metallic boxes shall be as per requirements of clause 4.2.3.

(iv) 3 mm thick phenolic laminated sheet covers for all types of boxes shall be as per requirements of clause 3.14(c).

5.3 Installation

5.3.1 ***Common Aspects for Both Recessed and Surface Conduit Works***

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

(ii) *Conduit Joints*

(a) All joints shall be sealed/cemented with approved cement. Damaged conduit pipes/fittings shall not be used in the work. Cut ends of conduit pipes shall have neither sharp edges nor any burrs left to avoid damage to the insulation of conductors while pulling them through such pipes.

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

(iii) *Bends in Conduit*

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

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

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

(iv) *Outlets*

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

(v) *Painting*

After installation, all accessible surfaces of metallic accessories shall be painted in compliance with clauses under Chapter 15 “Painting”.

5.3.2 ***Additional Requirements for Surface Conduit Work***

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

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

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

5.3.3 ***Additional Requirements for Recessed Conduit Work***

(i) *Making Chase*

Requirements under clause 4.3.3 (i) shall be complied with.

(ii) *Fixing Conduits in Chase*

(a) The conduit pipe shall be fixed by means of staples, or by means of non-metallic saddles, placed at not more than 60 cm apart, or shall be fixed by any other approved means of fixing.

(b) At either side of the bends, saddles/staples shall be fixed at a distance of 15 cm from the centre of the bends.

(iii) *Erection in RCC Work*

Requirements under clause 4.3.3 (iii) shall be complied with.

(iv) *Fixing Inspection Boxes*

Requirements under clause 4.3.3 (iv) shall be complied with.

(v) *Fixing Switch Boxes and Accessories*

Requirements under clause 4.3.3 (v) shall be complied with.

(vi) *Fish Wire*

Requirements under clause 4.3.3 (vi) shall be complied with.

(vii) *Bunching of Cables*

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

5.3.4 ***Earthing Requirements***

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

(ii) Gas or water pipe shall not be used as protective conductors (earth medium).

TABLE III

Dimensional Details of Rigid Non-metallic Conduits

[Clause 5.2.1(ii)]

(All dimensions in mm)

S. No.	*Nominal Outside Diameter (in mm)*	*Maximum Outside Diameter (in mm)*	*Minimum Inside Diameter (in mm)*	*Maximum Permissible Eccentricity (in mm)*	*Minimum Permissible Ovality (in mm)*
1.	20	20 + 0.3	17.2	0.2	0.5
2.	25	25 + 0.3	21.6	0.2	0.5
3.	32	32 + 0.3	28.2	0.2	0.5
4.	40	40 + 0.3	35.8	0.2	0.5
5.	50	50 + 0.3	45.0	0.4	0.6

TABLE IV

Ordinary Clips or Girder Clips

[Clause 5.2.2(vi]

Size of Conduit	*Width*	*Thickness*
(1) 20 mm & 25 mm	19 mm	20 SWG (0.9144 mm)
(2) 32 mm & above	25 mm	18 SWG (1.219 mm)

CHAPTER 6

TRUNKING CABLE MANAGEMENT SYSTEM

6.0 Scope

This chapter covers the requirements of mini trunking (casing wiring) and adaptable metallic or PVC trunking ("otherwise also called wire ways").

6.1 Adaptable trunking shall be used for power cables and data cables to run parallel in two different compartments with partition.

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

Wherever data cables are used for information outlets, adaptable trunking shall be used.

6.1.2 (i) This system using PVC trunking shall be adopted in residential buildings, or office building where there is a need of tidy wiring system.

(ii) PVC trunking for distribution of Voice Data and Power should be used for cable management and should accept RJ45 Data socket and Power socket or other wiring accessory like switches, indicators etc.

(iii) Where the trunking has to be necessarily adopted in situations under (i) above, PVC trunking shall be used.

(iv) Preferred size of the mini trunking should be 25 x 16 mm, 32 x 16 mm, 40 x 25 mm, 40 x 40 mm and for adaptable trunking it should be 100 x 34 mm or 100 x 50 mm or 160 x 50 mm or 200 x 50mm for making upto four isolated compartments.

(v) Trunking should be equipped with rail on its surface on which clip-on partition can be clipped which should accept frames/plates for wiring devices upto 6/8 modules.

(vi) Trunking should have insulation rating of 5 mega Ohm. Trunking should have the following fire resistance characteristics:

- Operating temperature between – 40 Deg to 60 Deg. C
- Glow wire test 960 Deg. C
- Oxygen index – 50 ± 5
- UL94 – VO

6.2 Material

6.2.1 The mini trunking and adaptable trunking shall be of the same material, viz. either PVC or anodized aluminium in extruded sections.

6.2.2 The mini trunking shall have a square or rectangular body. The trunking cover shall be "CLIP-ON" type with double grooving in the case of PVC wire-ways, and CLIP-ON type for the metallic wire ways. All surfaces shall have smooth finish inside and outside. The top of the side walls of the body shall be suitable for the above types of fixing arrangement of trunking. PVC trunking or Aluminium trunking should have uniform thickness throughout its length and shall be of factory finish.

6.2.3 PVC trunking shall be of good quality PVC, free from defects like deformation, unevenness, blisters, cavities etc.

6.2.4 ***Dimensions***

(i) The sizes of mini trunking for the various sizes of cables and the maximum number of 650/1100 V grade PVC insulated aluminium / copper conductor cables that can be carried in one trunking are given size wise in Table V.

(ii) The thickness of the mini trunking & adaptable trunking shall be 1 mm minimum.

(iii) When mini trunking cover is clipped onto the trunking body, cover should completely overlap on the base (casing).

6.2.5 ***Outlet Boxes***

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

6.3 Installation

6.3.1 ***Attachment to Wall and Ceiling***

(i) The mini trunking and adaptable trunking shall be fixed by means of suitable screws to approved type of asbestos or fibre fixing plugs, at intervals not exceeding 60 cm for all sizes for mini trunking. In case of Adaptable trunking, the screwing distance shall be such that the weight of the trunking & cable hold firmly on the wall or ceiling. On either side of the joints, the distance of the fixing arrangement shall not exceed 15 cm from the joint.

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

(iii) Trunking shall be used only on dry walls and ceiling, avoiding outside walls as far as possible and shall not be buried in walls not fixed in proximity to gas, steam or water pipes or immediately below the heater.

(iv) Adaptable trunking shall be with pill off cover for protection against dust. Pill off cover shall be removed only on completion of painting of walls.

6.3.2 ***Passing through Floors or Walls***

When conductors pass through floors, the same shall be carried in an approved PVC conduit, or heavy gauge steel conduit properly bushed at both ends. The conduit shall

be carried 20 cm above floor level and 2.5 cm below ceiling level and neatly terminated into the casing. Steel conduit pipes wherever accessible shall be securely earthed.

6.3.3 ***Joints in Casing and Capping***

(i) The wire ways in straight runs should be in single piece as far as possible so as to avoid joints. Trunking shall be of 2 m or 3 m standard length for the ease of installation.

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

(iii) Joints arising out of bends or diversion shall be done using standard accessories like Internal angle, External angle, Flat angle (elbows), Flat junction (T) and end caps. For the separation of data and power cables there shall be partition in both trunking and accessories. Internal and external angle shall have variable angle for the alignment at the wall corners. In no case the radius of curvature of the cables inside a bend shall be less than 6 times their overall diameter.

6.3.4 Trunking should be of white colour in case of PVC trunking and of white or grey colour in case of Aluminium trunking.

(i) Mini Trunking attached to ceiling shall be carried completely across the ceiling/ wall whenever required by the Engineer-in-charge, instead of being stopped at an outlet location and in all such cases, dummy mini trunking must be provided.

6.3.5 ***Attachment of Capping***

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

(ii) Cover shall be attached to body after all the insulated wires are laid inside.

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

(iv) Aluminium cover shall be fixed by using cadmium plated flat head / round head screws with an axial spacing not exceeding 30 cm.

6.3.6 ***Installation of Cables***

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

(ii) Mini trunking shall be of such a design that it holds the wires inside the trunking body (casing) at suitable intervals, so that at the time of opening of the trunking cover (capping), the wires may remain in position in the trunking body (casing) and do not fall out.

6.3.7 ***Earth Continuity***

(i) A protective (earth continuity) conductor shall be drawn inside for earthing of all

metallic boxes of the installations as well as for connections to the earth pin of the socket outlets.

(ii) In the case of metallic trunking there shall be a metallic link between adjacent trunking covers with screw connections, and also connections from the end casing to the earth terminal of metallic boxes / outlets / switch boards as per the case may be, for the complete body earthing of the system.

TABLE V

Maximum Number of PVC Insulated 650/1100 Volt Grade Aluminium/Copper Conductor Cable conforming to IS 694 : 1990

[Clause 6.2.4(i)]

Nominal Cross Section Area	*10/15 mm x 10 mm*	*20/15 mm x 10 mm*	*25/15 mm x 16 mm*	*32 mm x 16 mm*	*40 mm x 25 mm*	*40 mm x 40 mm*
1.5	3	5	6	8	12	18
2.5	2	4	5	6	9	15
4	2	3	4	5	8	12
6		2	3	4	6	9
10		1	2	3	5	8
16			1	2	4	6
25				1	3	5
35					2	4
50					1	3
70					1	2

Note : Dimensions shown above are outer dimensions of mini turnking.

CHAPTER 7

M.V. PANEL, D.B., RISING MAINS, BUS TRUNKING AND OVERHEAD BUS BAR SYSTEM

7.0 Scope

This covers supply/ erection/ testing and commissioning of the equipments suitable for 415 Volt, 3 Phase, 50 HZ 4 wire system.

7.1 Requirements

(i) For each equipment, required IP rating and short circuit rating capacity will be specified. Governing BIS also will be specified.

(ii) All the equipments will be factory fabricated in an approved factory having modern fabrication and testing process. It shall have seven tank pre-treatment process comprising of degreasing, rinsing, de-rusting, rinsing, phosphatising, rinsing and passivation followed by powder coat painting having a paint thickness of 60 microns or as specified. The powder paint will be subjected to oven-heated process. All panels will be provided with suitable gasket to make it dust/ vermin proof.

7.1.1 *Specification of LT Cubicle Panel*

(i) Cubicle panel shall be floor mounted (on a base frame) totally enclosed and extensible type. The general construction shall conform to IS 8623 : 93. The design shall include all provisions for safety of operating and maintenance personnel. Degree of IP protection shall be IP-42 for indoor application and IP-54 for outdoors, unless otherwise specified.

(ii) The panel shall be compartmentalized type having space and arrangement for incoming cable/ bus ducting, incoming switchgear/ switchgears, bus coupler, insulated and properly supported compartmentalized bus bars, outgoing compartmentalized switchgear, bus bar supports, joint shrouds, cable alleys of suitable size for cabling routing, support and terminations, inter-connection between bus bars and switchgear with auxiliary bus bars/ insulated conductors/ strips etc. Also the panel will be provided with necessary instrumentation like CTs, PTs, Ammeters, Voltmeters, phase indicating lamps, other required instruments, wiring, fuses etc.

(iii) It shall be fabricated out of CRCA sheet not less than 2.0 mm thick for load bearing members and 1.6 mm for doors of LT panels. The framework may be Angle Iron/ Channel/ Bolted type construction. General constructions shall employ the principle of compartmentalization and segregation of each circuit. Unless otherwise

approved, incomer and bus section panels shall be separate and independent and shall not be mixed with sections required for feeders. Each section of the rear accessible type board shall have hinged access door at the rear. Operating handle of the highest unit shall be at a height not more than 1.7 mt. Overall height of the board shall not exceed 2.3 metre.

(iv) ***Arrangement for Incoming/Outgoing Cable Termination***

Cable entries shall be provided either from the rear or from the front through cable alleys of suitable size. Removable gland plate to be provided for each cable entry. Cable support arrangement to be provided inside cable alley so that cables are neatly arranged and fixed. From each outgoing switch, insulated strip/ conductor of suitable size to be provided up to suitable terminal block, which will receive incoming/ outgoing cable termination. It is desirable that cables are not terminated directly to switchgear, but terminated through proper terminal blocks.

(v) ***Specification of Cable Terminal Block***

Terminal block of reputed make shall be used. The housing material shall be polyamide having unbreakable and fire-retardant characteristic. All the metal parts shall be made up of copper alloy including the screws. Mounting shall be 'Din' or 'G-rail' type. Screws shall be self captive type. No protection cover is required, and the block should be touch proof.

(vi) ***Bus bars/ Supports/ Clearances***

The bus bar system may comprise of a system of main/ auxiliary bus bars run in bus bar alleys.

For bus bar material, ratings, current density, insulation, supports, bus bar clearances and joints see para 7.2 (iii).

(vii) ***Earthing***

2 Nos. 20 x 3 mm copper strip for LT panel upto 400 Amp. capacity or 2 Nos. 20 x 5 mm copper strip for LT panel of higher capacity shall be fixed all around the panel connected to 2 Nos. earth bus copper strips connected to incoming earth conductors.

(Typical Cubicle Panel is explained in Fig. 8)

(viii) ***Commissioning***

After erection, the LT panel will be commissioned after:

(a) Tightening of all nuts and bolts.

(b) Closing any left out holes to ensure the entire panel is insect proof.

(c) Megger testing.

(d) Earth testing.

7.1.2 ***Specification of Prewired DB***

As a general practice only prewired MCB/HRC type DBs shall be used, on account

of their superior technical features, compared to conventional DBs, which don't allow for proper wiring space and wiring termination. Rewirable fuse type DBs shall not be used.

Prewired DBs shall have following features:

(i) Recess/ Surface type with integral loose wire box.

(ii) Phase/ neutral/ earth terminal blocks for termination of incoming & outgoing wires.

(iii) Din Channel for mounting MCBs.

(iv) Arrangement for mounting incomer MCB/ RCCB/ RCBO/ MCCB as required.

(v) Copper Bus bar.

(vi) Earthing terminals.

(vii) Wiring from MCBs to phase terminal block.

(viii) Interconnection between terminal block/ incoming switch/ bus bar/ neutral terminal block/ earth terminal connector with specified size of FRLS preinsulated copper conductor cable duly fitted with copper lugs/ thimbles.

(ix) Terminal blocks should be suitable for termination of conductor/ cable of required size but minimum rated cross section of the terminal blocks should be 6 sq. mm.

(x) Terminal block shall be made of flame retardant polymide material.

(xi) Colour terminal blocks and FRLS wires for easy identification of RYB Phases, Neutral and Earth.

(xii) Prewired DB shall be provided with a detachable cassette for safe removal of MCBs, RCCBs. Terminal connectors from the DB without loosening the internal cable connections of phase and neutral circuits. (This is an optional feature.)

(xiii) The prewired DB shall have peelable poly layer on the cover for protection from cement, plaster, paints etc. during the construction period.

(xiv) Detachable plate with Knock out holes shall be provided at the top/ bottom of board. Complete board shall be factory fabricated and pre-wired in factory ready for installation at site. The box and cover shall be fabricated from 1.6mm sheet steel, properly pre-treated, phosphatized with powder coated finish.

Where specified it shall be of double door construction provided with hinged cover in the front. (See Fig. 9)

Note: Prewired DB will be factory manufactured by reputed manufacturer of MCB DBs.

7.2 Rising Mains

(i) ***Application***

(a) The rising mains are essentially used in electrical distribution system in building 2 storied and above. These are only for indoor applications. For

vertical power distribution, this is a preferred method, compared to rising cable system and is more reliable and safe from point of view of fire hazard.

(b) Tap-off arrangements shall be provided on the rising mains with tap-off boxes.

(c) The rising main shall comprise of sheet metal enclosure, bus bars, tap-off points, tap-off boxes, end feed units, fire barriers, expansion joints, thrust pads, end covers and fixing brackets etc.

(d) The rising main shall conform to IS 8623 and IEC 439 and shall be suitable for 415 V, 3 phase, 50 Hz supply and insulation of rising mains shall be capable of withstanding the voltage of 660 volt AC. Degree of IP protection and short circuit rating shall be specified.

(ii) ***Enclosure***

The enclosure shall be made from sheet steel of 1.6 mm thickness.

(iii) ***Bus bars***

(a) *Rating*

Bus bars shall be made of wrought aluminium or aluminium alloy, or electric grade copper, conforming to relevant Indian Standard, as specified. The ratings of the bus bars shall be 100A, 200A, 300A, 400A, 500A, 600A, or 800A as specified.

(b) *Current Density*

Bus bars shall be of sufficient cross-section so that a current density of 130A/ sq.cm (800A/sq.inch) is not exceeded at nominal current rating for aluminium bus bars, and 160A/sq.cm (1000A/sq.inch) for copper bus bars. The minimum sizes of sections of bus bars are given in Table VI.

(c) *Cross Section of Bus Bars*

The cross section of the neutral bus bar shall be the same as that of the phase bus bar for bus bars of capacities upto 200A; for higher capacities, the neutral bus bar must not be less than half the cross-section of that of the phase bus bar.

(d) *Insulation*

Each bus bar shall be suitably insulated with PVC sleeves/ tapes.

The insulation of the rising mains shall be capable of withstanding the voltage of 660 V of AC.

(e) *Bus Bar Supports*

Bus bar support insulators shall be class F insulators made of non-hygroscopic, non-combustible, track resistant and high strength FRP/ SMC/ DMC material, and shall be of suitable size and spacing to with-stand the dynamic stresses due to short circuit currents. The spacing between two insulators should be provided by the manufacturers according to the design approved by CPRI for their bus bar supports.

(f) *Bus Bar Clearances*

(i) The minimum clearance to be maintained for enclosed indoor air insulated bus bars for medium voltage applications shall be as follows:

Between	Min. Clearances
Phase to earth	26 mm
Phase to phase	32 mm

Note: For strip connection from bus bars to switchgear, the above clearances don't apply.

(ii) (a) Bus bar joints shall be thoroughly cleaned and a suitable oxidizing grease shall be applied before making the joint.

(b) High tensile bolts, plain and spring washers shall be provided to ensure good contact at the joints.

(c) The overlap of the bus bars at the joints shall be not less than the area of the cross section of the bus bars.

(g) *Bus Bar Marking*

Bus bars and main connections shall be marked by color or letter as per Table VII.

(iv) ***Expansion Joint***

Expansion joint made of aluminium/copper strips shall be provided wherever necessary, to take care of expansion and contraction of the bus bars under normal operating conditions. This shall be invariably provided whenever the length of the rising mains exceeds 15 m.

(v) ***Thrust Pads***

(a) The bus bars shall be provided with thrust pads so that the expansion of the conductors is upwards only.

(b) The bus bar clamps and insulators shall be designed to withstand the forces due to short circuit current. They shall also permit free vertical movement of the bus bars during expansion and contraction.

(vi) ***Mounting***

(i) Incoming cable will be connected to the rising main through an end feed unit, consisting of switch fuse unit with HRC fuse/ MCCB/ ACB of required capacity and cable end box.

(ii) Tap-off boxes at specified intervals and height shall be provided on rising main to tap power. The box shall consist of set of HRC fuses or MCCB/ Switch fuse unit, so that power from rising main can be switched ON/OFF and provided with suitable overload/ short circuit protection.

(iii) Distribution boards/ switch boards will not be mounted on rising main. Such boards will be separately erected on floor/ wall and connected to tap-off box with suitable copper conductor cable (See Fig. 10).

(vii) ***Construction Features***

(a) The rising mains shall be manufactured in convenient sections to facilitate easy transportation and installation. The sections shall be connected to form a vertical run at site. Each section shall be provided with suitable wall straps at convenient intervals for fixing to the wall.

(b) The enclosure shall be sturdy so as to withstand the internal and external forces resulting from the various operating conditions.

(c) The front covers shall be detachable. Neoprene gaskets shall be provided between the covers and the side channels.

(d) The enclosure shall have a degree of protection not less than IP 42.

(e) The rising main shall be designed for temperature rise not exceeding 40 degree C over ambient temperature of 45 degree C.

(f) Built-in fireproof barriers having 2 hr. fire rating shall be provided to restrict the spread of fire through the rising mains from one section to the adjacent section.

(g) Necessary provisions for ventilation shall be made at suitable intervals. These shall be complete with welded non-ferrous metallic mesh to prevent entry of vermin.

(h) Two numbers of copper earth strips of 20 x 3 mm (for Rising Main upto 400 Amp.) and 20 x 5 mm (for Rising main above 400 Amp. and upto 800 Amp.) shall be provided along side the rising mains enclosure, and shall be bolted to each section of the rising mains.

(viii) ***Installation of Rising Mains***

(i) Rising mains shall be installed on walls, to which the foundation bolts shall be suitably grouted (in a shaft of adequate size for rising main and floor distribution panel). The foundation bolts shall be provided by the contractor without extra payment.

(ii) (a) No structural member in the building shall be damaged/ altered, without prior approval from the competent authority through the Engineer-in-charge.

(b) Structural provisions like openings, cutouts, if any, provided by the department for the work, shall be used. Where these require modifications, or where fresh provisions are required to be made, such contingent works shall be carried out by the contractor at his cost.

(c) All such openings in floors provided by the Department shall be closed by the contractor after installing the cables/ conduits/ rising mains etc. as the case may be, by any suitable means as approved by the Engineer-in-charge without any extra payment.

(d) All chases required in connection with the electrical works shall be provided and filled by the contractor at his own cost to the original architectural finish of the buildings.

(ix) ***Commissioning***

Before connecting mains supply after installation, pre-commissioning checks comprising megger test, checking the tightness of connections, body earth connection etc. shall be carried out and recorded.

7.3 Bus Trunking

7.3.1 *Application*

These are generally provided for interconnections between the transformers of 400 KVA and above and DG sets 300 KVA and above and their switch board panels, and also for interconnections between large switch board panels where specified, thereby avoiding use of large sizes of cables for such interconnections.

7.3.2 *Materials*

7.3.2.1 *Enclosure*

Sheet steel of minimum 2 mm thickness shall be used for fabricating the enclosure.

7.3.2.2 *Bus Bars and Supports*

Bus bars and their supports shall comply with clauses 7.2 (iii) of these specifications. The current rating shall be as specified in individual cases.

7.3.3 *Construction*

7.3.3.1 *Enclosure*

(i) The enclosure shall be of bolted type, box type, welded type or any other type as per the manufacturer's standard practice, and shall be made out from sheet steel of minimum 2 mm thickness. The front cover only shall be detachable. The section of the bus duct shall be rectangular. The enclosure shall be sturdy so as to withstand the internal and external forces resulting from the various operating conditions.

(ii) The bus trunking enclosure shall be fabricated in convenient sections for easy transportation and installation. The sections shall be connected to form horizontal and vertical runs as required at site. The enclosure shall be provided with flanged ends with drilling arrangements to suit the flanges at the switchgear and transformer terminals. All flanges shall be provided with gaskets, nuts, bolts, washers etc.

(iii) The entire bus trunking enclosure shall be designed for dust and vermin proof construction. The enclosure for outdoor installation shall be additionally in weatherproof construction. The enclosure shall have a degree of protection not less than IP 42 for indoor application, and IP 54 for outdoor application in accordance with IS 2147.

(iv) Bus trunking, if required to be installed outdoors, shall be provided with a metallic protecting canopy of adequate size above the bus trunking, fabricated as part of the enclosure.

(v) Neoprene gaskets shall be provided to satisfy the operating conditions imposed by temperature, weather etc. and durability.

(vi) Provisions for ventilation shall be made as per clause 7.2 (vii) (g) of these specifications.

(vii) Two numbers of Copper earth strips of appropriate size shall be provided alongside the bus trunking enclosure and shall be bolted with each section of the bus trunking (See Table VIII).

7.3.3.2 *Expansion Joint/ Flexible Termination*

(i) Flexible connections shall be provided by braided or multi-leafed conductors for terminations at transformer bushing and switchgear.

(ii) Expansion joints shall be provided as per clause 7.2 (iv) of these specifications.

7.3.4 ***Installation***

(i) Each section of the enclosure shall be suspended from the ceiling slab with suitable MS suspenders and support angles/ channels. The runs shall be neat and the route shall be as directed by the Engineer-in-charge.

(ii) The bus trunking shall be supported such that its weight does not come on the terminations.

(iii) Danger notice boards shall be provided on the bus trunking enclosure at suitable intervals in every room through which it passes.

(iv) The earthing strips shall be properly terminated to the earth bars at both ends.

(v) Pre-commissioning checks shall be conducted.

7.4 Overhead Bus Bar System

7.4.1 ***Application***

The overhead bus bar system is generally used for distribution of power to a number of distributed power loads, such as motors, as in a workshop. This system has an in-built flexibility for meeting additional loads without much change in the distribution system. These specifications cover indoor application only.

7.4.2 ***Materials***

7.4.2.1 *Enclosure*

Sheet metal used for fabrication of side channels shall be 1.6 mm thick and the top and bottom covers 1.2 mm thick.

7.4.2.2 *Bus Bars and Supports*

(i) The bus bars shall comply with clause 7.2 (iii) of these specifications. The bus bars shall however be rated for 200A, 300A or 400A as specified. Each bus bar shall be individually insulated by means of PVC sleeves.

(ii) The bus bar supports shall comply with clause 7.2 (iii)(e) of these specifications.

7.4.3 ***Construction***

(i) The enclosure shall be sturdy to withstand the internal and external forces resulting from the various operating conditions. The enclosure shall have a degree of protection not less than IP 42 in accordance with IS 2147.

(ii) The top and bottom cover plates shall be detachable, and shall complete with gaskets to make the enclosure totally dust and vermin proof.

(iii) The enclosure shall be fabricated in convenient sections for easy transportation and installation. The bus sections shall be jointed together with flanges and tie bolts. Each section of the enclosure shall be suspended from the ceiling slab with suitable and rigid MS suspenders and brackets as required. Detachable blank sheet steel covers shall be provided for enclosing the free ends of the bus bar run.

(iv) Two numbers of Copper earth strips of appropriate size shall be provided for the complete run of bus bar enclosure and shall be bolted to each section of the bus bar enclosure. Suitable provision should be made to enable earth connection to the plug-in box, when plugged in.

7.4.4 ***Plug-in Boxes***

(i) Each section of the bus bar enclosure shall have plug-in points spaced at intervals of approximately 600 mm for the insertion of plug-in boxes.

(ii) The plug-in boxes shall be fabricated as compact sheet steel boxes with hinged doors and shall house the fuse holders/ MCCB/ MCB. The fuse holders/ MCCB/ MCB shall be solidly connected to high conductivity copper clip-on contacts and reinforced by spring steel strips. These clip-on contacts shall plug-in directly on to the bus bars at the plug-in points.

(iii) Two earth points shall be located at the ends of the plug-in boxes. While inserting these boxes into the plug-in points, the earth points shall engage first in the special earth bushes provided on the underside of the bus bar enclosure before the main contacts are made. While withdrawing these boxes, the earth contact is maintained even after the main contacts are isolated.

(iv) The plug-in boxes after insertion into the plug-in points shall be fastened by wing nuts.

(v) Each plug-in box shall be fitted with a brass compression gland suitable for the size of the cable specified. It should be possible to provide this gland in any position, i.e. left hand side, right hand side or lower side of the plug-in box.

(vi) The unused plug-in points shall be blanked with detachable sheet steel covers.

7.4.5 ***Installation***

(i) The bus sections shall be jointed together with flanges and tie bolts. Each section of the enclosure shall be suspended from the ceiling slab with suitable MS suspenders and support angles/ channels as required.

(ii) Bus trunking shall be suspended at a uniform height of about 2.4 m above floor level. The layout shall be got approved from the Engineer-in-charge before erection.

The runs shall be straight, except at points of changes in direction.

(iii) A connector assembly shall be supplied loose with each section of the enclosure for coupling two sections, and it shall comprise a rubber locating ring, bus bar insulating tube and a connector insulating tube.

7.4.6 ***Earthing***

The Copper earth strips of the bus duct shall be connected to the earth bus/ earth terminal(s) of the switchboard controlling the bus ducts, by appropriate protective conductors, notwithstanding the connection by the armouring of the feeder cable.

7.4.7 ***Danger Notice Board***

These shall be provided on the enclosure at suitable intervals and not exceeding 5 m.

7.4.8 Pre-commissioning checks shall be conducted.

TABLE VI

Aluminium/ Copper Bus Bar Sections

[Clause 7.2 (iii)(b)]

Current Ratings in amps. upto	*Recommended Rectangular Cross-section*			
	Aluminium		*Copper*	
	No. of Strips/ Phase	*Size in mm*	*No. of Strips/ Phase*	*Size in mm*
100	1	20 x 5	1	20 x 3
200	1	30 x 5	1	25 x 5
300	1	50 x 5	1	40 x 5
400	1	50 x 6	1	50 x 5
500	1	75 x 6	1	60 x 5
600	1	80 x 6	–	–
800	1	100 x 6	–	–
1000	1	100 x 10	–	–
1200	1	125 x 10	–	–
1600	2	100 x 10	–	–
2000	2	125 x 10	–	–
2500	3	125 x 10	–	–

Note:

(i) In larger bus bars of sizes above 1000 amps, the sections can be accepted in other rectangular cross-sections and numbers also, provided the total cross-sectional area offered is not less than the total cross-sectional area shown in the above table against the respective bus bar rating.

(ii) With aluminium bus bars, only aluminium wire/ solid bar connections shall be made for incoming/ outgoing mountings on the switchboards.

(iii) With copper bus bars, only copper wire/ solid bar connections shall be made for incoming/ outgoing mountings on the switchboards.

TABLE VII

[Clause 7.2 (iii)(g)]

(i) Marking for A.C. Bus Bars & Main Connections

	Bus Bar and Main Connections	*Colour*	*Letter/Symbol*
(i)	Three Phase	Red, Yellow, Blue	R.Y.B.
	Two Phase	Red, Blue	R.B.
	Single Phase	Red	R
(ii)	Neutral connection	Black	N
(iii)	Connection to earth	Green	E
(iv)	Phase variable (such as connections to reversible motors)	Grey	Gy.

(ii) For D.C. Bus Bars and Main Connections

	Bus Bar and Main Connections	*Colour*	*Letter/Symbol*
(i)	Positive	Red	R, or plus
(ii)	Negative	Blue	B, or minus
(iii)	Neutral connection	Black	N
(iv)	Connection to earth	Green	E
(v)	Equalizer	Yellow	Y
(vi)	Phase variable (such as connections to reversible motors)	Grey	Gy

Note: In the wiring diagram, positive and negative should be indicated by '+' and '-' respectively.

TABLE VIII

[Clause 7.3.3.1(vii)]

A: Earth Continuity Strip for Protective Earthing of Sub-Station Equipment

S.No.	*Type of Installation*	*Earth Electrode*	*Earth Strip from Earth Electrode to Earth Bus and Loop Earthing of Equipment*
1.	Indoor sub-station with HT panel, Transformer capacity up to 1600 KVA, LT panel, Generating set.	Copper Plate	25 x 5 mm Copper Strip
2.	Indoor sub-station with HT panel, Transformer capacity above 1600 KVA, LT panel, and Generating set.	Copper Plate	32 x 5 mm Copper Strip
3.	HT Outdoor sub-station	Copper Plate	25 x 5 mm Copper Strip
4.	LT Indoor sub-station with generator	Copper Plate	25 x 5 mm Copper Strip
5.	LT switch room having Main LT Switch Board	Copper Plate	20 x 3 mm Copper Strip

B: Earth Continuity Strip for Bus Trunking and Rising Main

S.No.	*Type of Installation*	*Material of Main Conductor*	*Earth Strip*
1.	Bus trunking up to 2500 Amp capacity	Copper/ Aluminium	2 Nos. 25 x 5 mm copper strip
2.	Bus trunking above 2500 Amp capacity	Copper/ Aluminium	2 Nos. 32 x 5 mm copper strip
3.	Bus trunking for connecting generating set and LT panel	Copper/ Aluminium	2 Nos. 25 x 5 mm copper strip
4.	Rising main up to 400 Amp capacity	Copper/ Aluminium	2 Nos. 20 x 3 mm copper strip
5.	Rising main above 400 Amp and up to 800 Amp capacity	Copper/ Aluminium	2 Nos. 20 x 5 mm copper strip

C: Neutral Earthing of Transformers and Generators

S.No.	*Equipment*	*Earth Electrode*	*Earth Strip from Earth Station to Neutral*
1.	Transformer of capacity up to 1600 KVA	Copper plate	25 x 5 mm Copper strip
2.	Transformer of capacity above 1600 KVA	Copper plate	32 x 5 mm Copper strip
3.	Generating set of all capacity	Copper plate	25 x 5 mm Copper strip

CHAPTER 8

EARTHING

8.0 Scope

This chapter covers the essential requirements of earthing system components and their installation. This shall be read with Appendix F, which lays down criteria for their design. For details not covered in these specifications IS code of Practice on Earthing (IS 3043 : 1987) shall be referred to.

8.1 Application

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

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

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

(iv) ***Application for Internal E.I.***

(a) Every sub-main will have earth continuity conductor to run along with sub-main wiring. In case of 3-phase sub-main wiring two earth continuity conductors shall be provided.

(b) Every circuit will have its earth continuity conductor to run alongwith circuit wiring. In case of 3-phase circuit two earth continuity conductors shall be provided.

(c) Looping of earth is allowed only in case of point wiring.

(d) When 2/3 power outlets are looped to one circuit, earth looping of these outlets is permissible.

8.2 Types of Electrodes & Material

8.2.1 *Earth Electrodes*

8.2.1.1 *Types*

The type of earth electrode shall be any of the following, as specified. (For selection criteria in designs, Appendix F may be referred to).

(a) Pipe earth electrode.

(b) Plate earth electrode.

(c) Strip or conductor earth electrode.

8.2.1.2 *Electrode Materials and Dimensions*

(i) The materials and minimum sizes of earth electrodes shall be as per Table IX (revised).

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

(iii) The length of the buried strip or conductor earth electrode shall be not less than 15 m. This length shall suitably be increased if necessary, on the basis of the information available about soil resistance, so that the required earth resistance is obtained. Prior approval of the Engineer-in-charge shall be taken for any such increase in length.

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

8.2.2. *Earthing Conductor & Sizes*

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

(ii) The size of earthing conductor shall be specified, but this shall not be less than the following (For calculating the size of the earthing conductor in design, Appendix F para 3.5.1).

(a) 4 mm dia. (8 SWG) copper wire,

(b) 25 mm x 4 mm in the case of GI strip, or

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

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

(a) 150 sq.mm. in case of GI, or

(b) 100 sq.mm. in case of copper.

8.2.3 ***Earth Continuity / Loop Earthing Conductor & Sizes***

(i) The material and size of protective conductors shall be as specified below (for criteria in design of these Appendix F may be referred to):

Size of phase conductor	*Size of protective conductor of the same material as phase conductor*
Upto 4 sq.mm.	Same size as that of phase conductor
Above 4 sq.mm. up to 16 sq.mm.	Same size as that of phase conductor
Above 16 sq.mm. up to 35 sq.mm.	16 sq.mm.
Above 35 sq.mm.	Half of the phase conductor

8.3 Location for Earth Electrodes

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

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

8.4 Installation

8.4.1 ***Electrodes***

8.4.1.1 *Various Types of Electrodes*

(i) (a) Pipe electrode shall be buried in the ground vertically with its top at not less than 20 cm below the ground level. The installation shall be carried out as shown in Fig. 11 (revised).

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

(ii) Plate electrode shall be buried in ground with its faces vertical, and its top not less than 3.0 m below the ground level. The installation shall be carried out as shown in Fig. 12 (revised).

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

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

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

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

8.4.1.2 *Artificial Treatment of Soil*

When artificial treatment of soil is to be resorted to, the same shall be specified in the schedule of work. The electrode shall be surrounded by charcoal / coke and salt as indicated in Fig. 11 and 12. In such cases, excavation for earth electrode shall be increased as per the dimensions indicated in these figures.

8.4.1.3 *Watering Arrangement*

(i) In the case of plate earth electrodes, a watering pipe 20 mm dia. Medium class pipe shall be provided and attached to the electrodes as shown in Fig. 11 and 12. A funnel with mesh shall be provided on the top of this pipe for watering the earth.

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

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

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

8.4.2 ***Earthing Conductor (Main Earthing Lead)***

(i) In the case of plate earth electrode, the earthing conductor shall be securely terminated on to the plate with two bolts, nuts, check nuts and washers.

(ii) In the case of pipe earth electrode, wire type earthing conductor shall be secured as indicated in Fig. 11 using a through bolt, nuts and washers and terminating socket.

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

(iv) The earthing conductor from the electrode up to the building shall be protected from mechanical injury by a medium class, 15 mm dia. GI pipe in the case of wire, and by 40 mm dia, medium class GI pipe in the case of strip. The protection pipe in ground shall be buried at least 30 cm deep (to be increased to 60 cm in case of road crossing and pavements). The portion within the building shall be recessed in walls and floors to adequate depth in due co-ordination with the building work.

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

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

(b) Bolt, nut and washer in case of strip conductor.

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

8.4.3 ***Loop Earthing/ Earth Continuity Conductor***

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

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

(iii) Loop earthing of individual units will not be however necessary in the case of cubicle type switchboards.

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

(v) The earth pin of socket outlets as well as metallic body of fan regulators shall be connected to the earth stud in switch boxes by protective conductor. Where the switch boxes are of non-metallic type, these shall be looped at the socket earth terminals, or at an independent screwed connector inside the switch box. Twisted earth connections shall not be accepted in any case.

8.5 Earth Resistance

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

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

8.6 Marking

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

(ii) Main earthing terminal shall be marked “SAFETY EARTH – DO NOT DISCONNECT”.

8.7 Use of Residual Current Devices (RCDs)

An extract on selection and application of RCDs (also known as RCCBs) from IS 12640: 1988 is given at Appendix G. Provision of RCD shall be specified in individual cases keeping in view the type, use, importance, system of earthing and nature of electrical installations to be protected by the RCCBs, requirements of the local electric supply company, etc. The sensitivity shall be 30 mA, 100 mA, 300 mA, or 500 mA, as specified.

TABLE IX (Revised)

Materials and Sizes of Earth Electrodes

[Clause 8.2.1.2(i)]

Type of Electrodes	*Material*	*Size*
Pipe	GI medium class	40 mm dia 4.50 m long (without any joint)
Plate	(i) GI (ii) Copper	60 cm x 60 cm x 6 mm thick 60 cm x 60 cm x 3 mm thick
Strip	(i) GI (ii) Copper	100 sq. mm section 40 sq. mm section
Conductor	(i) Copper	4 mm dia (8 SWG)

Note : Galvanisation of GI items shall conform to Class IV of IS 4736 : 1986.

CHAPTER 9

PROTECTION OF BUILDING AGAINST LIGHTNING

9.0 Scope

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

9.1 Application

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

9.2 Principal Components

The principal components of a lightning protective system are :-

(a) Air terminations,

(b) Down conductors,

(c) Joint and bonds,

(d) Testing joints,

(e) Earth terminations, and

(f) Earth electrodes.

9.3 Materials

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

(a) ***Copper:*** Solid or flat copper strip of at least 98% conductivity conforming to relevant I.S. Specifications shall be used.

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

(c) ***Galvanized Steel:*** Steel thoroughly protected against corrosion by a zinc coating shall be used.

(d) ***Aluminium:*** Aluminium, 99% pure, and with sufficient mechanical strength, and protected against corrosion shall be used.

9.3.2 Aluminium should not be used underground, or in direct contact with walls .

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

9.3.4 The recommended shape and minimum sizes of conductors for use above and below ground are given in Tables X and XI respectively.

9.4 Layout

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

9.4.2 ***Air Terminations***

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

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

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

(iv) Horizontal air terminations should be carried along the contours such as ridges, parapets and edges of flat roofs, and, where necessary, over flat surfaces, in such a way as to join each air termination to the rest, and should themselves form a closed network.

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

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

9.4.3 ***Down Conductors***

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

(ii) *Routing*

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

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

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

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

(iii) *Provision when External Route is Not Available*

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

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

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

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

9.5 Installation

9.5.1 ***General***

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

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

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

9.5.2 ***Air Terminations***

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

9.5.3 ***Down Conductors***

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

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

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

(iii) *Bonding to Prevent Side Flashing*

Any metal in, or forming a part of the structure, or any building services having metallic parts which are in contact with the general mass of the earth, should be either isolated from, or bonded to the down conductor. This also applies to all exposed large metal items having any dimension greater than 2 m whether connected to the earth or not.

9.5.4 ***Joints and Bonds***

9.5.4.1 *Joints*

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

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

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

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

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

9.5.4.2 *Bonds*

(i) Bonds have to join a variety of metallic parts of different shapes and composition, and cannot therefore be of a standard form.

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

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

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

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

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

9.5.5 ***Test Joints***

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

9.5.6 ***Earth Termination Network***

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

(ii) Each of the earth stations should have a resistance not exceeding the product given by 10 ohms multiplied by the number of earth electrodes to be provided therein. The whole of the lightning protective system, including any ring earth, should have a combined resistance to earth not exceeding 10 ohms without taking account of any bonding [as per 9.5.3 (iii)].

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

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

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

TABLE X

Shapes and Minimum Sizes of Conductors for Use Above Ground

[Clause 9.3.4]

SI. No.	*Material and Shape*	*Minimum Size*
1.	Round copper wire or copper clad steel wire	6 mm diameter
2.	Stranded copper wire	50 sq. mm or (7/3.00 mm dia)
3.	Copper strip	20 mm x 3 mm
4.	Galvanized iron strip	20 mm x 3 mm
5.	Round aluminium wire	8 mm diameter
6.	Aluminium strip	25 mm x 3 mm

TABLE XI

Shapes and Minimum Sizes of Conductors for Use Below Ground

[Clause 9.3.4]

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

CHAPTER 10

SAFETY PROCEDURE

10.1 While the Indian Electricity Rules 1956, as amended upto date, are to be followed in their entirety, particular attention is drawn to the various clauses indicated in Appendix 'C'. Any installation or portion of installation, which does not comply with these rules, should be got rectified immediately.

10.2 The detailed instructions on safety procedures given in B.I.S. Code No. 5216 : 1982 "Code of Safety Procedures and Practices in Electrical Works" shall be strictly followed.

10.3 (a) **Schematic Diagram**

It shall be responsibility of the JE (E)/AE (E) to ensure that for each building, a comprehensive schematic diagram is prepared starting from the main board upto the final DBs. All such boards are to be duly marked and numbered.

Similarly, for each campus consisting of sub-station/ sub-stations and a number of buildings, a comprehensive power distribution schematic diagram for the entire campus shall be prepared.

Based on additions/ alterations such diagrams should be updated from time to time.

(b) **Keep Premises Clean**

Premises like sub-stations, switch rooms, pump house, generating rooms etc. shall be kept clean. Such premises should not be used to store broken furniture, dismantled materials, waste material, packing boxes etc.

(c) **Keep all Electrical Shafts Clean and Locked**

Such shafts should not be used for dumping floor malba etc.

(d) **Protected Premises**

All premises like sub-station, pump house etc. to be maintained as protected area, admission allowed to authorized persons only.

(e) Also, the frontage of such areas shall be kept free and parking etc. in front shall not be allowed.

10.4 No inflammable materials shall be stored in places other than the rooms specially constructed for this purpose in accordance with the provisions of Indian Explosives Act.

10.5 Rubber or insulating mats should be provided in front of the main switchboards or any other control equipments of medium voltage and above.

10.6 Protective and safety equipments such as rubber gauntlets or gloves, earthing rods, linemen's belt, portable artificial respiration apparatus etc. should be provided in each sub-station, service center/enquiry office and important installations. Where electric welding or such other nature of work is undertaken, goggles shall also be provided.

10.7 Necessary number of caution boards such as "Man on Line, Don't switch on" should be readily available in each sub-station, enquiry office and important installations.

10.8 Standard first aid boxes containing materials as prescribed by the St. John Ambulance Brigade or Indian Red Cross should be provided in each sub-station, enquiry office and important installations and should be readily available.

10.9 Periodical examination of the first aid facilities and protective and safety equipments provided at the various installations shall be undertaken for their adequacy and effectiveness and a proper record shall be maintained.

10.10 Charts (one in English and another one in the regional language) displaying methods of giving artificial respiration to a recipient of electrical shock should be prominently displayed at appropriate places.

10.11 A chart containing the names, addresses and telephone numbers of nearest authorized medical practitioners, hospitals, fire brigade and also of the officers in executive charge shall be displayed prominently along with the First Aid Box.

10.12 Executive Engineers should take immediate steps to train supervisory and authorized persons of the Engineering staff viz. A.Es, J.Es, Head Electricians, Foremen, Electricians and Wiremen in the First Aid Practices, including various methods of artificial respiration with the help of local authorities such as Fire Brigade, St. John Ambulance Brigade, Indian Red Cross or other recognized institutions equipped to impart such training, as prompt rendering of artificial respiration can save life at times of electric shock.

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

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

10.15 Details of preventive maintenance to be undertaken shall be in accordance with the chapter 14 of these specifications. All preventive maintenance works shall be pre-planned as far as possible and names of persons who are assigned to this work should be entered in a logbook.

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

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

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

10.19 No work of live L.T. switch board in the sub-stations should be handled by a person below the rank of a Wireman and such a work should preferably be done in the presence of the Junior Engineer (E) in charge of the work.

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

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

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

10.23 Before energizing on an installation after the work is completed, it should be ensured that all tools have been removed and accounted, no person is present inside any enclosure of the switch board etc., any earthing connection made for doing the work has been removed, “Permit to Work” is received back duly signed by the person to whom it was issued in token of having completed the work and the installation being ready for re-energising and “Men at Work” caution boards removed.

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

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

10.26 These instructions should be explained in Hindi/local language to those staff that does not understand English.

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

CHAPTER 11

FIRE HAZARDS

11.1 The main pre-requisites of a fire hazard free building are: -

(a) Installation based on sound design and use of quality materials and equipments.

(b) Good house keeping.

(c) Proper maintenance based on skilled personnel, proper supervision and preventive maintenance.

(d) Periodic inspection from fire hazard point of view by a qualified engineer.

11.2 Following instructions should be followed. Besides, based on the requirement of a particular building, other instructions may be issued for avoidance of possible fire hazard.

(i) No over loading of main board, DB, submain, wiring.

(ii) No loose wiring.

(iii) One socket outlet to feed one appliance only and do not use multiple outlets.

(iv) The AE (E) in charge will have an annual inspection of the building and list out deficiencies and report to the EE who will take necessary remedial action.

(v) Only MCB type DBs to be provided, so that overload, short circuit currents are interrupted immediately. Rewirable type fuses not to be used.

(vi) Change old/ outlived wiring, switchboard, and appliance.

(vii) Extension to wiring/ EI only after proper design and capacity of augmentation of the existing installation (Para 1.18).

(viii) **Record Room** – No power outlet / switches should be provided inside the room. Use flameproof electrical fittings. In case it is a must to provide switches / outlets in a record room, they should be flameproof.

(ix) **Fire Protection**

(a) The building should have a comprehensive fire protection system in conformity with CFO's requirement, backed by proper manning and maintenance.

(b) Important building will have a fire control room, for monitoring and control of fire safety of the building.

(c) Local fire extinguishers for various electrical Switchgears Locations, Lift Machine Room, Electrical Sub-station, Generating Rooms, Pump Houses etc.

(d) Get CFO's annual inspection of the building done.

(e) Organize fire drill periodically, at least once in six months.

(x) **Maintenance**

Maintenance by qualified/ licensed (as applicable) personnel. When maintenance is done by contract system, only properly prequalified and skilled contractors to be deployed. Such contract should have preventive maintenance items.

(xi) Only quality and genuine material should be used.

(xii) When repairs are needed, act immediately, don't postpone repairs.

(xiii) Keep telephone/ address details of Fire Station/ Police/ Hospital/ Departmental Officials/Client Department Officials, both Office and Residence (in case of emergency).

(xiv) All switch rooms/ electrical shafts to be kept clean and duly locked. All locks will have common key, with keys available to all authorized personnel.

(xv) Keep appliances 'OFF' after office hours. Instruction to be issued, so that all switches and appliances are 'OFF' after office hours.

CHAPTER 12

ENERGY CONSERVATION

Energy is very costly. Guidelines for energy conservation:

12.1 Lighting and Controls

12.1.1 *Lighting Design*

Lighting design to be done in such a way that it achieves the required visual comfort at working plane and is energy efficient. Visual comfort can be defined in terms of lux level at the working plane and energy efficiency can be defined in terms of lighting power density (Watt/m^2). The recommended lux levels and lighting power densities have been specified in Chapter 2 Section 2.9.

Wherever possible, a combination of task lighting and general lighting shall be provided to get desired lighting levels. In addition to general lighting, local task luminaires shall be provided for adequate lighting level and quality in the task areas.

For general lighting, lux levels required for circulation and other non-critical applications should be maintained.

12.1.2 *Efficient Lamp Selection*

Selection of lamp is the most important criterion for lighting design. The lamp selection should be on the basis of efficacy and good colour rendering index (CRI).

Lamps used for general lighting scheme should comply to the following:

- *Point Light Source* – All the point light sources installed in the building for general lighting should be CFL or LED based with minimum lamp efficacy of 50 lm/W.
- *Linear Light Source* – All the linear light sources installed in the building for general lighting should be T-5 or at least 5 Star BEE rated TFLs.

Table 9 lists the Wattage, luminous flux, efficacy and CRI of different types of lamps.

Incandescent lamps should not be used at all.

New high frequency electronic ballasts should be used instead of traditional magnetic ballasts.

12.2 Lighting Controls

12.2.1 *Automatic Lighting Shutoff*

Interior lighting systems in buildings larger than 500 m^2 (5000 ft^2) shall be equipped with an automatic control device. Within these buildings, all office areas less than 30 m^2 (300 ft^2) enclosed by walls or ceiling-height partitions, all meeting and conference rooms, all school classrooms, and all storage spaces shall be equipped with occupancy sensors.

For other spaces, this automatic control device shall function on either :

- A scheduled basis at specific programmed times. An independent program schedule shall be provided for areas of no more than 2500 m^2 (25000 ft^2) and not more than one floor,

  Or

- Occupancy sensor that shall turn the lighting off within 3 minutes of an occupant leaving the space. Light fixtures controlled by occupancy sensors shall have a wall mounted, manual switch capable to turning off lights when the space is occupied.

  Exception to above: Lighting systems designed for 24-hour use.

12.2.2 *Space Control*

Each space enclosed by ceiling-height partitions shall have at least one control device to independently control the general lighting within the space. Each control device shall be activated either manually by an occupant or automatically by sensing an occupant. The maximum coverage area for each control device is given in the table below:

Space Area and Lighting Control

Sl. No.	*Space Area (m^2)*	*Maximum Coverage Area for each Control Device (m^2)*
1	⩽ 1000	250
2	> 1000	1000

Each control device shall be capable of overriding the required shut off control for no more than 2 hours. It should be readily accessible and located such that the occupant can see the control.

Exception to above: The required control device may be remotely installed if required for reasons of safety or security. A remotely located device shall have a pilot light indicator as part of or next to the control device and shall be clearly labeled to identify the controlled lighting.

12.2.3 *Day-lighting Controls*

Luminaires in day lighted areas greater than 25 m^2 (250 ft^2) shall be equipped with either a manual or automatic lighting control device that is capable of reducing lighting output of the luminaires in the day lighted areas by at least 50% and controls only the luminaires located entirely within the day lighted area.

12.2.4 ***Exterior Lighting Control***

Lighting for exterior applications shall be controlled by a photo sensor or astronomical time switch that is capable of automatically turning off the exterior lighting when daylight is available or the lighting is not required.

12.2.5 ***Lighting Control Devices***

Following is a description of different types of control devices available for controlling the lighting:

Timers: These are the simplest type of controls and are most popular. Some areas in buildings may require lighting for specific durations like security lighting, landscape lighting or building floodlighting. Timers allow this type of control by switching 'on' and 'off' as per preset times. These can have one setting (same time) for the whole year or several (seasonal/ weekly/daily) settings to take care of the changing sunset times.

Photocell Lighting Control: These measure the amount of natural light available and suitable for both indoor and outdoor applications. When available light falls below a specified level, a control unit switches the lights on (or adjusts a driver to provide more light). Photocells can be programmed so that lights do not flip on and off on partially cloudy days.

Occupancy Sensors **:** These devices – also known as 'motion detectors' – turn lights off and on in response to human presence. Once sensitivity and coverage area is established, sensors are selected from two predominant technology types.

Passive Infrared Sensors : These detect the motion or heat between vertical and horizontal detection zones. This technology requires a direct line of sight and is more sensitive to lateral motion, but it requires layer motion as distance from the sensor increases. The coverage pattern and field of view can also be precisely controlled. It typically finds its best application in smaller spaces with a direct line of sight, such as restrooms.

Ultrasonic Sensors : These detect movement by sensing disturbances in high-frequency ultrasonic patterns. Because this technology emits ultrasonic waves that are reflected around the room surfaces, it does not require a direct line of sight. It is more sensitive to motion towards and away from the sensor and its sensitivity decreases relative to its distances from the sensor. It also does not have a definable coverage pattern or field of view. These characteristics make it suitable for use in layer-enclosed areas that may have cabinets, shelving, partitions, or other obstructions. If necessary, these technologies can also be combined into one product to improve detection and reduce the likelihood of triggering a false on or off mode.

12.3 Efficient Motors

Motors shall comply with the following:

- All permanently wired poly-phase motors of 0.375 kW or more serving the building and expected to operate more than 1500 hours per year and all permanently wired polyphase motors of 50 kW or more serving the building and expected to operate more than 500 hours per year shall have a minimum acceptable nominal full load motor efficiency not less than IS 12615 for Energy Efficient motors.
- Motors of horsepower differing from those listed in the table shall have efficiency greater than that of the listed kW motor. See Table 14.

- Motor horsepower ratings shall not exceed 20% of the calculated maximum load.
- Motor nameplates shall list the nominal full load motor efficiencies and the full load power factor.
- Motor users should insist on proper rewinding practices for rewound motors. If the proper rewinding practices cannot be assured, the damaged motor should be replaced with a new, efficient one rather than suffer the significant efficiency penalty associated with typical rewind practices.
- Certificates shall be obtained and kept on record indicating the motor efficiency. Whenever a motor is rewound, appropriate measures shall be taken so that the core characteristics of the motor is not lost due to thermal and mechanical stress during removal of damaged parts. After rewinding, a new efficiency test shall be performed and similar records shall be maintained.
- Motors should be installed with soft start energy savers and Variable Speed drives based on the application required.

12.4 Metering

- Services exceeding 1000 KVA shall have permanently installed electrical metering to record demand (kVA), energy (kWh), and total power factor. The metering shall also display current (in each phase and the neutral), voltage (between phases and between each phase and neutral), and total harmonic distortion (THD) as a percentage of total current.
- Services not exceeding 100 kVA but over 65 kVA shall have permanently installed electric metering to record demand (kW), energy (kWh), and total power factor (or kVARh).
- Services not exceeding 65 kVA shall have permanently installed electrical metering to record energy (kWh).
- Electrical meters shall be installed to measure the energy units generated on site through DG/ GG sets.
- Separate electrical sub-meters shall be installed to measure energy consumption by HVAC plant, AHU fans and indoor lighting.
- BTU meters* shall be installed for each chiller at the entry and leaving points to measure the cooling generated by chillers.
- BTU meter* shall be installed on the chilled water loop to measure the building's total cooling demand.

***BTU Meter:** BTU is the acronym for British Thermal Unit, which is a traditional unit of energy. BTU meters are used for thermometric billing as they measure heat in terms of BTU. These meters are used for measuring energy consumption of heating and cooling systems. By installing BTU meters at individual chillers, cooling generated by individual chillers can be measured and by installing the BTU meter on the chilled water loop, building's total cooling demand can be measured.*

CHAPTER 13

MAINTENANCE

13.1 Organized maintenance based on preventive maintenance is essential to ensure:

(i) Un-interrupted service

(ii) No break-down

(iii) Safety, no mishaps

(iv) Economic operation

(v) Lower energy bills

(vi) Long useful life.

13.2 Therefore, due importance is to be given for maintenance.

13.3 **General Guidelines**

13.3.1 Persons engaged in maintenance works should be competent for the type of work involved and should possess necessary license.

13.3.2 Safety procedures as indicated in Chapter 10 should be duly followed.

13.3.3 (a) In any building, additions and alterations are bound to occur at any time. When such additions/ alterations are to be undertaken, it is very important to check in advance the likely loading of the distribution system and to strengthen the system as necessary before allowing the extra load to be connected, so as to avoid overloading of any part of the system. Even phase balancing may need to be redone so as to keep the neutral current low. To enable compliance to this safety aspect, the detailed distribution schematic diagram indicating also the wire/cable sizes, current rating of switchgear/ fuses, loading on individual circuit etc. should be available at site. This may be kept up even in a register form, with different pages for different floors/ wings, for ready reference at any time. This should be supplemented with detailed inventory.

(b) These should be updated, as and when additions/ alterations are carried out so that the data may be fully relied upon, for further references. In fact, if any major additions alterations/ rewiring is carried out, proper record should be kept in the history book for the installation.

(c) It is necessary that those responsible for the site maintenance should have a clear knowledge about the distribution system.

13.3.4 The number of items to be maintained in a building may be many like fittings, fans, DBs, earth sets etc. In order to achieve compliance to the prescribed periodicities for the various activities on them as per this schedule, each of these items may be divided into convenient numbers, to carry out the respective activities in sub periods, in a cyclic (sequential) order. For example, if DB's are to be checked every month, and there are 50 DBs in a building, these may be checked at the rate of 2 or 3 DBs every day in a sequential order (programmed in advance) so that all DBs are checked in a month.

13.3.5 Maintenance activities carried out as per this schedule should be noted in the Maintenance Register. When tests are carried out, the test results should be recorded with appropriate identification references (For Example: SDB7; Earth pit No.4; R/M-Wing A etc.)

13.3.6 (a) The voltage of supply, total load current and PF should be noted in logbook every day, preferably during peak loading time of the day. (In the case of isolated/ unattended buildings where it is not feasible to log daily, the period may be increased to weekly or fortnightly as feasible).

(b) If any instrument is not provided, provide the same now. If any of the instruments is defective, get it repaired early.

13.3.7 Inspection of electrical installations is intended primarily from fire safety considerations. Following points need to be observed as part of inspection, and corrective action as necessary should be taken immediately, including coordination with the client departments concerned, as may be required.

(i) Check that there is no sign of heating up, burning smell, decolouration or sparking at any of the boards (SDBs as well as main boards), and Rising Mains. These may occur due to overloading or loose terminations. Highly unbalanced loading may cause heavy neutral currents and consequent heating of neutral conductors and terminals.

(ii) No temporary wiring exists anywhere in the building.

(iii) There is no joint in cords connecting the WTAC units/ voltage regulators/office equipment like photocopier, PC etc.

(iv) No bare wiring exists over the flooring without mechanical protection by a metallic conduit / channel.

(v) There is no misuse of socket outlets, such as connecting power load to light socket, connection of multiple loads to one socket, use of heaters in record room, library etc. In such cases of additional demands of outlets, these should be provided early, after taking approval of the competent authority.

(vi) All DBs should be only of MCB type and all sockets for WTAC units should be of industrial type controlled by MCB.

(vii) The shafts/ spaces for electrical services are not misused, for storage or for dumping rubbish.

(viii) The spaces in front of DB's and sockets are free (without any storage of files/ papers etc.)

(ix) No additions/ alterations are done by the user departments to the electrical installations by themselves.

13.3.8 (a) A record of loading upto DB level (in each phase in case of 3 phase DBs) should be maintained, after measurements using a clip on ammeter. Such measurement should be done, as far as possible during peak season (summer and winter), when the loads are likely to be the highest.

(b) The PF should be maintained above 0.8 (or any higher value fixed by the licensee without penalty). Examine the adequacy of capacitors (if any) accordingly.

(c) Note down from the electricity bills, details of maximum demand, energy & PF to examine the trend of loading, penal charges if any being paid etc. (Even if the bills are paid directly by client Depts.) review of contract demand, strengthening of system, PF correction requirements etc. should be done with this review.

13.3.9 (a) While cleaning fittings and fans, the fixing/ suspending arrangements should also be checked and attended to as necessary. Care should be taken that the alignment is not disturbed.

(b) (i) In the case of ceiling fans, remove the blades, and wash the same with detergent, without causing any deformation of blade angle. Check the shackle and replace if damaged. Check that down rod is fully screwed upto the last thread on both ends and that threads are not loose. If so required, replace with new down rod of the same size, thickness and length of threading (not less than 20 mm). Check split pins and replace if any strain deformation or damage is observed. If any other system of suspension had been adopted, check the soundness of the same and tighten as necessary. Fix fan blades tightly to the body. Operate the fan at different speeds; the run should be without wobbling/ noise.

(ii) As per specifications, lubrication needs to be done as necessary. In such cases, the fan needs to be brought down, after removing the blades. The old grease should be replaced with a fresh one, after cleaning the bearing. If damaged, the bearing should be replaced. When reinstalling the fan, the suspension bolts should be well tightened.

13.3.10 (a) Insulation test should be done during monsoon season, as per clause 16.2 of CPWD General Specifications for Electrical Works Part I Internal, 2013.

(b) Earth continuity test and earth electrode resistance test should be conducted during summer season, as per clauses 16.4 and 16.5 of the above specifications.

(c) Record the test results giving identification references. If results are not satisfactory in any part of the installation, reason should be checked and corrective action be taken immediately.

CHAPTER 14

PREVENTIVE MAINTENANCE

14.1 Cleanliness is the mother of preventive maintenance. Keep areas clean.

14.2 Have schematic diagram for each installation.

14.3 No loose wiring.

14.4 No overloading.

14.5 Preventive maintenance of switchboards, DBs every six months.

14.6 For multi-storied building go for fuseless switchgear like ACBs, MCCBs, and MCBs, as a precaution against fire on account of short circuit.

14.7 Prepare preventive maintenance schedule for each installation.

14.8 Proper manning/ supervision of installation.

14.9 Maintenance of logs records and history sheet of events and breakdowns. Ensure working of all measuring and indicating instruments.

14.10 Take safety measures.

14.11 Annual inspection to ensure system adequacy, safety, efficiency and take remedial measures.

14.12 Replacement of old/outlived equipments.

14.13 Six monthly survey report of dismantled materials.

14.14 Display important telephone numbers.

14.15 Entrust repairs and maintenance to only skilled personnel and firms.

14.16 No short circuit to problem like patchy repairs.

14.17 **Compound Lighting**

Annual painting of poles. 3 monthly cleaning of fittings. Weekly check of working of all fittings. This ensures a bright and safe premises during night.

14.18 For proper maintenance of electrical installations, the following items of work shall be carried out regularly as per periodicity stated below and a proper record of such work shall be maintained.

(a) Earth testing	-	Once in a year
(b) Insulation test	-	Once in a year

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

CHAPTER 15

PAINTING

15.0 Scope

This chapter covers the requirements of painting work in internal electrical installations, carried out manually by brush. This does not cover spray-painting work of factory made items.

15.1 Painting Work in General

15.1.1 *Paints*

Paints, oils, varnishes etc. of approved make in original tin to the satisfaction of the Engineer-in-charge shall only be used.

15.1.2 *Preparation of the Surface*

The surface shall be thoroughly cleaned and made free from dust or foreign matter before painting is started. The proposed surface may be inspected by the Engineer-in-charge before the paint is applied.

15.1.3 *Application*

(i) Paint shall be applied with brush. The paint shall be spread as smooth and even as possible. Particular care shall be paid to rivets, nuts, bolts and over- lapping. Before drawing out in smaller containers, it shall be continuously stirred with a smooth stick, while painting work is taken up.

(ii) Primer coat of anti-corrosive paint shall be given in the case of steel work, after preparing the surface. In all cases of painting work, finishing shall be with 2 coats of paint in approved shade.

(iii) Each coat shall be allowed to dry out sufficiently before a subsequent coat is applied.

15.1.4 *Precautions*

All furniture, fixtures, glazing, floors etc. shall be protected by suitable covering. All stains, smears, splashing, dropping etc. shall be removed. While painting of wiring etc. it shall be ensured that the painting of wall and ceiling etc. is not spoiled in any way.

15.1.5 *Repainting*

(i) Painting on old surface in indoor situations will not include primer coat except where specially mentioned in the tender documents. However, where rust has formed on iron and steel surfaces, the spots will be painted with one anti-rust primer coat, after preparing the surface.

(ii) In cases of repainting, the old paint shall be removed by first scrapping, or by applying a suitable solvent, and thereafter a fresh coat of the paint shall be applied.

15.2 Painting of Conduits and Accessories

(i) Requirement of painting of metallic conduits before installation on surface shall be met as per clause 4.3.2 (i).

(ii) Requirement of painting of metallic boxes shall be as per clauses 4.2.3 (i) and 4.3.1 (iv).

(iii) After installation in surface or recess, all accessible surface of metallic conduit pipes and fittings, switch boxes and regulator boxes etc. shall be painted with two coats of enamel paint of approved shade.

15.3 Repainting of Ceiling Fan by Spray Painting

The spray painting of ceiling fan shall be done as per following procedure:

(i) Clean the surface free from all foreign and harmful materials as dirt, moisture, greasy dirt, salts, rust etc. by means of any suitable detergent as required and dry the surface.

(ii) Rub down lightly with waterproof emery paper, if required in case surface is rusty and wipe off the surface using a piece of clean and dry soft cloth.

(iii) Apply one coat of finishing enamel conforming to IS 2932 : 1974 uniformly by spraying and allow it to dry.

CHAPTER 16

TESTING OF INSTALLATION

16.0 Scope

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

16.1 General

16.1.1 *Tests*

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

(1) Insulation resistance test.

(2) Polarity test of switch.

(3) Earth continuity test.

(4) Earth electrode resistance test.

16.1.2 *Witnessing of Tests*

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

16.1.3 *Test Instruments*

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

16.2 Insulation Resistance

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

16.2.2 The insulation resistance shall also be measured between all the conductors connected to one pole, or phase conductor of the supply, and all the conductors connected to the neutral, or to the other pole, or phase conductors of the supply with all the lamps in position and switches in “off” position, and its value shall be not less than that specified in sub-clause 16.2.3.

16.2.3 The insulation resistance in mega ohms measured as above shall not be less than 12.5 mega ohms for the wiring with PVC insulated cables, subject to a minimum of 1 mega ohm.

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

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

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

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

16.3 Polarity Test of Switch

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

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

16.3.3 The installation shall be connected to the supply for testing. The terminals of all switches shall be tested by a test lamp, one lead of which is connected to the earth. Glowing of test lamp to its full brilliance, when the switch is in “on” position irrespective of appliance in position or not, shall indicate that the switch is connected to the right polarity.

16.4 Testing of Earth Continuity Path

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

16.5 Measurement of Earth Electrode Resistance

16.5.1 Two auxiliary earth electrodes, besides the test electrode, are placed at suitable distance from the test electrode (see Fig. 13). A measured current is passed between the electrode 'A' to be tested and an auxiliary current electrode 'C', and the potential difference between the electrode 'A' and auxiliary potential 'B' is measured. The resistance of the test electrode 'A' is then given by:

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

Where,

R - Resistance of the test electrode in ohms,

V - Reading of the voltmeter in volts,

I - Reading of the ammeter in amps.

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

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

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

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

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

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

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

16.6 Test Certificate

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 the prescribed form as given in Appendix 'E' in addition to the test certificate required by the local Electric Supply Authorities.

APPENDIX A

TERMINOLOGY

[Clause 1.3.1]

This appendix indicates some of the commonly used and important terms, relevant for the Internal EI works. For complete list of terms, relevant IS may be referred to.

1. **Exposed Conductive Part** – A conductive part of electrical equipment, which can be touched and which is not normally live, but which may become the earth potential.

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

3. **Direct Contact** – Contact of persons or livestock with live parts, which may result in electrical shock.

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

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

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

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

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

9. **Earth Electrode** – A conductor or group of conductors in intimate contact with and providing an electrical connection to earth.

10. **Earth Fault Loop Impedance** – The impedance of the earth fault current loop (phase to earth loop), starting and ending at the point of earth fault.

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

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

13. **Equipotential Bonding** – Electrical connections putting various exposed conductive parts and extraneous conductive parts at a substantially equal potential.

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

(a) Protective conductor

(b) Earth continuity conductor, and

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

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

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

(a) Exposed conductive parts,

(b) Extraneous conductive parts

(c) The main earthing terminal, and

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

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

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

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

19. **Simultaneously Accessible Parts** – Conductors or conductive parts which can be touched simultaneously by a person or, where applicable, by livestock.
Note: In the context of protection against direct contact, a live part may be accessible with:

(a) Another live part, or

(b) An exposed conductive part, or

(c) An extraneous conductive part, or

(d) A protective conductor

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

21. **Switchboard** – An assembly of switchgear with or without instruments, but the term does not apply to a group of local switches in a final circuit.
Note: This is as per BIS. In these specifications, this term is used for the mounting frame in particular. With the mountings, it is termed as a switchboard panel.

22. **Switchgear** – An assembly of main and auxiliary switching apparatus for operation, regulation, protection, or other control of electrical installations.
Note: For more comprehensive definitions of the terms in 2.103 to 2.106, See IS 1885 (Part 17) : 1979.

APPENDIX B

CONVENTIONAL SIGNS & SYMBOLS FOR ELECTRICAL INSTALLATION

[Clause 1.3.2]

General wiring
Wiring on the surface
Wiring under the surface

WIRING IN CONDUIT

Conduit on surface

Consealed conduit

Wiring going upwards

Wiring going downwards

Wiring passing vertically

FUSE BOARDS
LIGHTING CIRCUIT FUSE-BOARDS

Main fuse-board without switches

Main fuse-board with switches

Distribution fuse-board without switches

Distribution fuse-board with switches

POWER CIRCUIT FUSE-BOARDS

Main fuse-board without switches

Main fuse-board with switches

Distribution fuse-board without switches

Distribution fuse-board with switches

SWITCHES & SWITCH OUTLETS

ONE WAY SWITCH

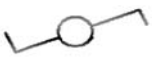
Single pole

Two pole

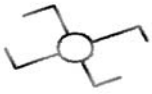
Three pole

Single pole pull switch

Multi-position switch (for different degrees of lighting)

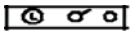


Two-way switch



Intermediate switch

Period limiting switch


Time switch

Pendant Switch


Push button


Luminous push button


Restricted access push button

SOCKET OUTLETS


Socket-outlet, 5A


Socket-outlet, 15A


Combined switch & socket-outlet, 5A


Combined switch & socket-outlet, 15A


Interlocking switch & socket-outlet, 5A


Interlocking switch & socket-outlet, 15A

LAMPS AND LIGHTING APPARATUS


Lamp or outlet for lamp

Group of three 40W lamps


Lamp mounted on a wall


Lamp mounted on a ceiling


Counter-weight lamp fixture


Chain lamp fixture


Road lamp fixture


Lamp fixture with built-in-switch

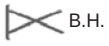

Lamp fed from variable voltage supply


Emergency lamp


Panic lamp

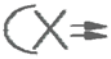

Bulk head lamp

Water-tight lighting fitting



Batten lamp holder


Projector


Spot light


Flood light


Flourescent lamp

Group of three 40 W flourescent lamps

ELECTRICAL APPLIANCES


General

BELLS, BUZZERS


Bell push


Bell


Buzzer

FIRE ALARM


Fire alarm push

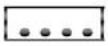

Automatic contact


Bell connected to fire alarm

Fire alarm indicator
(At 'N' insert number of ways)

PUBLIC ADDRESS SYSTEM

Amplifier


Control board


Microphone outlet


Loudspeaker outlet

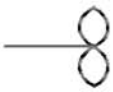
RADIO RECEPTION OUTLETS


Receiver outlet


Aerial

FIXED APPARATUS OUTLETS

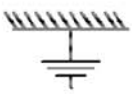

Ceiling fan


Bracket fan


Exhaust fan


Fan regulator

EARTHING


Earth point

APPENDIX C

IMPORTANT CLAUSES OF INDIAN ELECTRICITY RULES, 1956

[Clause 1.21]

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

Clause No.	*Subject*
3	Authorization.
29	Construction, installation, protection, operation maintenance of electric supply lines and apparatus.
31	Cutout on consumer's premises.
32	Identification of earthed and earthed neutral conductors and position of switches and cutouts therein.
33	Earthed terminal on consumer's premises.
36	Handling of electric supply lines and apparatus.
41	Distinction of circuits of different voltages.
42	Accidental charges.
43	Provisions applicable to protective equipment.
44	Instructions for restoration of persons suffering from electric shock.
44A	Intimation of Accident.
45	Precautions to be adopted by consumers, owners, occupiers, electrical contractors, electrical workmen and suppliers.
46	Periodical inspections and testing of consumer's installation.
48	Precautions against leakage before connection.
50	Supply and use of energy.
50A	Additional provisions for supply and use of energy in multistoried building (more than 15 meters in height).
51	Provisions applicable to medium, high or extra-high voltage installations.
54	Declared voltage of supply to consumer.
55	Declared frequency of supply to consumer.
56	Sealing of meters and cutouts.

Clause No.	*Subject*
58	Point of commencement of supply.
59	Precautions against failures of supply; Notice of failures.
61	Connection with earth.
61A	Earth leakage protective device.
64	Use of energy at high and extra-high voltage.
64A	Additional provisions for use of energy at high and extra high voltage.
67	Connection with earth.
68	General conditions as to transformation and control of energy. All clauses (74-93) under Chapter VIII on Overhead Lines.
137	Mode of entry.
138	Penalty for breaking seal.
138A	Penalty for breach of rule 44A.
139	Penalty for breach of Rule 45.
140	Penalty for breach of Rule 82.
140A	Penalty for breach of Rules 77, 79 or 80.
141	Penalty for breach of Rules.

APPENDIX D
IMPORTANT INDIAN STANDARDS

[Clause 1.22.4]

CODES OF PRACTICE GUIDE

Sl.No.	*Standard*	*Title*	*Reaffirm Date*	*Amdt.*
(1)	IS 732:1989	Code of practice for electrical wiring installations (third revision)	March 2010	
(2)	IS 4648:1968	Guide for electrical layout in residential buildings	August 2012	
(3)	IS 8061:1976	Code of practice for design, installation and maintenance of service lines upto and including 650 V	March 2011	
(4)	IS 8884:1978	Code of practice for the installation of electric bells and call systems	August 2012	
(5)	IS 5578:1984/ IEC 60391 (1972)	Guide for marking of insulated conductors (first revision)	March 2011	
(6)	IS 11353:1985/ IEC 60445 (1973)	Guide for uniform system of marking and identification of conductors and apparatus terminals	July 2012	
(7)	IS 13234:1991/ IEC 60909: 1988	Guide for short circuit current calculations in three-phase ac systems (superseding IS 5728)	August 2012	
(8)	IS 7752 (Part 1): 1975	Guide for improvement of power factor in consumer installation: Part 1 Low and medium supply voltages	March 2011	
(9)	IS 3646 (Part 1): 1992	Code of practice for interior illumination: Part 1 General requirements and recommendations for working interiors (first revision)	March 2008	
(10)	IS 3646 (Part 2): 1966	Code of practice for interior illumination: Part 2 Schedule of illumination and glare index	March 2008	
(11)	IS 3646 (Part 3): 1968	Code of practice for interior illumination: Part 3 Calculation of coefficients of utilization by the BZ method	March 2008	
(12)	IS 4347:1967	Code of practice for hospital lighting	May 2010	
(13)	IS 6665:1972	Code of practice for industrial lighting	May 2010	
(14)	IS 2672:1966	Code of practice for library lighting	May 2010	
(15)	IS 10118 (Part 1):1982	Code of practice for selection, installation and maintenance of switchgear and controlgear : Part 1 General	March 2011	
(16)	IS 10118 (Part 2):1982	Code of practice for selection, installation and maintenance of Switchgear and controlgear : Part 2 Selection	March 2011	
(17)	IS 10118 (Part 3):1982	Code of practice for selection, installation and maintenance of switchgear and controlgear : Part 3 Installation	March 2011	

Sl.No.	Standard	Title	Reaffirm Date	Amdt.
(18)	IS 10118 (Part 4):1982	Code of practice for selection, installation and maintenance of switchgear and controlgear : Part 4 Maintenance	March 2011	
(19)	IS 4146:1983	Application guide for voltage transformers (first revision)	September 2011	
(20)	IS 4201:1983	Application guide for current transformers (first revision)	September 2011	
(21)	IS 5547:1983	Application guide for capacitor voltage transformers (first revision)	September 2011	
(22)	IS 2309:1989	Code of practice for protection of buildings and allied structures against lightning (second revision)	March 2010	1
(23)	IS 3043:1987	Code of practice for earthing	March 2011	2
(24)	IS 5216 (Part 1):1982	Recommendations on safety procedures and practices in electrical work: Part 1 General (first revision)	March 2010	
(25)	IS 5216 (Part 2):1982	Recommendations on safety procedures and practices in electrical work: Part 2 Life saving techniques (first revision)	March 2010	

ELECTRIC FANS

CODES OF PRACTICE GUIDE

Sl.No.	Standard	Title	Reaffirm Date	Amdt.
(1)	IS 555:1979	Electric table type fans and regulators (third revision)	July 2010	2
(2)	IS 1169:1967	Electric pedestal type fans and regulators (first revision)	Mar 2009	6
(3)	IS 374:1979	Electric ceiling type fans and regulators (third revision)	September 2010	6
(4)	IS 2997:1964	Air circulator type electric fans and regulators	July 2010	8
(5)	IEC: 60665 (1981) IS 2312:1967	Propeller type ac ventilating fans (first revision) Draft Standard issued in wide circulation	July 2010	8
(6)	IS 3588:1987	Electric axial flow fans (first revision)	August 2009	1
(7)	IS 3963:1987	Roof extractor units (first revision)	August 2009	3
(8)	IS 4283:1981	Hot air fans (first revision)	August 2009	3
(9)	IS 6272:1987	Industrial cooling fans (man coolers) (first revision)	August 2009	2
(10)	IS 4894:1987	Centrifugal fans (first revision)	August 2009	3
(11)	IS 11037:1984	Electronic type fan regulators	August 2010	3
(12)	IS 12155:1987	General and safety requirements for fans and regulators for household and similar purposes		

LOW VOLTAGE SWITCH GEAR AND CONTROL GEAR

CODES OF PRACTICE GUIDE

Sl.No.	*Standard*	*Title*	*Reaffirm Date*	*Amdt.*
(1)	IS 4237:1982	General requirements for switchgear and controlgear for voltages not exceeding 1000 volts ac or 1200 volts dc (first revision) [superseded by IS 13947 (Part 1):1993]		
(2)	IS 6875 (Part 1): 1973	Control switches (switching devices for control and auxiliary circuits including contactor relays) for voltages upto and including 1000 V ac & 1200 V dc: Part 1 General requirements [superseded by IS 13947 (Part 5/Section 1)]		
(3)	IS 6875 (Part 2): 1973	Control switches (switching devices for control and auxiliary circuits including contactor relays) for voltages upto and including 1000 V ac and 1200 V dc: Part 2 Push-buttons and related control switches [Superseded by IS 13947 (Part 5/Section1)]		
(4)	IS 6875 (Part 3): 1980	Control switches (switching devices for control and auxiliary circuits including contactor relays) for voltages upto and including 1000 V ac and 1200 V dc : Part 3 Rotary control switches [superseded by IS 13947 (Part 5/ Section 1)]		
(5)	IS 10027:2000	Composite units of air-break switches and rewirable type fuses for voltages not exceeding 650 volt ac - Specification (first revision)	March 2010	
(6)	IS 4064 (Part 1): 1978	Air-break switches, air break disconnectors, air-break switch disconnectors and fuse-combination units for voltages not exceeding 1000 V ac or 1200 V dc: Part 1 General requirements (revised) [superseded by IS 13947 (Part 3): 1993]		
(7)	IS 2675:1983	Enclosed Distribution Fuse Boards and Cut Outs for voltages not exceeding 1000 V A.C. or 1200 V D.C.	March 2011	
(8)	IS 8828:1996	Circuit-breakers for over current protection for household and similar installations (second revision)		
(9)	IS 13032:1991	Miniature circuit breaker boards for voltage upto and including 1 000 Volt ac	March 2011	1
(10)	IS 12640 (Part 1): 2008	Residual current operated circuit-breakers for household and simililar uses : Part 1 circuit-breakers without integral over current protection (RCCBs) (First Revision)		
(11)	IS 12640 (Part 2): 2008	Residual current operated circuit-breakers for household and similar uses: Part 2 circuit breakers with integral over current protection (RCBOs) (First Revision)		
(12)	IS 2959:1985	Contactors for voltages not exceeding 1000 V ac or 1200 V dc (first revision) [superseded by IS 13947 (Part 4/ Section 1)]		
(13)	IS 12021:1987	Specification for control transformers for switchgear and controlgear for voltages not exceeding 1000 Volt AC	March 2010	2

Sl.No.	Standard	Title	Reaffirm Date	Amdt.
(14)	IS 5039:1983	Distribution pillars for voltages not exceeding 1000 volts (first revision)	March 2011	2
(15)	IS 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 (first revision).	March 2008	2
(16)	IS 8623 (Part 2):1993/ IEC 60439-2 (1987)	Specification for low voltage switchgear and controlgear assemblies: Part 2 Particular requirements for busbar trunking systems (busways)-(first revision)	March 2008	2
(17)	IS 8544 (Part 1): 1977	Motor starters for voltages not exceeding 1000 V: Part Direction line ac starters [superseded by IS 13947 (Part 4/Section 1): 1993]		2
(18)	IS 8544 (Part 2): 1977	Motor starters for voltages not exceeding 1000 V : Part 2 Star-delta starters [superseded by IS 13947 (Part 4/ Section 1): 1993]		
(19)	IS 8544 (Part 3/ Sec 1): 1979	Motor starters for voltages not exceeding 1000 V : Part 3 Rheostatic motor starters, Section 1 General requirements [superseded by IS 13947 (Part 4/Section 1): 1993]		
(20)	IS 8544 (Part 4): 1979	Motor starters for voltages not exceeding 1000 V: Part 4 Reduced voltage ac starters: two step auto-transformer starters [superseded by IS 13947 (Part 4/Section 1): 1993]		

POWER CABLE

CODES OF PRACTICE GUIDE

Sl.No.	Standard	Title	Reaffirm Date	Amdt.
(1)	IS 694:1990/ IEC 60227- 1 to 5 (1979)	PVC Insulated cables for working voltages upto and including 1100 V	February 2010	5
(2)	IS 694: 2010	Polyvinyl chloride insulated sheathed and unsheathed cables with rigid and flexible conductor for rated voltages upto and including 450/750 V : Part 1 General requirements (fourth revision)		1
(3)	IS 1554 (Part 1): 1988/ IEC 60502 (1983)	PVC insulated (heavy duty) electric cables: Part 2 For working voltages upto and including 1100 V (Third revision)		
(4)	IS 3961 (Part 1): 1967	Recommended current ratings for cables: Part 1 Paper insulated lead sheathed cables	November 2011	
(5)	IS 4288:1988	PVC insulated (heavy duty) electric cables with solid aluminium conductors for voltages upto and including 1100 V (second revision) (withdrawn)		
(6)	IS 4289 (Part 1): 1984/ IEC 60245-5	Flexible cables for lifts and other flexible connections: Part 1 Elastomer insulated cables (first revision)		

ELECTRIC WIRING ACCESSORIES

CODES OF PRACTICE GUIDE

Sl.No.	*Standard*	*Title*	*Reaffirm Date*	*Amdt.*
(1)	IS 9537 (Part 1): 1980/ IEC 60614-1 (1978)	Conduits for electrical installations: Part 1 General Requirements	November 2010	(1)
(2)	IS 9537 (Part 2): 1981	Conduits for electrical installations: Part 2 Rigid steel conduits (superseding IS:1653)	May 2012	(2)
(3)	IS 3480:1966	Flexible steel conduits for electrical wiring	May 2012	(1)
(4)	IS 2667:1988	Fittings for rigid steel conduits for electrical wiring (first revision) [Superseded by IS 14768 (Part 2): 2003]	February 2008	
(5)	IS 3837:1976	Accessories for rigid steel conduits for electrical wiring (first revision)	May 2012	(1)
(6)	IS 9537 (Part 4): 1983	Conduits for electrical installations: Part 4 Pliable self-recovering conduits of insulating materials	May 2012	
(7)	IS 9537 (Part 5): 2000/ IEC 60614-2-3 (1990)	Conduits for a electrical installations: Part 5 Pliable conduits of insulating material [Superseding IS 6946]	June 2010	
(8)	IS 3419:1989	Fittings for rigid non-metallic conduits (second revision)	May 2012	
(9)	IS 14772:2000/ IEC 60670-1 (1989)	Enclosures for accessories for household and similar fixed electrical installations [Superseding IS 5133 (Part 1 and 2)]	May 2010	
(10)	IS 2412:1975	Link clips for electrical wiring (first revision)	May 2012	(2)
(11)	IS 371:1999	Ceiling roses (third revision)	March 2010	(4)
(12)	IS 3854:1997/ IEC 60669-1 (1998)	Switches for domestic and similar purposes (second revision)	July 2012	(6)
(13)	IS 4615:1968	Switch-socket outlets (non-interlocking type) (Withdrawn)		
(14)	IS 4160:2005/ IEC 60884-2-6 (1997)	Interlocking switch socket outlets - Specification (first revision)	June 2010	
(15)	IS 1293:2005/ IEC 60884-1 (2002)	Plugs and socket outlets of rated voltage upto and including 250 volts and rated current upto and including 16 amperes - Specification (third revision)	June 2010	(5)

ELECTRICAL LAMPS AND THEIR AUXILIARIES

CODES OF PRACTICE GUIDE

Sl.No.	*Standard*	*Title*	*Reaffirm Date*	*Amdt.*
(1)	IS 418:2004/ IEC 60064 (1993)	Tungsten filament lamps for domestic and similar general lighting purposes (fourth revision)	March 2009	(4)
(2)	IS 2418 (Part 1): 1977/ IEC 81 (1974)	Tubular fluorescent lamps for general lighting service: Part 1 Requirements and tests (first revision)	December 2010	(8)
(3)	IS 9900 (Part 1): 1981 / IEC 188 (1974)	High pressure mercury vapour lamps: Part 1 Requirements and test [Superseding IS 2183 and IS 7023]	October 2012	(4)
(4)	IS 9974 (Part 1): 1981/ IEC 662 (1980)	High pressure sodium vapour lamps : Part 1 General requirements and tests	October 2012	(4)
(5)	IS 1258:2005/ IEC 61184 (1997)	Bayonet lamp holders (fourth revision)	June 2010	(3)
(6)	IS 3323:1980/ IEC 60400 (1972)	Bi-pin lamp holders for tubular fluorescent lamps (first revision)	October 2012	(1)
(7)	IS 3324:1982/ IEC 400 (1972)	Holders for starters for tubular fluorescent lamps (first revision)	June 2008	
(8)	IS 2215:2006/ IEC 60155 (1993)	Starters for fluorescent lamps (third revision)	Jun 2010	
(9)	IS 1534 (Part 1): 1977 / IEC 82 (1973)	Ballasts for fluorescent lamps: Part 1 For switch start circuits (second revision)	July 2011	(5)
(10)	IS 1569:1976/ IEC 566	Capacitors for use in tubular fluorescent	July 2011	(1)
(11)	IS 6616:1982/ IEC 262 (1969)	Ballasts for high pressure mercury vapour Lamps (first revision)	July 2011	(1)

LIGHT FITTINGS AND LUMINAIRES

CODES OF PRACTICE GUIDE

Sl.No.	*Standard*	*Title*	*Reaffirm Date*	*Amdt.*
(1)	IS 1913 (Part 1): 1978	General and safety requirements for luminaires: Part 1 Tubular fluorescent lamps (second revision)		
(2)	*IS 10322 (Part 1) :1982 / IEC 598 - 1(1979)	Luminaires: Part 1 General requirements	May 2010	
(3)	IS 10322 (Part 2): 1982 / IEC 598 - 1(1979)	Luminaires: Part 2 Constructional Requirements	May 2010	

CODES OF PRACTICE GUIDE

Sl.No.	*Standard*	*Title*	*Reaffirm Date*	*Amdt.*
(4)	IS 10322 (Part 5/ Sec. 2):2012	Luminaires: Part 5 Particular requirements, Sec 2 Recessed luminaires (First Revision)	March 2012	
(5)	IS 10322 (Part 5/ Sec. 3):2012/ IEC 60598-2-3 (1979)	Luminaires: Part 5 Particular requirements, Sec 3 Luminaires for road and street lighting (First revision)	March 2012	
(6)	IS 10322 (Part 5/ Sec 4):1987/ IEC 60598-2-4 (1979)	Luminaires: Part 5 Particular requirements, Section 4 Portable general purpose	May 2010	1
(7)	IS 10322 (Part 5/ Sec 5):1987/ IEC 60598-2-5	Luminaires: Part 5 Particular requirements, Section 5 Flood lights [superseding IS 1947]	May 2010	(1)
(8)	IS 3287:1965	Industrial lighting fittings with plastic reflectors		
(9)	IS 1777:1978	Industrial luminaires with metal reflectors (first revision)		
(10)	IS 2206 (Part 1): 1984	Flameproof electric lighting fittings: Part 1 Well-glass and bulkhead types (first revision)		
(11)	IS 3528:1966	Waterproof electric lighting fittings	May 2010	
(12)	IS 3553:1966	Watertight electric lighting fittings	May 2010	
(13)	IS 8030:1976/ IEC 162 (1972)	Luminaires for hospitals	March 2008	
(14)	IS 7537:1974	Road traffic signals	March 2008	
(15)	IS 9583:1981/ IEC 598-2-22 (1980)	Emergency lighting units	March 2008	

ELECTRICAL APPLIANCES

CODES OF PRACTICE GUIDE

Sl.No.	*Standard*	*Title*	*Reaffirm Date*	*Amdt.*
(1)	IS 302 (Part 1): 2008/ IEC 60335-1 (2006)	Safety of household and similar electrical appliances: Part 1 General requirements (sixth revision)		(1)
(2)	IS 2268:1994	Electric call bells and buzzers for indoor use (second revision)	March 2009	
(3)	IS 3412:1994	Electric water boilers (second revision)	March 2009	

CODES OF PRACTICE GUIDE

Sl.No.	*Standard*	*Title*	*Reaffirm Date*	*Amdt.*
(1)	IS 6236:1971/ IEC 60258 (1968)	Direct recording electrical measuring Instruments	January 2010	
(2)	IS 1248(Part 1): 2003/ IEC 600 51-1 (1997)	Direct acting indicating analogue electrical measuring instruments and their accessories: Part 1 General requirements (fourth revision)	Sep 2008	
(3)	IS 1248(Part 2): 2003/ IEC 600 51-2 (1984)	Direct acting indicating analogue electrical measuring instruments and their accessories: Part 2 Ammeters and voltmeters (third revision)	Aug 2008	
(4)	IS 1248(Part 3): 2003/ IEC 600 51-3 (1984)	Direct acting indicating analogue electrical measuring instruments and their accessories: Part 3 Wattmeters and varmeters (third revision)	Aug 2012	
(5)	IS 1248(Part 4): 2003/ IEC 600 51-4 (1984)	Direct acting indicating analogue electrical measuring instruments and their accessories: Part 4 Frequency meters (third revision)	Aug 2008	
(6)	IS 1248 (Part 5): 2003/ IEC 600 51-5 (1984)	Direct acting indicating analogue electrical measuring instruments and their accessories: Part 5 Phase meters, power factor meters and synchroscope (third revision)	Aug 2008	
(7)	IS 722(Part 1): 1998	AC electricity meters : General requirement and tests		
(8)	IS 722 (Part 2): 1977	AC electricity meters: Part 2 Single-phase whole-current watt-hour meters, Class 2 (first revision)		
(9)	IS 722 (Part 3): 1988	AC electricity meters: Part 3 Three-phase whole current and transformer operated and single-phase transformer operated watt-hour meters, class 2 (second revision)		
(10)	IS 722 (Part 5): 1980	AC electricity meters: Part 5 Volt-ampere hour meters for restricted power factor range, class 3.5 (first revision)		
(11)	IS 722 (Part 7/Sec 1): 1987	AC electricity meters: Part 7 Volt-ampere hour meters for full power factor range, Section 1 General requirements (first revision)		
(12)	IS 722 (Part 8): 1972	AC electricity meters: Part 8 Single-phase 2-wire whole current watt-hour meter (class 1.0)		
(13)	IS 722 (Part 9): 1972	AC electricity meters: Part 9 Three-phase whole current and transformer operated watt-hour meters and single-phase two-wire transformer operated watt-hour meters (class 1.0)		
(14)	IS 8530: 1977 IEC 60211:1966	Maximum demand indicators (class 1)		
(15)	*IS 2992:1987	Insulation resistance testers, hand operated (magneto generator type) (second revision)	Jan 2010	

INSTRUMENT TRANSFORMERS

CODES OF PRACTICE GUIDE

Sl.No.	*Standard*	*Title*	*Reaffirm Date*	*Amdt.*
(1)	IS 2705 (Part 1): 1992/ IEC 60185 (1966)	Current transformers: Part 1 General requirements (second revision)	Aug 2012	(1)
(2)	IS 2705 (Part 2): 1992/ IEC 60185 (1966)	Current transformers: Part 2 Measuring current transformers (second revision)	Aug 2012	
(3)	IS 2705 (Part 3): 1992/ IEC 60185 (1966)	Current transformers: Part 3 Protective current transformers (second revision)	Aug 2012	
(4)	IS 2705 (Part 4): 1992/ IEC 60185 (1966)	Current transformers: Part 4 Protective current transformers for special purpose applications (second revision)	Aug 2012	
(5)	IS 6949:1973	Summation current transformers	Sep 2011	

FUSES

CODES OF PRACTICE GUIDE

Sl.No.	*Standard*	*Title*	*Reaffirm Date*	*Amdt.*
(1)	IS 9224 (Part 1): 1979	Low voltage fuses: Part 1 General requirements [superseded by IS 13703 (Part 1):1993]		
(2)	IS 9224 (Part 2): 1979	Low voltage fuses: Part 2 Supplementary requirements for fuses for industrial applications (superseding IS 2208) [superseded by IS 13703 (part 2/Section 1):1993]		
(3)	IS 2086:1993	Carriers and bases used in rewirable type electric fuses for voltages upto 650 V (third revision) [Superseding IS 8724]	Mar 2009	(1)
(4)	IS 9926:1981	Fuse wires used in rewirable type electric fuses upto 650 volts	Mar 2011	
(5)	IS 8187:1976/ IEC 269-3 (1973)	D-type fuses		

MISCELLANEOUS

CODES OF PRACTICE GUIDE

Sl.No.	*Standard*	*Title*	*Reaffirm Date*	*Amdt.*
(1)	IS 2551:1982	Danger notice plates (first revision)	Mar 2010	
(2)	IS 2448 (Part 1): 1963	Adhesive insulating tapes for electrical purposes: Part 1 Tapes with cotton textile substrates	Oct 2010	(5)

ELECTROTECHNICAL VOCABULARY

CODES OF PRACTICE GUIDE **Date** **Amdt**

Sl.No.	*Standard*	*Title*	*Reaffirm Date*	*Amdt.*
(1)	IS 1885 (Part 1): 1961	Electrotechnical vocabulary: Part 1 Fundamental Definitions	Jul 2012	(2)
(2)	IS 1885 (Part 9): 1992/ IEC 60050 (446):1983	Electrotechnical Vocabulary: Part 9 Electrical relays (second revision)	Jul 2012	
(3)	IS 1885 (Part 11): 1966	Electrotechnical vocabulary: Part 11 Electrical Measurements	Jul 2012	
(4)	IS 1885 (Part 16/ Sec 1):1968	Electrotechnical vocabulary: Part 16 Lighting, Section 1 General aspects	Jul 2012	
(5)	IS 1885 (Part 16/ Sec. 2):1968	Electrotechnical vocabulary: Part 16 Lighting, Section 2 General illumination, lighting fittings and lighting for traffic and signaling	Jul 2012	
(6)	IS 1885 (Part 16/ Sec. 3):1967	Electrotechnical vocabulary: Part 16 Lighting, Section 3 Lamps and auxiliary apparatus	Jul 2012	
(7)	IS 1885 (Part 17): 1979	Electrotechnical vocabulary: Part 17 Switchgear and controlgear (first revision)	Jul 2012	
(8)	IS 1885 (Part 32):1993/ IEC 60050 (461): 1984	Electrotechnical Vocabulary: Part 32 Electric cables (first revision)	Mar 2009	

SAFETY

CODES OF PRACTICE GUIDE

Sl.No.	*Standard*	*Title*	*Reaffirm Date*	*Amdt.*
(1)	IS 4770:1991	Rubber Gloves for electrical purposes		
(2)	IS 5424:1969	Rubber mats for electrical purpose (Superseded by IS 15652:2006)	April 2011	(2)

APPENDIX E

FORM OF COMPLETION CERTIFICATE

[Clauses 1.26]

I/We certify that the installation detailed below has been installed by me/us and tested and that to the best of my/our knowledge and belief it complies with Indian Electricity Rules, 1956, as well as the C.P.W.D. General Specifications of Electrical Works 2013.

Electrical installation at .....

Voltage and system of supply .....

I. Particulars of work:

(a) Internal Electrical Installation

	No.	Total Load	Type or system of wiring
(i) Light point			
(ii) Fan point			
(iii) Plug Point			
(a) 3 pin 5 Amp.			
(b) 3 pin 15 Amp.			

(b) Others

	Description	HP/KW	Type of Starting
(a) Motors:			
(i)			
(ii)			
(iii)			
(b) Other plants:			

(c) If the work involves installation of overhead line and/or underground cable.

(d) (i) Type & description of overhead line.

(ii) Total length and no. of spans.

(iii) No. of street lights and its description.

(e) (i) Total length of underground cable & its size.

(ii) No. of joints: End joint :

Tee joint:

St. through joint:

II. Earthing

(i) Description of earthing electrode.

(ii) No. of earth electrodes.

(iii) Size of main earth lead.

III. Test results:

(a) Insulation resistance

(i) Insulation resistance of the whole system of

Conductors to earth – Mega ohms

(ii) Insulation between the phase conductor and neutral

Between Phase R and neutral – Mega ohms

Between Phase Y and neutral – Mega ohms

Between Phase B and neutral – Mega ohms

(iii) Insulation resistance between the phase conductors in case of polyphase supply.

Between Phase R and Phase Y – Mega ohms

Between Phase Y and Phase B – Mega ohms

Between Phase B and Phase R – Mega ohms

(b) Polarity test

Polarity of linked single pole branch switches.

(c) Earth continuity test

Maximum resistance between any point in the earth continuity conductor including metal conduits and main earthing lead …… Ohms

(d) Earth electrode resistance

Resistance of each earth electrode

(i) Ohms

(ii) Ohms

(iii) Ohms

(iv) Ohms

(e) Lighting protective system

Resistance of the whole of lightning protective system to earth before any bonding is effected with earth electrode and metal in/on the structure …… Ohms.

Signature and name of
Junior Engineer (E) / AE (E)

Signature and Name of the
Contractor

APPENDIX F

EARTHING

[Clause 8.0]

F.1 General

This Appendix indicates details useful in the design of earthing as applicable to the installations generally encountered in the Department. For complete details, IS 3043: 1987 shall be referred to. This Appendix shall supplement the requirements laid down in Chapter 8 of these specifications.

F.2 Earthing Requirements

F.2.1 *Statutory Requirement*

(i) All medium voltage equipments shall be earthed by two separate and distinct connections with earth. In the case of high and extra high voltages, the neutral points shall be earthed by not less than two separate and distinct connections with earth, each having its own electrode at the generating station or 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 suitable impedance.

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

F.2.2 *Supply System Requirement*

"System Earthing" is provided to preserve the security of the supply system. This is done by limiting the potential of live conductors with reference to earth, to such values as consistent with the level of insulation applied. Earthing the neutral point of the transformer ensures reasonable potential to earth, including at the time when the HV supply is impressed on the transformer. Earthing also ensures efficient operation of protective gear in the case of earth faults. Earthing may not give protection against faults that are not essentially earth faults. For example, if a phase conductor on an overhead spur line breaks, and the part remote from the supply falls to the ground, it is unlikely that any protective gear relying on earthing, other than current balance protection at the sub-station, will operate, since the earth fault current circuit includes the impedance of the load that would be high relative to the rest of the circuit.

F.2.3 *Installation Protection Requirement*

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

F.2.4 *Special Requirements*

F.2.4.1 "Static Earthing" is provided to prevent building up of static charges, by connections to earth at appropriate locations. Example, operation

theaters in hospitals. (For details, please refer to IS 7689 : 1974 and the National Electrical Code).

F.2.4.2 "Clean Earth" may be needed for some of the data processing equipments. These are to be independent of any other earthing in the building. (For details, please refer to IS 10422 : 1982 and IS 3043 : 1987).

F.2.4.3 Earthing is essentially required in protection of buildings against lightning. (For details, please refer to Chapter 9 and Appendix I of these Specifications).

F.3 Types of System Earthing

F.3.1 The various types of system earthing in practice are indicated below, out of which TN-S and T-TN-S systems are generally applicable to installations in the Department.

F.3.1.1 *TN-S System*

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

F.3.1.2 *TN-C System*

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

F.3.1.3 *TN-C-S System (Also called Protective Multiple Earthing – PME system)*

Supply is as per TN-C system. The arrangement in the installations is as per TN-S system, i.e. The PE and N are combined in one conductor at supply line. This is earthed at source as well as at frequent intervals. There will be independent protective conductor in the installation. Consumer also normally provides earth electrode terminating on to main earth electrode in his installation, and this is in turn "linked" to the PE & N conductor from supply line.

All the exposed conductive parts in the installation are connected to the PE & N conductor, through protective conductors and this main earthing terminal link.

F.3.1.4 *T-TN-S System (for 6, 6.6 or 11 KV bulk supply)*

No earth is provided with HV supply line, which is terminated in delta connected transformer primary. Neutral of the transformer (star

connected) secondary is earthed. Independent earth electrodes and bus are provided for the body earthing. Protective conductors are run throughout the LT distribution from the same for equipotential bonding.

F.3.1.5 *TT System*

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

F.3.1.6 *IT System*

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

F.3.2 ***Concept of Protection Against Indirect Contact***

F.3.2.1 The most commonly and successfully used method of protection against indirect contact is by "Earthed Equipotential bonding and automatic disconnection of supply" details of which are elaborated in IS 732 : 1989 and IS 3043 : 1987. All the exposed conductive parts are connected through protective (loop earthing) conductors to the main earthing terminal. All the extraneous conductive parts, which are simultaneously accessible with the exposed conductive parts, are also bonded to the main earthing terminal through main bonding conductor so that there is no dangerous potential between the exposed and the extraneous conductive parts. The earth fault loop impedance (EFLI) and the characteristics of the tripping devices are coordinated such that the faulty circuit is automatically disconnected before there is a persistent touch voltage at the exposed conductive part over a period of time, causing a shock hazard. If the disconnecting time is not satisfactory due to large EFLI, supplementary bonding between the exposed and the extraneous conductive parts is provided. Alternatively, use of RCDs becomes very relevant in most such situations. (See Appendix H for information on selection of RCDs). For more details, IS 3043 : 1987 may be referred to.

Note: Decision regarding the providing of RCD (RCCB) shall be taken in individual cases keeping in view the type, use, importance, system of earthing and nature of electrical installations to be protected by the RCD, requirements of the local Electric Supply Companies etc.

F.3.2.2 Earthing (comprising the electrode, earthing conductor, main earthing terminal etc.) and protective conductors in an installation are thus vital components in this system of protection against shock hazards. The concept is indicated diagrammatically in Fig. 14 & Fig. 15 indicates the method of ensuring the same, as envisaged in these specifications.

F.3.2.3 Rule 61A of I.E. Rules, 1956 calls for protective devices against earth leakages for certain loads. This should be complied with.

F.3.2.4 The following exposed conductive parts are exempted from bonding to earth:

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

(ii) Inaccessible steel reinforcement in RCC poles.

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

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

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

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

F.3.3 ***Selection of Type of Electrodes***

Following are general guidelines for the selection of the type of electrodes.

Type of electrode	*Application*
GI pipe	Internal electrical installations like Distribution Board and Meter Boards (in residential quarters), feeder pillars and poles etc.
GI plate	(i) For Fire fighting pumps and water supply pumps. (ii) Lightning conductors.
Copper plate	Neutral earthing of transformers/ generating sets.
Strip/ Conductor	Locations where it is not possible to use other types.

F.3.4 ***Number of Earth Electrodes***

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

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

(iii) The number of earthing electrodes for sub-stations and generating sets shall be as under:-

For neutral earthing of each transformer	-	2 sets
For body earthing of all the transformers, HT/LT Panels and other electrical equipments in the Sub-station/ power house	-	2 sets

For neutral earthing of each generating set	-	2 sets
For body earthing of all the generating sets, LT panels and other electrical equipments in the generator room	-	2 sets

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

(iv) Separate earth electrodes shall be provided for lightning arrester/ lightning conductors.

F.3.5 ***Size of Protective Conductor***

F.3.5.1 The cross section of a protective conductor may be calculated by either of the following 2 methods, the second one being used for designs in general, and the first one for checking purposes.

(i) $S \geq \frac{\sqrt{I^2t}}{K}$

Where, S = Cross sectional area of protective conductor in sq.mm.

I = Earth fault (Leakage) current in Amp.

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

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

$I = \frac{U_o}{Z_s}$ where, U_o = Nominal phase voltage to earth.

Z_s = Earth fault loop impedance, (considering its 5 seconds value).

Note 1 : Values of Z_s are available in Tables in IEE Wiring Regulations, U, K, dependent on tripping devices. Alternatively, this can be calculated.

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

(ii) The minimum cross section of a protective condutor shall be as per the following:

Size of phase conductor	*Size of protective conductor of the same material as phase conductor*
S upto 16 sq.mm.	S sq.mm.
S = 16 to 35 sq.mm.	16 sq.mm.
S > 35 sq.mm	S/2 sq.mm.

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

K1/K2 for

$$\frac{\text{Copper}}{\text{Aluminium (Insulated)}} = 1.20 \text{ to } 1.24$$

$$\frac{\text{Copper}}{\text{Steel wire (Insulated)}} = 2.17 \text{ to } 2.25$$

$$\frac{\text{Copper}}{\text{Steel (Conduits/Trunking)}} = 2.31 \text{ to } 2.45$$

F.3.5.2 The minimum acceptable size of a protective conductor shall be 2.5 sq.mm. if protected mechanically, and 4 sq.mm. if otherwise.

F.3.6 ***Size of Earthing Conductor***

F.3.6.1 The earthing conductors shall comply with the provisions of clause F.3.5 above, except that the minimum cross sectional area shall be 16 sq.mm. (Copper or steel) when protected against corrosion, and 25 sq.mm. copper, or 50 sq.mm. steel when not protected against corrosion.

F.3.6.2 For determining the size of earthing conductor for sub-stations and generating sets, IS 3043 : 1987 may be referred to.

F.3.7 ***Size of Bonding Conductor***

The main bonding conductor should be half the size of the earthing conductor, subject to a minimum of 6 sq.mm. and maximum of 25 sq.mm. copper, or equivalent sizes for other materials. This is applicable for TN-S and TN-C-S system only.

F.3.8 ***Details for Contract Purposes***

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

APPENDIX G

GUIDELINES FOR SELECTION AND APPLICATION OF RCCBs (RCDs)

[Clause 8.7 & F.3.2.1]

G.0 General

G.0.1 IS 732 : 1989 recognizes two forms of shock hazard, 'Indirect contact' and 'Direct contact'. The objective is to achieve safety to personnel and property through the best possible means in the most economic manner.

G.0.2 The most commonly used protective measure against indirect contact is termed "main equi-potential bonding and automatic disconnection of supply". Irrespective of the type of protective device used, the aim is to prevent dangerous 'touch voltages' persisting on accessible conductive parts which become live under earth fault conditions. Use of RCCBs is only one of the means that would provide automatic disconnection of supply in the event of shock hazard. The use of RCCB is not considered, as a sole means of protection and it does not obviate the need to apply other protective measures. Some broad guidelines are provided in this Appendix on these issues.

G.1 Residual Current Operated Circuit Breaker (RCCB)

G.1.1 In general, every circuit is provided with a means of over current protection. If the earth fault loop impedance is low enough to cause these devices to operate within the specified times, such devices can be relied upon to give the requisite automatic disconnection of supply. Where the earth fault loop impedance is too large, efforts are required to make it low enough. Guidelines are available in IS 3043 : 1987. When protection against indirect contact is decided to be provided by RCCB, IS 732 : 1989 prescribes that the product of its rated residual current (rated tripping current) in amperes and the earth loop impedance in ohms should not exceed the value 50.

G.1.2 Fault voltage operated circuit breakers voltage operated ELCB are not preferred devices against shock protection. This Appendix covers only truly current-operated devices. These are of different types. The following are the two main types:

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

(b) Residual current devices dependent on line voltage.

G.2 Choice of RCCBs

G.2.0 Where RCCBs are required to be used for affording shock protection; there are several broad parameters that are required to be carefully chosen. These are described in the following clauses.

G.2.1 ***Location***

RCCB can be used as a protective measure to the entire installation, or part, or to an item of equipment. This is determined by the security of supply desired in

certain parts of the same installation when RCCB operates. Where only one RCCB is being employed to protect the entire installation, it is necessary that it is located at the main distribution board, at the origin of the installation.

G.2.2 ***Type of RCCB***

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

G.2.3 ***Rated Current***

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

G.2.4 ***Rated Tripping Current***

(i) The preferred rated currents of RCCBs are 10, 30, 100 and 300 mA. RCCBs having minimum operating currents of 30 mA are intended to give protection against 'indirect contact'. RCCB having minimum operating currents of 30 mA and below are generally referred to as having 'high sensitivity' and can give protection against 'direct contact' in case of failure of other protective measures. It is essential that an RCCB is not used as a sole means for protection against direct contact.

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

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

G.2.4.1 *Discrimination*

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

G.2.4.2 *Type of System Earthing*

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

G.2.5 ***Breaking Capacity***

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

(ii) In practice, the functions of RCCB and that of the over current/ short circuit protective device in series may tend to overlap and under certain conditions both may attempt to clear the fault. This may occur, for example, when a severe earth fault produces a current of similar magnitude to that under short circuit conditions, or when an earth fault and short circuit occur simultaneously. Another possible cause is the inherent out of balance in the primary windings of the balance transformer causing the RCCB to trip. Care is, therefore, necessary to be exercised in ensuring that RCCB is coordinated with over current devices.

G.2.6 ***Neutral Grounding or Failure***

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

G.3 Guidelines for Specific Occupancies or Locations

G.3.1 ***Household and Similar Installations***

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

G.3.2 ***Locations containing Bath Tub/Shower Basin and Swimming Pools***

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

G.3.3 Where individual socket outlets are required to be protected by RCCB, the rated tripping current shall not exceed 30 mA.

G.3.4 ***Industrial Installations***

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

G.3.5 ***Data Processing Installations/ Industrial Control/ Telecommunication Equipment***

Radio frequency interference suppression filters fitted to these equipments may produce high earth leakages. Failure of the protective earth connection may cause a dangerous touch voltage. Use of RCCBs under such circumstances should be carefully considered owing to their frequent tripping, besides capacitor charging currents at switching on shall have to be considered. Under such circumstances, where leakages exceed 10 mA, one of the three measures given below may be necessary:

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

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

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

G.3.6 The presence of generating sets within an installation may change the conditions of application of RCCB. The contribution to the prospective short circuit current by the generating set should be taken into account.

G.3.7 ***Medical Establishment and Electrical Installations in Hazardous Locations***

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

APPENDIX H

PRINCIPLES OF PROTECTION OF BUILDING AGAINST LIGHTNING

[Clause 9.0]

H.1 This Appendix shall supplement the requirements in Chapter 9 of these specifications.

H.2 Introduction

H.2.1 Protection of special structures, such as those exceeding 30 m in height, structures with roofs of high inflammability, buildings with explosive or highly inflammable contents, fences, trees and structures near trees, structures supporting overhead electricity supply, telephone and other lines, structures with radio and television aerials, tents, metal scaffolding and similar structures, tall metal masts, tower cranes and revolving and travelling structures, farm buildings in areas of high lightning incidence, sports stadium, raised motorways, bridges, dwelling houses, etc. shall be strictly done in accordance with IS 2309 : 1989. These are not covered in these specifications.

H.2.2 These specifications are confined only to all other structures, and which have no inherent explosive risks. The need for protection in such structures may be self-evident, for example:

(a) Where large numbers of people congregate,

(b) Where essential public services are concerned,

(c) Where much lightning strokes are prevalent,

(d) Where there are very tall or isolated structures,

(e) Where there are structures of historic or cultural importance, etc.

However, there can be cases for which a decision is not so easy to make. Various factors affecting the risk of being struck, and the consequential effects of a lightning stroke in these cases are discussed below.

H.3 Need for Protection

H.3.1 ***Estimation of Exposure Risk***

(i) The probability of a structure, or a building being struck by lightning in one year is the product of the “lightning flash density”, and the “effective collection area” of the structure.

(ii) The lightning flash density, N_g, is the number of flashes to ground per sq.km. per year. The annual thunderstorm days for certain selected cities are given in Appendix I. These are to be translated in terms of estimated average annual density N_g. The table below indicates the relationship between the thunderstorm days per year and lightning flashes per square kilometer per year.

Thunderstorm Lightning flashes per sq.km. per year. Days/year		
	Mean	*Limits*
5	0.2	0.10 – 0.5
10	0.5	0.15 – 1
20	1.1	0.30 – 3
30	1.9	0.60 – 5
40	2.8	0.80 – 8
50	3.7	1.20 – 10
60	4.7	1.80 – 12
80	6.9	3.00 – 17
100	9.2	4.00 – 20

(iii) The effective collection area of a structure is the area on the plan of the structure extended in all directions to take account of its height. The edge of the effective collection area is displaced from the edge of the structure by an amount equal to the height of the structure at that point. Hence, for a simple rectangular building of length L, width W, and height H meters, the collection area has length (L + 2H) meters, and width (W+2H) meters, with four rounded corners formed by quarter circles of radius, H meters.

This gives a collection area, A_c (in sq.m) of:

$$A_c = (L \times W) + 2 (L \times H) + 2 (W \times H) + (22/7) \times H^2 \quad \text{— (1)}$$

(iv) The probable number of strikes (risk) to the structure per year is:

$$P = Ac \times N_g \times 10^{-6} \quad \text{— (2)}$$

(v) It must first be decided whether this risk P is acceptable, or, whether some measure of protection is necessary.

H.3.2 ***Suggested Acceptable Risk***

The acceptable risk figure has been taken as 10^{-5}, i.e. 1 in 100,000 per year.

H.3.3 ***Overall Assessment of Risk***

The weighting factors for evaluating the overall assessment of risk are given in Tables 1A to 1E in Appendix J. It must be seen whether the value of P [see (2) under H.3.1 (iv)] multiplied by the appropriate weighting factors exceeds the acceptable risk of P = 10^{-5} per year.

H.3.4 ***Weighting Factor***

In Tables 1A to 1E in Appendix J, the weighting factor values are given, denoting a relative degree of importance or risk in each case. The tables are mostly self-explanatory. The term consequential effect in Table 1C is intended to cover not only material risks to goods and property, but also such aspects as the disruption of essential services of all kinds, particularly in hospitals, where if a lightning strikes, fire or panic can naturally result.

H.3.5 ***Interpretation of Overall Risk Factor***

The risk factor given herein is to be taken as giving guidance on what might, in some cases, be a difficult problem. If the result obtained is considerably less than 10^{-5} (1 in 100,000), then in the absence of other overriding considerations, protection does not appear necessary. If the result is greater than 10^{-5}, say for example 10^{-4} (1 in 10,000) then sound reasons would be needed to support a decision not to give protection.

H.3.6 ***Anomalies***

(i) Structures are so varied that any method of assessment may lead to anomalies, and those who have to decide on protection must exercise judgement. For example, a steel-framed building may be found to have a low risk factor but, as the addition of an air termination and earthing system will greatly improve protection, the cost of providing this may be considered worth-while.

(ii) A low risk factor may result for chimneys made of brick or concrete. However where chimneys are free standing, or where they project more than 4.5 m above the adjoining structure, they will require protection regardless of the factor. Such chimneys are, therefore, not covered by the method of assessment. Similarly, structures containing explosives or flammable substance are also not covered.

H.3.7 ***Sample Calculation of Need for Protection***

A sample calculation for a hospital building is given in Appendix K for guidance.

H.4 Principle of Protection

(i) The principle for protection of buildings against lightning is to provide a conducting path between earth and the atmosphere above the building through which the lightning discharge may enter the earth without causing damage to the building. If adequately earthed metal parts of proper proportions are provided and spread properly on and around the building, damage can be largely prevented.

(ii) The required conditions of protection are generally met by placing all the air terminals, whether in the form of vertical finials or horizontal conductors, on the upper most part of the building or its projections, with lightning conductors connecting the air terminals with each other and to the earth.

H.5 Zone of Protection

H.5.1 ***General***

The zone of protection is the volume within which a lightning conductor gives protection against a direct lightning stroke by directing the stroke to itself. For a vertical conductor rising from ground level, the zone is described as a cone with

its apex at the tip of the conductor and its base on the ground. For a horizontal conductor, the zone is defined as the volume generated by a cone with its apex on the horizontal conductor from end to end.

H.5.2 ***Protective Angle***

(i) This cannot be precisely stated, since it depends upon the severity of the stroke and the presence within the protective zone of conducting objects providing independent paths to the earth. All that can be stated is that the protection afforded by a lightning conductor increases as the assumed protective angle decreases.

(ii) (a) However, for the practical purpose of providing an "acceptable degree" of protection for an ordinary structure, the protective angle of any single component part of an air termination network, namely, either one vertical, or one horizontal conductor is considered to be 45 degrees.

(b) Between three or more vertical conductors, spaced at a distance not exceeding twice their height, the equivalent protective angle may, as an exception, be taken as 60 degrees to the vertical.

(iii) Protective angles of zones of protection for some forms of air termination are illustrated in IS 2309 : 1989.

H.5.3 ***Structures of Exceptional Vulnerability***

For structures of exceptional vulnerability by reason of explosive or highly inflammable contents, every possible protection may need to be provided, even against the rare occurrence of a lightning discharge striking within the protected zone. For this reason, a reduced zone of protection and other special measures should be taken as detailed in IS 2309 : 1989.

H.6 Components

H.6.1 ***Air Terminations***

(i) Air termination networks may consist of vertical or horizontal conductors, or combinations of both.

(ii) For the purpose of lightning protection, the vertical and horizontal conductors are considered equivalent and the use of pointed air terminations, or vertical finial is, therefore, not regarded as essential.

H.6.2 ***Down Conductors***

(i) *General*

The function of a down conductor is to provide a low impedance path from the air termination to the earth electrode so that lightning current can be safely conducted to the earth. In practice, depending upon the form of a building, it is often necessary to have many down conductors in parallel, some or all of which may be a part of the building structure itself.

(ii) *Recommended Number*

The position and spacing of down conductors on large structures are often governed by architectural convenience. However, recommendations for their number are given below:

(i) A structure having a base area not exceeding 100 sq.m. need have only one down conductor, except when built on a bare rock, or where access for testing is difficult.

(ii) For a structure having a base area exceeding 100 sq.m. the number of down conductors should be at least the smaller of the following:

(a) One plus an additional one for each 300 sq.m., or a part thereof, in excess of the first 100 sq.m.

(b) One for each 30 m of the perimeter of the structure protected.

(iii) *Tall structures presenting inspection difficulties*

For tall structures, where testing and inspection could be difficult, at least two down conductors will be required for such tests.

H.7 Illustrations

The IS 2309 : 1989 shows several arrangements for air terminations, down conductors, voltage gradient along ground surface near to masts, towers, columns and single down conductors, re-entrant loops, typical joints, earth termination, bonding to building services, fixing of lightning conductors, test points, typical forms of vertical air terminations, etc. which may be referred to.

APPENDIX I

AVERAGE NUMBER OF THUNDERSTORM DAYS IN THE YEAR

[Clause H.3.1(ii)]

Sl. No.	*Name of Place*	*Annual Thunerstorm Days*	*Sl. No.*	*Name of Place*	*Annual Thunerstorm Days*
1.	Chloht	7	29.	Neemuch	23
2.	Skarou	5	30.	Kota	27
3.	Gulmarg	53	31.	Jhalawar	40
4.	Srinagar	54	32.	Mussorie	61
5.	Dras	3	33.	Roorkee	76
6.	Kargil	2	34.	Moradabad	36
7.	Leh	3	35.	Mukteshwar	53
8.	Jammu	2	36.	Meerut	—
9.	Dharamsala	13	37.	Bareilly	34
10.	Amritsar	49	38.	Aligarh	30
11.	Pathankot	4	39.	Agra	24
12.	Mahoi	46	40.	Mainpuri	23
13.	Ludhiana	12	41.	Bharaich	31
14.	Shimla	40	42.	Gonda	22
15.	Patiala	26	43.	Lucknow	10
16.	Ambala	9	44.	Kanpur	26
17.	Hissar	27	45.	Fetehpur	24
18.	Delhi	30	46.	Jhansi	20
19.	Bikaner	10	47.	Allahabad	51
20.	Phalodi	14	48.	Varanasi	51
21.	Sikar	17	49.	Azamgarh	1
22.	Barmer	12	50.	Gorakhpur	11
23.	Jodhpur	23	51.	Kathmandu	74
24.	Ajmer	26	52.	Motihari	38
25.	Jaipur	39	53.	Darbhanga	10
26.	Kankroli	36	54.	Patna	33
27.	Mount Abu	4	55.	Gaya	38
28.	Udaipur	34	56.	Daltonganj	73

Sl. No.	*Name of Place*	*Annual Thunerstorm Days*	*Sl. No.*	*Name of Place*	*Annual Thunerstorm Days*
57.	Hazari Bagh	73	91.	Surat	4
58.	Ranchi	34	92.	Gwalior	53
59.	Chaibassa	74	93.	Guna	33
60.	Jamshedpur	66	94.	Nowgong	59
61.	Purnea	52	95.	Satna	41
62.	Sabour	76	96.	Sagar	36
63.	Dumka	63	97.	Bhopal	44
64.	Darjeeling	20	98.	Jabalpur	50
65.	Jalpaiguri	68	99.	Umaria	37
66.	Malda	50	100.	Ambikapur	29
67.	Asansol	71	101.	Indore	34
68.	Burdwan	33	102.	Hoshangabad	37
69.	Kharagpur	76	103.	Panchmarhi	30
70.	Kolkata	70	104.	Seoni	51
71.	Sagar Island	41	105.	Penda Dam	56
72.	Dhubri	8	106.	Raipur	34
73.	Tezpur	27	107.	Chindara	27
74.	Dibrugarh	70	108.	Kanker	37
75.	Sibsagar	103	109.	Jagdalpur	38
76.	Shillong	75	110.	Balasore	81
77.	Cheerapunji	49	111.	Chandbali	75
78.	Silchar	33	112.	Angul	81
79.	Kohnia	34	113.	Bhubaneshwar	46
80.	Imphal	49	114.	Puri	33
81.	Deesa	7	115.	Gopalpur	34
82.	Dwarka	5	116.	Sambalpur	67
83.	Jamnagar	6	117.	Jharsuguda	85
84.	Rajkot	12	118.	Titlagarh	24
85.	Ahmedabad	11	119.	Rajgangpur	1
86.	Dohad	17	120.	Damamu	4
87.	Porbandar	3	121.	Nasik	17
88.	Verawal	3	122.	Malegaon	13
89.	Bhavnagar	1	123.	Akola	20
90.	Vadodara	8	124.	Khraoti	32

Sl. No.	*Name of Place*	*Annual Thunerstorm Days*	*Sl. No.*	*Name of Place*	*Annual Thunerstorm Days*
125.	Nagpur	45	155.	Gadag	21
126.	Gonda	10	156.	Bellari	22
127.	Aurangabad	36	157.	Karwar	27
128.	Mumbai	18	158.	Honawar	5
129.	Alibag	12	159.	Chikalthana	24
130.	Ahmednagar	10	160.	Mangalore	36
131.	Parbhani	32	161.	Hassan	76
132.	Pune	22	162	Bangalore	45
133.	Mahabaleshwar	14	163.	Mysore	44
134.	Ratnagiri	6	164.	Hozhmoode	39
135.	Sholapur	23	165.	Palghat	35
136.	Miraj	25	166.	Cochin	63
137.	Vengurla	39	167	Alleppy	57
138.	Nizamabad	36	168.	Trivandrum	48
139.	Hanamkonda	43	169.	Vellore	25
140.	Hyderabad	28	170.	Madras	47
141.	Khamma	26	171.	Ootacamund	24
142.	Kalingapatnam	26	172.	Salem	65
143.	Vishakapatnam	20	173.	Cuddalore	37
144.	Rentichintala	47	174.	Coimbatore	40
145.	Machhilipatnam	20	175.	Tiruchirapalli	41
146.	Ongole	25	176.	Nagapattinam	15
147.	Kurnool	29	177.	Kodaikanal	82
148	Anantapur	27	178.	Madurai	39
149.	Nellore	18	179.	Pamban	5
150.	Bidar	16	180.	Tuticorin	14
151.	Gulbarga	34	181.	Kanyakumari	60
152.	Bijapur	9	182.	Port Blair	62
153.	Belgaum	31	183.	Car Nicobar I	10
154.	Raichur	17	184.	Minicoy	20

APPENDIX J

WEIGHTING FACTORS FOR OVERALL ASSESSMENT OF RISK FOR LIGHTNING PROTECTIVE SYSTEM

[Clause H.3.4]

Table 1A

Weighting Factor 'A' (Use of Structure)

Use to which structure is put	*Value of 'A'*
Houses and other buildings of comparable size	0.3
Houses and other buildings of comparable size with outside aerial	0.7
Factories, workshops, and laboratories	1.0
Office Blocks, hotels, blocks of flats and other residential buildings other than those included below	1.2
Places of assembly, for example, churches, halls, theaters, museums, exhibitions, departmental stores, post offices, stations, airports, and stadium structures.	1.3
Schools, hospitals, children's and other homes	1.7

Table 1B

Weighting Factor 'B' (Type of Construction)

Type of construction	*Value of 'B'*
Steel framed encased with any roof other than metal*	0.2
Reinforced concrete with any roof other than metal	0.4
Steel framed encased or reinforced concrete with metal roof.	0.8
Brick, plain concrete or masonry with any roof other than metal or thatch	1.0
Timber framed or clad with any roof other than metal or thatch	1.4
Brick, plain concrete, masonry, timber framed but with metal roofing	1.7
Any building with a thatched roof	2.0

* A structure of exposed metal, which is continuous down to ground level, is excluded from these tables, as it requires no lightning protection beyond adequate earthing arrangement.

Table 1C

Weighting Factor 'C' (Contents or Consequential Effects)

Contents or Consequential Effects	*Value of 'C'*
Ordinary domestic or office buildings, factories and workshops not containing valuable or specially susceptible contents	0.3
Industrial and agricultural buildings with specially susceptible* contents	0.8
Power stations, gas works, telephone exchange, radio stations	1.0
Industrial key plants, ancient monuments and historic buildings, museums, art galleries or other buildings with specially valuable contents	1.3
Schools, hospitals, children's and other places of assembly	1.7

* This means specially valuable plant or materials vulnerable to fire or the results of fire.

Table 1D

Weighting Factor 'D' (Degree of Isolation)

Degree of Isolation	*Value of 'D'*
Structure located in a large area of structures or trees of the same or greater height, for example, in a large town or forest	0.4
Structure located in an area with few other structures or trees of similar height	1.0
Structure completely isolated or exceeding at least twice the height of surrounding structures or trees.	2.0

Table 1E

Weighting Factor 'E' (Type of Country)

Type of Country	*Value of 'E'*
Flat country at any level	0.3
Hill country	1.0
Mountain country between 300 m and 900 m	1.3
Mountain country above 900 m	1.7

APPENDIX K

SAMPLE CALCULATION OF NEED FOR PROTECTION WITH A LIGHTNING PROTECTION SYSTEM

[Clause H.3.7]

A hospital building is 10 m high and covers an area of 70 m x 12 m. The hospital is located in flat country and is isolated from other structures. The construction is of brick and concrete with a non-metallic roof. Is lightning protection needed?

(a) Flashes/sq.km/year – Let us say, for the protection of the hospital a value for N_g is 0.7.

(b) Collection area – Using equation (1) in H.3.1 (iii)

A_c = (70 x 12) + 2 (70 x 10) + 2 (12 x 10) + (22/7 x 100)

= 840 + 1400 + 240 + 314

= 2794 sq.m.

(c) Probability of being struck – Using equation (2) in H.3.1 (iv) :

P = $A_c \times N_g \times 10^{-6}$ times per year

= $2794 \times 0.7 \times 10^{-6}$

= 2.0×10^{-3} approximately.

(d) Applying the weighting factors

A = 1.7

B = 0.8

C = 1.7

D = 2.0

E = 0.3

The overall multiplying factor = A x B x C x D x E

= 1.7

Therefore, the overall risk factor = $2.0 \times 1.7 \times 10^{-3}$

= 3.4×10^{-3}

Conclusion: Protection is necessary.

TABLE 1

Chart showing the Distance upto which Different Sizes of UG Aluminium Conductor Cables can be used for Different Peak Load Current Ratings for 8 Volts Drop when Laid in Ground (PVC Insulated, PVC Sheathed, 3 core or 4 core) when Cable Grading is 1.1 KV

(Maximum Conductor Temperature - 70 deg C)														
S.No.	*Current*	*Distance in mtrs for the following cable sizes in sqmm*												
	Amp	*6*	*10*	*16*	*25*	*35*	*50*	*70*	*95*	*120*	*150*	*185*	*240*	*300*
1	5	165	260	415	725	895	1300	1925	2360	3065	3555	4300	5770	6460
2	10	80	130	205	360	450	650	960	1180	1530	1775	2150	2885	3230
3	15	55	85	140	240	300	430	640	785	1020	1185	1430	1920	2155
4	20	40	65	100	180	225	325	480	590	765	890	1075	1440	1615
5	25	30	50	80	145	180	260	385	470	610	710	860	1150	1290
6	30	25	40	70	120	150	215	320	390	570	590	715	960	1075
7	40	20	30	50	90	110	160	240	295	380	445	535	720	805
8	50	–	25	40	70	90	130	190	235	305	355	430	575	645
9	60	–	–	35	60	75	110	160	195	255	295	355	480	535
10	70	–	–	30	50	65	90	135	165	215	255	305	410	460
11	80	–	–	–	45	55	80	120	145	190	220	265	360	405
12	90	–	–	–	40	50	70	105	130	170	195	235	320	360
13	100	–	–	–	35	45	65	95	115	150	175	215	290	320
14	110	–	–	–	–	40	60	85	105	140	160	195	260	290
15	120	–	–	–	–	35	55	80	95	125	145	180	240	270
16	130	–	–	–	–	–	50	75	90	115	135	165	220	250
17	140	–	–	–	–	–	45	70	80	110	125	150	205	230
18	150	–	–	–	–	–	–	65	75	100	115	140	190	215
19	160	–	–	–	–	–	–	60	70	95	110	130	180	200
20	170	–	–	–	–	–	–	55	70	90	105	125	170	190
21	180	–	–	–	–	–	–	50	65	85	100	120	160	180
22	190	–	–	–	–	–	–	–	60	80	90	110	150	170
23	200	–	–	–	–	–	–	–	60	75	90	105	145	160
24	225	–	–	–	–	–	–	–	–	65	80	95	125	145
25	250	–	–	–	–	–	–	–	–	–	70	85	115	130
26	275	–	–	–	–	–	–	–	–	–	–	80	105	115
27	300	–	–	–	–	–	–	–	–	–	–	70	95	105

Note 1 : PVC Insulated electrical cable for voltage grade upto 1.1 KV is based on 8 volts drop.

1. This table is based on current and resistance as given in M/s Incab's table for cables (April 1964. Table No.17 and 33)
2. The distances are given in meters and after rounding.
3. The condition of installation of cable is ground temp.15 degree C.

Note 2 : For Temperature Correction please see as detailed below:

1. When the voltage drop and length is constant then to find the size of cable for following current ratings of the chart to obtain the calculated load current by the following factors and then see the size according to that ratings which was multiplied by the temperature factor.

Ground Temp:	20 Degree C	25 Degree C	30 Degree C	35 Degree C
Rating Factors:	0.95	0.9	0.85	0.8

TABLE 2

Current Rating (in Ground) for XLPE Insulated 1.1 KV Grade Cables

Nominal Area of the Conductor	*Aluminium Conductor*				*Copper Conductor*			
	Single Core		*Multi Core*		*Single Core*		*Multi Core Unity*	
mm^2	*PVC*	*XLPE*	*PVC*	*XLPE*	*PVC*	*XLPE*	*PVC*	*XLPE*
10	51	55	46	50	65	71	60	65
16	66	74	60	68	85	95	77	87
25	86	98	76	90	110	125	99	115
35	100	118	92	108	130	150	120	138
50	120	137	110	126	155	175	145	161
70	140	172	135	158	190	220	175	202
95	175	204	165	187	220	260	210	239
120	195	234	185	215	250	301	240	276
150	220	262	210	240	280	336	270	308
185	240	298	235	273	305	381	300	350
240	270	344	275	316	345	441	345	405
300	295	387	305	355	375	496	385	455
400	325	458	335	420	400	586	425	538
500	345	495	-	-	425	635	-	-
630	390	555	-	-	470	710	-	-
800	440	625	-	-	-	-	-	
1000	490	685	-	-	-	-	-	-

RATING FACTORS FOR VARIATION IN AMBIENT AIR TEMPERATURE			
Air Temperature (^{O}C)	40	45	50
Rating Factor (XLPE)	1.00	0.94	0.88
Rating Factor (PVC)	1.00	0.90	0.81

TABLE 3

Permissible Maximum Short Circuit Current Ratings for XLPE Cables

Conductor Area	*Short Circuit Ratings for One Second Duration*	
	Copper Conductors	*Aluminium Conductors*
Sq.mm.	*A*	*B*
16	2570	1730
25	3970	2670
35	5500	3690
50	7800	5220
70	10850	7400
95	14600	9740
120	18400	12200
150	23000	15200
185	28200	18700
240	36400	24200
300	45300	30100
400	60200	39900
500	74800	49800
630	92700	62000
800	–	78800
1000	–	97800

Initial Conductor Temperature 90 Deg. C

Final Conductor Temperature 250 Deg. C

For durations other than one second the short circuit current may be calculated from the following formula:

$$I_{sc} = \frac{I}{\sqrt{t}}$$

Where I_{sc} – Short circuit current during time t, amperes.

I – Short circuit current during the time one second as given in above table.

t – Short circuit current duration, seconds.

Note : For large currents the force between the conductors must be considered especially when single core cable are used.

TABLE 4

Tripping Characteristics of MCBs

Based on the tripping characteristics, MCBs are available in 'B' and 'C' curve to suit different types of applications.

'B' Curve: For protection of electric circuits with equipment that does not cause surge current (lighting and socket outlet circuits)

Short circuit release is set to 3 - 5 I_n

'C' Curve: For protection of electric circuits with equipment that cause surge current (inductive and motor circuits)

Short circuit release is set to 5 - 10 I_n

'D' Curve: For protection of electric circuits which cause high in rush current when they are switched ON, typically 15 times the normal running current (Transformers, Heavy Start Motors, 2 Pole Motors)

Short circuit release is set to 10 - 20 I_n

TABLE 5

Duty Category of Switches

Utilization Category	*Typical Applications*
AC20/DC20	Connecting and disconnecting under no-load. Assumes all switching operations are carried out by other applicable devices before this device is operated.
AC21/DC21	Switching of resistive loads including moderate overloads. Suitable for purely resistive type loads. Device can switch 150% of its rated current under fault conditions.
AC22/DC22	Switching of mixed resistive/ inductive loads, including moderate overloads Suitable for mixed resistive/inductive loads. Device can switch 300% of its rated current under fault conditions.
AC23/DC23	Switching of highly inductive loads. Devices complying with AC23/DC23 are provided mainly as backup to other means of switching. Eg. Contacts. In the event of failure of functional devices, an AC23/DC23 type device can safely interrupt a stalled motor current. Where devices are the only means of controlling individual motors, they should comply with the requirements of Appendix A of the standard.

TABLE 6

Class of Insulation (For Electric Motors)

Type	*Max. Operating Temp.*	*Materials Used*
Y	90°C	Cotton, silk, paper, and similar organic material and combination of such material which are not (impregnated) nor immersed in oil.
A	105^0C	Above materials impregnated with Varnish or enamel or oil immersed.
E	120°C	Comprise inorganic materials such as mica, glass fibre asbestos or combination of these materials in built up form with binding cement.
B	130°C	
F	155°C	Class B materials when built up with suitable cement or binder.
H	180°C	Consists of materials or combination of materials such as mica, glass fibre Silicon lastomer with suitable winding, impregnating or coating substances as silicon resins.
C	Above 180°C	Materials such as mica Porcelain, glass quartz and asbestos with or without an inorganic binder.

TABLE 7

Fire Protection

Class of Fire

Class A	:	Fires involving Paper, Wood, Textile, Packing materials and the like.
Class B	:	Fires involving Oil, Petrol, Solvent, Grease, Paints, Celluloid and the like.
Class C	:	Fires involving Electrical Hazards, Motor Vehicle Gaseous substance under pressure.
Class D	:	Fires involving Chemicals, Metal and active like.
Class E	:	Fires involving Electrical equipment, Delicate machinery and the like.

Mode of Fire Protection

1.	Sand/ Water buckets	7.	Fire Dampers in AC Ducts
2.	Dry/ Wet Hydrant risers	8.	Fire Doors with fusible link
3.	Heat/ Smoke Detectors	9.	Pressurization Plant
4.	Automatic/ Manual Fire Alaram	10.	Public Address System
5.	Sprinklers	11.	Fire Escapes/ External Stairs
6.	Lightning Conductors		

Coverage (Floor) Area

1.	Water/ Sand Bucket	100 sq.mt.	4.	Sprinklers	6 sq.mt.
2.	Extinguishers (9 lts)	600 sq.mt.	5.	Heat Detectors	16 sq.mt.
3.	Hydrant Riser (Outlet 100 mm dia with landing valve and first aid hose reel)	100 sq.mt. 930 sq.mt.	6.	Smoke Detectors (For a ceiling height of 3 mts. and clean environment)	50 sq.mt.

Choice of Extinguishers

	Type of Extinguishers	***Suitable for Class of Fire***
1.	Soda Acid Type	Class - A
2.	Foam Type	Class - B
3.	Dry Chemical Powder Type	Class - B, C, D & E
4.	Carbon-di-oxide Type	Class - B, C & E
5.	Water Carbon-di-oxide Type	Class - A
6.	Carbo-Tetra-Chloride Type	Class - C

Water Requirement for the Fire Fighting

$Q = 3000\ P$

Q = Fire demand in Liters/Minutes

P = Population in Thousands

Note: The above rate must be maintained at a minimum pressure of 1 to 1.5 kg / cm^2 for at least four hours.

TABLE 8

Degrees of Protection

Degrees of Protection to DIN 40 050 and to IEC 144

The degree of protection is specified in accordance with DIN 40 050 and with Publications of the International Electro-technical Commission (IEC) by means of the letters IP (International Protection) and two characteristic numerals.		The first numeral indicates the degree of protection against contact with live parts and the ingress of foreign bodies; the second numeral indicates the degree of protection against water.	
First characteristic numeral Degree of protection against contact with live parts and the ingress of foreign bodies		***Second characteristic numeral*** Degree of protection against water	
First Chara-cteristic Numeral	*Degree of Protection*	*Second Chara-cteristic Numeral*	*Degree of Protection*
0	No protection of persons against contact with live or moving parts inside the enclosure. No protection of equipment against ingress of solid foreign bodies.	0	No protection
1	Protection against accidental or inadvertent contact with live or moving parts inside the enclosure body large surface of the human body as, for example, a hand, but no protection against deliberate access to such parts. Protection against ingress of large solid foreign bodies of diameters greater than 50 mm.	1	Protection against drops of condensate. Drops of condensate falling vertically on the enclosure shall have no harmful effect
2	Protection against contact with live or moving parts inside the enclosure by fingers. Protection against ingress of medium size solid foreign bodies of diameters greater than 12 mm.	2	Protection against drops of other liquids. Drops of falling liquid shall have no harmful effect when the enclosure is tilted at any angle up to 15° from the vertical.

First Chara-cteristic Numeral	*Degree of Protection*	*Second Chara-cteristic Numeral*	*Degree of Protection*
3	Protection against contact with live or moving parts inside the enclosure by tools, wires or such objects of thickness greater than 2.5 mm. Protection against ingress of small solid foreign bodies of diameters greater than 2.5 mm.	3	Protection against rain: Water falling as rain at an angle equal to or less than 60° with respect to the vertical shall have no harmful effect.
4	Protection against contact with live or moving parts inside the enclosure by tools, wires or such objects of thickness greater than 1 mm. Protection against ingress of small solid foreign bodies of diameters greater than 1 mm.	4	Protection against splashing liquid: Liquid splashed from any direction shall have no harmful effect
5	Complete protection against contact with live or moving parts inside the enclosure. Protection against harmful deposits of dust. The ingress of dust is not totally prevented, but dust cannot enter in an amount sufficient to interfere with the satisfactory operation of the equipment enclosed.	5	Protection against water-jets: Water projected by a nozzle from any direction under stated conditions shall have no harmful effect.
6	Complete protection against contact with live or moving parts inside the enclosure. Protection against ingress of dust.	6	Protection against conditions on ships decks (deck water tight equipment}: Water due to heavy seas shall not enter the enclosures under prescribed conditions[1].
		7	Protection against immersion in water: It must not be possible for water to enter the enclosure under stated conditions of pressure and time[1].
		8	Protection against indefinite immersion in water under specified pressure: It must not be possible for water to enter the enclosure[1].

1. For certain types of equipment there must be no ingress of water. Where required this is stated in a supplementary page for the equipment concerned.

TABLE 9

Selection of Lamps

Lamp type	*Range*	*Luminous flux*	*Efficacy (lm/W)*	*Average Life (hr)*	*Color Rendering (Ra)*
CFL	18W-36W	1200-2900	60-80	15000	75-85
Fluorescent					
T5	28W-54W	2900-4850	90-104	24000	80-90
T8	18W-36W	750-3250	50-90	20000	80-85
T12	20W-40W	950-2450	48-61	12000	50-75
Halogen	50W	1200	24	2000	75-90
Metal halide	70W-250W	5300-25000	76-100	12000	70-90
High pressure sodium vapor	70W-1000W	5600-130000	80-130	20000	20-65
Low pressure sodium vapor	55W-135W	8100-32000	100-230	20000	20-65
Induction lamp	70W-150W	6500-12000	80-95	100000	65-90
LED	3W-120W	750-14000	80-100	80000	65-90

TABLE 10

Capacitor Selection Chart

Present Power Factor	*Required Power Factor*				
	0.85	*0.90*	*0.95*	*0.98*	*Unity*
0.50	1.112	1.248	1.403	1.529	1.732
0.55	0.899	1.035	1.190	1.316	1.519
0.60	0.714	0.849	1.005	1.131	1.334
0.65	0.549	0.685	0.840	0.966	1.169
0.70	0.400	0.536	0.691	0.811	1.020
0.75	0.262	0.398	0.553	0.673	0.882
0.80	0.130	0.266	0.421	0.541	0.750
0.85	-	0.136	0.291	0.417	0.620
0.90	-	-	0.155	0.281	0.484
0.95	-	-	-	0.126	0.329

Required KVAR = KW x Multiplying factor.

TABLE 11

Recommended Values of Illumination as per BIS: 3646 (Part-II)

Recommended Illuminance Levels

Types of Interior or Activity	*Range of Service Illuminance in Lux*	*Quality Class of Direct Glare Limitation*	*Remarks*
1. AGRICULTURE AND HORTICULTURE			
1.1 Inspection of farm products where Colour is important	300-500-750	1	Local lighting may be appropriate
Other important tasks	200-300-500	2	Local lighting may be appropriate
1.2 Farm workshops			
1.2.1 General	50-100-150	3	
1.2.2 Workbench or machine	200-300-500	2	Local or portable lighting may be appropriate
1.3 Milk premises	50-100-150	3	
1.4 Sick Animal Pets, Calf Nurseries	30-50-100	3	
1.5 Other Firm and Horticulture Building	20-30-50	3	
2. COAL MINING (SURFACE BUILDING)			
2.1 Coal preparation plant			
2.1.1 Walkways, Floors, under converters	30-50-100	3	
2.1.2 Wagon loading, bunkers	30-50-100	3	
2.1.3 Elevators, Chute transfer pits, washbox area	50-100-150	3	
2.1.4 Drum filters, screen, rotating shafts	100-150-200	3	
2.1.5 Picking belts	150-200-300	3	Directional & colour properties of lighting may be important for easy recognition of coal & rock
2.2 Lamp Rooms			
2.2.1 Repair section	200-300-500	2	
2.2.2 Other areas	100-150-200	3	
2.3 Weight cabins, fan houses	100-150-200	3	
2.4 Winding houses	100-150-200	3	
3. ELECTRICITY GENERATION TRANSMISSION AND DISTRIBUTION			
3.1 General plant			
3.1.1 Turbine houses (operating floor)	150-200-300	2	
3.1.2 Boiler and turbine house basements	50-100-150	3	
3.1.3 Boiler house, platforms, areas around Burners	50-100-150	3	

Types of Interior or Activity	*Range of Service Illuminance in Lux*	*Quality Class of Direct Glare Limitation*	*Remarks*
3.1.4 Switch rooms, meter/rooms, oil plant rooms, HV substations (indoor)	100-150-200	2	
3.1.5 Control room	200-300-500	1	Localized lighting of control display & the control desks may be appropriate
3.1.6 Relay and telecommunication rooms	200-300-500	2	
3.1.7 Diesel generator & compressor rooms	100-150-200	3	
3.1.8 Pump houses, water treatment plant Houses	100-150-200	3	
3.1.9 Battery rooms, charges, rectifiers	50-100-150	3	
3.1.10 Precipitator chambers, platforms, etc.	50-100-150	3	
3.1.11 Cable tunnels & basements, Circulating Water culverts & screen chamber	30-50-100	3	
3.2 Coal Plant			
3.2.1 Conveyors, gantries, junction towers, Unloading hoppers, ash handling plants, Setting pits, dust hoppers	50-100-150	3	
3.2.2 Other areas where operators may be Attendance	100-150-200	3	
3.3 Nuclear Plants			
Gas circulation bays, reactor area, boiler platform, reactor charges and discharge face	100-150-200	2	
4. METAL MANUFACTURE			
4.1 Iron Making			
4.1.1 Sinter Plant			
Plant Floor	150-200-300	3	
Mixer drum, fan house, screen houses, coolers, transfer stations	100-150-200	3	
4.1.2 Furnaces, cupola			
General	100-150-200	3	
Control Platforms	200-300-500	2	Local lighting may be appropriate
Conveyor galleries, walkways	30-50-100	3	
4.2 Steel Making			
4.2.1 Electric Melting Shops	150-200-300	3	
4.2.2 Basic Oxygen Steel Making Plants			
4.2.2.1 General	100-150-200	3	
4.2.2.2 Converter Floor, teeming bay	150-200-300	3	
4.2.2.3 Control Platforms	200-300-500	2	Local lighting may be appropriate
4.2.2.4 Scrap bays	100-150-200	3	

Types of Interior or Activity	*Range of Service Illuminance in Lux*	*Quality Class of Direct Glare Limitation*	*Remarks*
4.3 Metal forming and treatment			
4.3.1 Ingot stripping, soaking pits, annealing and heat treatment bays, acid recovery plant. Pickling and cleaning bays, roughing mills, cold mills, finishing mills, tinning and galvanizing lines, cut up and rewind line	150-200-300	3	
4.3.2 General	100-150-200	3	
4.3.3 Control Platforms	200-300-500	2	Local lighting may be appropriate
4.3.4 Wire mills, product finishing, steel inspection and treatment	200-300-500	3	
4.3.5 Plate/strip inspection	300-500-500	2	
4.3.6 Inspection of tin plate, stainless steel, etc.		–	Special lighting to reveal faults in the specular surface of the material will be required
4.4 Foundries			
4.4.1 Automatic plant			
4.4.1.1 Without manual operation	30-50-100	3	
4.4.1.2 With occasional manual operation	100-150-200	3	
4.4.1.3 With continuous manual operation	150-200-300	3	
4.4.1.4 Control room	200-300-500	1	Localized lighting of control display & the control desks may be appropriate
4.4.1.5 Control Platforms	200-300-500	2	
4.4.2 Non-automatic Plants			
4.4.2.1 Charging floor, Pouring, Shaking Out, Cleaning, Grinding Felting	200-300-500	3	
4.4.2.2 Rough moulding, rough core making	200-300-500	3	
4.4.2.3 Fine moulding, fine core making	300-500-750	2	
4.4.2.4 Inspection	300-500-750	2	
4.5 Forges (severe vibration is likely to occur)			
4.5.1 General	200-300-500	2	
4.5.2 Inspection	300-500-750	2	
5. CERAMICS			
5.1 Concrete Products			
Mixing, Casting, Cleaning	150-200-300	3	

Types of Interior or Activity	*Range of Service Illuminance in Lux*	*Quality Class of Direct Glare Limitation*	*Remarks*
5.2 Potteries			
5.2.1 Grinding, moulding, pressing, cleaning, Trimming, glazing, firing	200-300-500	3	
5.2.2 Enameling, colouring	500-750-1000	1	
5.3 Glass works			
5.3.1 Furnace rooms, bending, annealing	100-150-200	3	
5.3.2 Mixing rooms, forming, cutting, grinding, Polishing, toughening	200-300-500	3	
5.3.3 Beveling, decorative cutting, etching, silvering	300-500-750	2	
5.3.4 Inspection	300-500-750	2	
6. CHEMICALS			
6.1 Petroleum, chemical and petrochemical works			
6.1.1 Exterior walkways, Platforms, stairs & ladders	30-50-100	3	
6.1.2 Exterior pump and valve areas	50-100-150	3	
6.1.3 Pump and compressor houses	100-150-200	3	
6.1.4 Process plant with remote control	30-50-100	3	
6.1.5 Process plant requiring occasional Manual interventions	50-100-150	3	
6.1.6 Permanently occupied work stations in Process plant	150-200-300	3	
6.1.7 Control rooms for process plant	200-300-500	1	
6.2 Pharmaceutical manufacturer and fine chemicals manufacturer			
6.2.1 Pharmaceutical Manufacturer			
Grinding, granulating, mixing, drying, tableting, sterilizing, washing, preparation of solutions, filling capping, wrapping, hardening	300-500-750	2	
6.2.2 Fine chemical manufacture			
6.2.2.1 Exterior walkways, platform, stairs and ladders	30-50-100	3	
6.2.2.2 Process plant	50-100-150	3	
6.2.2.3 Fine chemical finishing	300-500-750	2	
6.2.2.4 Inspection	300-500-750	1	Local Lighting may be appropriate
6.3 Soap Manufacture			
6.3.1 General Area	200-300-500	2	
6.3.2 Automatic Processes	100-200-300	2	
6.3.3 Control panels	200-300-500	1	Local Lighting may be appropriate
6.3.4 Machines	200-300-500	2	
6.4 Paint Works			
6.4.1 General	200-300-500	2	

Types of Interior or Activity	*Range of Service Illuminance in Lux*	*Quality Class of Direct Glare Limitation*	*Remarks*
6.4.2 Automatic Processes	150-200-300	2	
6.4.3 Control Panels	200-300-500	2	
6.4.4 Special Batch mixing	500-750-1000	2	
6.4.5 Colour Matching	750-1000-1500	1	
7. MECHNICAL ENGINEERING			
7.1 Structural Steel Fabrication			
7.1.1 General	200-300-500	3	
7.1.2 Marking off	300-500-750	3	Local Lighting may be appropriate
7.2 Sheet Metal Works			
7.2.1 Pressing, punching, shearing, stamping, spinning, folding	300-500-750	2	
7.2.2 Bench work, scribing, inspection	500-750-1000	2	
7.3 Machine and tool shops			
7.3.1 Rough bench and machine work	200-300-500	3	
7.3.2 Medium bench and machine work	300-500-750	2	
7.3.3 Fine bench and machine work	500-750-1000	2	
7.3.4 Gauge rooms	750-1000-1500	1	Optical aids may be required
7.4 Die Sinking Shops			
7.4.1 General	300-500-750	2	
7.4.2 Fine Works	1000-1500-2000	1	Flexible local lighting is desirable
7.5 Welding and soldering shops			
7.5.1 Gas and arc welding, rough spot welding	200-300-500	3	
7.5.2 Medium soldering, brazing, spot welding	300-500-750	3	
7.5.3 Fine soldering, fine spot welding	750-1000-1500	2	Local Lighting may be appropriate
7.6 Assembly Shops			
7.6.1 Rough work, for example, frame and heavy machine assembly	200-300-500	3	The lighting of vertical surface may be important
7.6.2 Medium work, for example, office machinery assembly	300-500-750	2	
7.6.3 Fine work, for example, office machinery assembly	500-750-1000	1	Local Lighting may be appropriate
7.6.4 Very fine work, for example, instrument assembly	750-1000-1500	1	Local or localized lighting may be appropriate
7.6.5 Minute work for example, watch making	1000-1500-2000	1	Local lighting and optical aids are desirable
7.7 Inspection and Testing Shops			
7.7.1 Coarse Work, for example, using go/ on go gauge, inspection of large sub-assembly	300-500-750	2	Local or localized lighting may be appropriate

Types of Interior or Activity	*Range of Service Illuminance in Lux*	*Quality Class of Direct Glare Limitation*	*Remarks*
7.7.2 Medium work for example, inspection of painted surfaces	500-750-1000	1	Local or localized lighting may be appropriate
7.7.3 Fine work, for example, using calibrated scales, inspection of precision mechanism	750-1000-1500	1	Local or localized lighting may be appropriate
7.7.4 Very fine work, for example, inspection of small intricate parts	1000-1500-2000	1	Local lighting and optical aids are desirable
7.7.5 Minute work, for example, inspection of very small instruments	2000	1	Local lighting and optical aids are desirable
7.8 Points shops and Spray Booths			
7.8.1 Dipping, rough spraying	200-300-500	3	
7.8.2 Preparation, ordinary painting, spraying & finishing	200-500-750	2	
7.8.3 Fine painting, Spraying and finishing	500-750-1000	2	
7.8.4 Inspection, retouching and matching	750-1000-1500	2	
7.9 Plating shops			
7.9.1 Vats and baths	200-300-500	3	
7.9.2 Buffing, polishing, burnishing	300-500-750	2	
7.9.3 Final buffing and polishing	500-750-1000	2	
7.9.4 Inspection	—	—	Special light to reveal fault in the surface of the material be required
8. ELECTRICAL AND ELECTRONIC ENGG.			
8.1 Electrical Equipment manufacture			
8.1.1 Manufacture of cables & insulated wires, winding, varnishing & immersion of coils, assembly of large machines, simple assembly work	200-300-500	3	
8.1.2 Medium assembly, for example Telephones, small motors	300-500-750	3	Local lighting may be appropriate
8.1.3 Assembly of precision components, for eg. telecommunication equipment, adjustment, inspection and calibration	750-1000-1500	1	Local light may be appropriate. Optical aids may be used
8.1.4 Assembly of high precision parts	1000-1500-2000	1	Local lighting may be appropriate. Optical aids may be used
8.2 Electronic Equipment Manufacture			
8.2.1 Printed Circuit Board			
8.2.1.1 Silk Screening	300-500-750	1	Local lighting may be appropriate
8.2.1.2 Hand insertion of components, soldering	500-750-1000	1	Local lighting may be appropriate

Types of Interior or Activity	*Range of Service Illuminance in Lux*	*Quality Class of Direct Glare Limitation*	*Remarks*
8.2.1.3 Inspection	750-1000-1500	1	A large, low luminance luminaire overhead ensures specular reflection conditions which are helpful for inspection of printed circuit
8.2.1.4 Assembly of wiring harness, clearing harness, testing and calibration	500-750-1000	1	Local lighting may be appropriate
8.2.1.5 Chassis assembly	750-1000-1500	1	Local lighting may be appropriate
8.2.2 Inspection and testing			
8.2.2.1 Soak test	150-200-300	2	
8.2.2.2 Safety and functional tests	200-300-500	2	
9. FOOD, DRINKS AND TOBACCO			
9.1 Slaughter houses			
9.1.1 General	200-300-500	3	
9.1.2 Inspection	300-500-750	2	
9.2 Canning, Preserving and Freezing			
9.2.1 Grading and sorting of raw materials	500-750-1000	2	Lamps of colour rendering ground 1A or 1B will be req. if colour judgments is required
9.2.2 Preparation	300-500-750	3	
9.2.3 Canned and bottled goods			
9.2.3.1 Retorts	200-300-500	3	
9.2.3.2 Automatic processes	150-200-300	3	
9.2.3.3 Labeling and packaging	200-300-500	3	
9.2.4 Frozen labeling			
9.2.4.1 Process area	200-300-500	3	
9.2.4.2 Packaging and storage	200-300-500	3	
9.3 Bottling, Brewing & Distilling			
9.3.1 Keg washing and handling, bottle washing	150-200-300	3	
9.3.2 Keg inspection	200-300-500	3	
9.3.3 Bottle inspection	—	—	Special lighting will be reuqired
9.3.4 Process area	200-300-500	3	
9.3.5 Bottle filling	500-750-1000	3	
9.4 Edible oils and Fats Processing			
9.4.1 Refining and Blending	200-300-500	3	
9.4.2 Production	300-500-750	2	
9.5 Mills-milling, Filtering and Packing	200-300-500	3	

Types of Interior or Activity	*Range of Service Illuminance in Lux*	*Quality Class of Direct Glare Limitation*	*Remarks*
9.6 Bakeries			
9.6.1 General	200-300-500	2	
9.6.2 Hand decorating, icing	300-500-750	2	
9.7 Chocolate and Confectionery Manufacturer			
9.7.1 General	200-300-500	3	
9.7.2 Automatic processes	150-200-300	3	
9.7.3 Hand decoration, inspection, wrapping and packing	300-500-750	2	If accurate colour judgements are req. lamps of colour rendering group of 1A or 1B are used
9.8 Tobacco Processing			
9.8.1 Material preparation, making and packing	300-500-750	2	
9.8.1 Hand processes	500-750-1000	2	
10. TEXTILES			
10.1 Fibre preparation			
10.1.1 Bale breaking, washing	200-300-500	3	
10.1.2 Stock dyeing, tinting	200-300-500	3	
10.2 Yarn manufacture			
10.2.1 Spinning, roving, winding, etc.	300-500-750	2	
10.2.2 Heading (drawing in)	750-1000-750	2	
10.3 Fabric Production			
10.3.1 Knitting	300-500-750	2	
10.3.2 Weaving			
10.3.2.1 Jute and hemp	200-300-750	2	
10.3.2.2 Heavy woolens	300-500-750	1	
10.3.2.3 Medium worsteds, fine woolens, cottons	500-500-750	1	
10.3.2.4 Fine worsteds, fine linens, synthetics	750-1000-750	1	
10.3.2.5 Mending	1000-1500-2000	1	
10.3.2.6 Inspection	1000-1500-2000	1	
10.4 Fabric Finishing			
10.4.1 Dyeing	200-300-500	3	
10.4.2 Calendering, Chemical treatment, etc.	300-500-750	2	
10.4.3 Inspection			
10.4.3.1 Grey cloth	750-1000-1500	1	
10.4.3.2 Final	1000-1500-2000	1	
10.5 Carpet Manufacturer			
10.5.1 Winding, beaming	200-300-500	3	
10.5.2 Setting pattern, tufting cropping, Trimming, Fringing, latexing and latex drying	300-500-750	2	
10.5.3 Designing, weaving, mending	500-750-1000	2	

Types of Interior or Activity	*Range of Service Illuminance in Lux*	*Quality Class of Direct Glare Limitation*	*Remarks*
10.5.4 Inspection			
10.5.4.1 General	750-1000-1500	1	Local lighting may be appropriate
10.5.4.2 Piece dyeing		1	Local lighting may be appropriate
11. LEATHER INDUSTRY			
11.1 Leather Manufacture			
11.1.1 Cleaning, tanning and stretching, vats, cutting, fleshing, stuffing	200-300-500	3	
11.1.2 Finishing, scarfing	300-500-750	2	
11.2 Leather Working			
11.2.1 General	200-300-500	3	
11.2.2 Pressing, glazing	300-500-750	2	
11.2.3 Cutting, splitting, scarfing, sewing	500-750-1000	2	Directional lighting may be useful
11.2.4 Grading, matching		2	Local lighting may be appropriate
12. CLOTHING AND FOOTWEAR			
12.1 Clothing Manufacture			
12.1.1 Preparation of cloth	200-300-500	2	
12.1.2 Cutting	500-750-1000	1	
12.1.3 Matching	500-750-1000	1	
12.1.4 Sewing	750-1000-1500	1	
12.1.5 Pressing	300-500-750	2	
12.1.6 Inspection	1000-1500-2000	1	Local lighting may be appropriate
12.1.7 Hand tailoring	1000-1500-2000	1	Local lighting may be appropriate
12.2 Hosiery and Knitwear Manufacture			
12.2.1 Flat bed knitting machines	300-500-750	2	
12.2.2 Circular knitting machines	500-750-1000	2	
12.2.3 Lock stitch and over locking machine	750-1000-1500	1	
12.2.4 Linking or running on	750-1000-1500	1	
12.2.5 Mending, hand finishing	1000-1500-3000	–	Local lighting may be appropriate
12.2.6 Inspection	1000-1500-2000	2	Local lighting may be appropriate
12.3 Glove Manufacture			
12.3.1 Sorting & grading	500-750-1000	1	
12.3.2 Pressing, knitting, cutting	300-500-750	2	
12.3.3 Sewing	500-750-1000	2	
12.3.4 Inspection	1000-1500-2000	–	Local lighting may be appropriate
12.4 Hat Manufacture			
12.4.1 Stiffening, braiding, refining, forming, sizing, pounding, ironing	200-300-500	2	

Types of Interior or Activity	*Range of Service Illuminance in Lux*	*Quality Class of Direct Glare Limitation*	*Remarks*
12.4.2 Cleaning, flanging, finishing	300-500-750	2	
12.4.3 Sewing	500-750-1000	2	
12.4.4 Inspection	1000-1500-2000	–	Local lighting may be appropriate
12.5 Boot and Shoe Manufacture			
12.5.1 Leather and Synthetics			
12.5.2 Sorting and Grading	750-1000-1500	1	
12.5.3 Clicking closing	750-1000-1500	2	Local or localized lighting may be appropriate
12.5.4 Preparatory Operations	750-1000-2000	2	Local or localized lighting may be appropriate
12.5.5 Cutting tables and pressure	1000-1500-2000	1	Local or localized lighting may be appropriate
12.5.6 Bottom stock preparation, lasting, Bottoming finishing, show rooms	750-1000-1500	1	Local or localized lighting may be appropriate
12.5.7 Rubber			
12.5.7.1 Washing, compounding, coating, drying, varnishing, vulcanizing	200-300-500	3	
12.5.7.2 Lining, making and finishing	300-500-750	2	
13. TIMBER AND FURNITURE			
13.1 Sawmills			
13.1.1 General	150-200-300	3	
13.1.2 Head saw	300-500-750	2	Local lighting may be appropriate
13.1.3 Grading	500-750-1000	2	
13.2 Woodwork Shops			
13.2.1 Rough sawing, bench work	200-300-500	3	
13.2.2 Sizing, planning, sanding, medium machining and bench work	300-500-750	2	
13.2.3 Fine bench & machine work, fine sanding, finishing	500-750-1000	2	Localized lighting may be appropriate
13.3 Furniture manufacture			
13.3.1 Raw material stores	50-100-150	3	
13.3.2 Finished goods stores	100-150-200	3	
13.3.3 Wood matching and assembly, rough sawing, cutting	200-300-500	2	Localized lighting may be appropriate
13.3.4 Machining, sanding and assembly, polishing	300-500-750	2	
13.3.5 Tool rooms	300-500-750	2	

Types of Interior or Activity	*Range of Service Illuminance in Lux*	*Quality Class of Direct Glare Limitation*	*Remarks*
13.3.6 Spray booths			
13.3.6.1 Colour finishing	300-500-750	2	
13.3.6.2 Clear finishing	200-300-500	2	
13.3.7 Cabinet making			
13.3.7.1 Vaneer sorting and grading	750-1000-1500	1	
13.3.7.2 Marquetry, pressing, patching and fitting	300-500-750	2	
13.3.7.3 Final inspection	500-750-1000	1	Special lighting will be required
13.4 Upholstery Manufacture			
13.4.1 Cloth inspection	1000-1500-2000	1	Special lighting will be required
13.4.2 Filling, covering	300-500-750	2	
13.4.3 Slipping, cutting, sewing	500-750-1000	2	
13.4.4 Mattress making			
13.4.5 Assembly	300-500-750	2	
13.4.6 Tape edging	750-1000-1500	2	Local lighting may be appropriate
14. PAPER AND PRINTING			
14.1 Paper Mills			
14.1.1 Pulp mills, preparation plants	200-300-500	3	
14.1.2 Paper and board making			
14.1.2.1 General	200-300-500	3	
14.1.2.2 Automatic process	150-200-300	3	Supplementary lighting may be necessary for maintenance work
14.1.2.3 Inspection, sorting	300-500-750	1	
14.1.3 Paper converting process			
14.1.3.1 General	200-300-500	3	
14.1.3.2 Associated printed	300-500-750	2	
14.2 Printed works			
14.2.1 Type foundries			
14.2.1.1 Matrix making, dressing type, hand and machine coating	200-300-500	3	
14.2.1.2 Front assembly, sorting	500-750-1000	2	
14.2.2 Composing room			
14.2.2.1 Hand composing, impostition and distribution	500-750-1000	1	
14.2.2.2 Hot metal keyboard	500-750-1000	2	
14.2.2.3 Hot metal casting	200-300-500		
14.2.2.4 Photo composing keyboard or setters	300-500-750	1	
14.2.2.5 Paste up	500-750-1000	1	
14.2.2.6 Illuminated tables-general lighting	200-300-500	–	Dimming may be required
14.2.2.7 Proof precess	300-500-750	2	
14.2.2.8 Proof reading	500-750-1000	1	
14.2.3 Graphic reproduction			
14.2.3.1 General	300-500-750	2	

Types of Interior or Activity	*Range of Service Illuminance in Lux*	*Quality Class of Direct Glare Limitation*	*Remarks*
14.2.3.2 Precision proofing, retouching, etching	750-1000-1500	1	Local lighting may be appropriate
14.2.3.3 Colour reproduction and inspection	750-1000-1500	1	
14.2.4 Printing Machine Room			
14.2.4.1 Presses	300-500-750	2	
14.2.4.2 Pre-make ready	300-500-750	2	
14.2.4.3 Printed sheet inspection	750-1000-1500	1	
14.2.5 Binding			
14.2.5.1 Folding, pasting, punching and stitching	300-500-750	2	
14.2.5.2 Cutting, assembling, embossing	500-750-1000	2	
15. PLASTIC AND RUBBER			
15.1 Plastic Product			
15.1.1 Automatic plant			
15.1.1.1 Without manual control	30-50-100	3	
15.1.1.2 With occasional manual control	50-100-150	3	
15.1.1.3 With continuous manual control	200-300-500	3	
15.1.1.4 Control rooms	200-300-500	1	
15.1.1.5 Control platforms	200-300-500	2	Local lighting may be appropriate
15.1.2 Non-automatic plant			
15.1.2.1 Mixing, calendering, extrusion, injection, compression and blow moulding, sheet fabrication	200-300-500	3	
15.1.2.2 Trimming, cutting, polishing	300-500-750	2	
15.1.2.3 Printing, inspection	750-1000-1500	1	
15.2 Rubber products			
15.2.1 Stock preparation - plastisizing, milling	150-200-300	3	
15.2.2 Calendering, fabric preparation, stock-cutting	300-500-750	3	
15.2.3 Extruding, moulding	300-500-750	2	
15.2.4 Inspection	750-1000-1500	–	
16. DISTRIBUTION AND STORAGE			
16.1 Work stores	100-150-200	3	Avoid glare to drivers of vehicles approaching the loading bay
16.1.1 Unpacking, sorting	150-200-300	3	Avoid glare to drivers of vehicles approaching the loading bay
16.1.2 Large item storage	50-100-150	3	Avoid glare to drivers of vehicles approaching the loading bay

Types of Interior or Activity	*Range of Service Illuminance in Lux*	*Quality Class of Direct Glare Limitation*	*Remarks*
16.1.3 Small item rack storage	200-300-500	3	Avoid glare to drivers of vehicles approaching the loading bay
16.1.4 Issue counter, records, storemans desk	300-500-750	2	Local or localized lighting may be appropriate
16.2 Warehouses and bulk stores			
16.2.1 Storage of goods where identification requires only limited preparation of details	50-100-150	3	
16.2.2 Storage of goods where identification requires perception of detail	100-150-200	3	
16.2.3 Automatic high bay rack stores			
16.2.3.1 Gangway	20	–	
16.2.3.2 Control station	150-200-300	3	
16.2.3.3 Packing and dispatch	200-300-500	3	
16.2.3.4 Loading bays	100-150-200	3	Avoid glare to drivers of vehicles approaching the loading bay
16.3 Cold stores			
16.3.1 General	200-300-500	3	
16.3.2 Breakdown, make-up and dispatch	200-300-500	3	
16.3.3 Loading bays	100-150-200	3	Avoid glare to drivers of vehicles approaching the loading bay
17. COMMERCE			
17.1 Offices			
17.1.1 General offices	300-500-750	1	
17.1.2 Deep plan General offices	500-750-1000	1	
17.1.3 Computer work station	300-500-750	1	
17.1.4 Conference Rooms, Executive offices	300-500-750	1	
17.1.5 Computer and data preparation Rooms	300-500-750	1	
17.1.6 Filling rooms	200-300-500	1	
17.2 Drawing Offices			
17.2.1 General	300-500-750	1	
17.2.2 Drawing Board	500-750-1000	1	
17.2.3 Computer aided design and drafting	–	–	Special lighting is required
17.2.4 Print rooms	200-300-500	1	
17.3 Banks and building societies			
17.3.1 Counter, office area	300-500-750	1	
17.3.2 Public area	200-300-500	1	
18. SERVICES			
18.1 Garages			
18.1.1 Interior parking areas	20-30-50		
18.1.2 General repairs, servicing, washing, polishing	200-300-500	3	

Types of Interior or Activity	*Range of Service Illuminance in Lux*	*Quality Class of Direct Glare Limitation*	*Remarks*
18.1.3 Workbench	300-500-750	2	Local or localized lighting may be appropriate
18.1.4 Spray Booths	300-500-750	1	
18.1.5 External apron		1	
18.1.5.1 General	30-50-100	–	Care should be taken to avoid glare to drivers & neighbouring residents
18.1.5.2 Pump area (retail detials)	200-300-500	–	See retailing
18.2 Appliance servicing			
18.2.1 Workshop			
18.2.1.1 General	200-300-500	2	
18.2.1.2 Workbench	300-500-700	2	Localized lighting may be appropriate
18.2.1.3 Counter	200-300-500	2	Localized lighting may be appropriate
18.2.1.4 Stores	200-300-500	3	
18.3 Laundries			
18.3.1 Commercial laundries			
18.3.2 Receiving, sorting, washing, drying, ironing, dispatch, dry-cleaning, bulk machine work	200-300-500	3	
18.3.3 Head ironing, pressing, mending, spotting, inspection	300-500-750	3	
18.3.4 Launderettes	200-300-500	3	
18.4 Sewage Treatment Works			
18.4.1 Walkways	30-50-100	3	
18.4.2 Process areas	50-100-150	3	
19. RETAILING			
19.1 Small Shops with Counters	300-500-750	1	The service illuminance should be provided on the horizontal plane of the counter. Where wall displays are used, a similar illuminance on the walls is desirable
19.2 Small Self Service shops with island displays	300-500-750	1	
19.3 Super Markets, Hyper-Markets			
19.3.1 General	300-500-750	2	
19.3.2 Checkout	300-500-750	2	
19.3.3 Showroom for large objects, for e.g. cars, furniture	300-500-750	1	
19.3.4 Shopping precincts and arcades	100-150-200	2	
20. PLACES OF PUBLIC ASSEMBLY			
20.1 Public rooms, Village halls, Worship halls	200-300-500	1	
20.2 Concert Halls, Cinemas and theatres			
20.2.1 Foyer	150-200-300	–	
20.2.2 Booking Office	200-300-500	–	Local or localized lighting may be appropriate

Types of Interior or Activity	*Range of Service Illuminance in Lux*	*Quality Class of Direct Glare Limitation*	*Remarks*
20.2.3 Auditorium	50-100-150	–	Dimming facilities will be necessary. Special lightning of the aisles is desirable
20.2.4 Dressing Rooms	200-300-500	–	Special mirror lighting for make up may be required
20.2.5 Projection Rooms	100-150-200	–	
20.3 Churches			
20.3.1 Body of church	100-150-200	2	
20.3.2 Pulpit, Lectern	200-300-500	2	Use local lighting
20.3.3 Choir Stalls	200-300-500	2	Local lighting may appropriate
20.3.4 Alter, communion table, cancel	100-150-200	2	Additional lighting to provide emphasis is desirable
20.3.5 Vestries	100-150-200	2	
20.3.6 Organ	200-300-500	–	
20.4 Hospitals			
20.4.1 Anaesthetic Rooms			
20.4.1.1 General	200-300-500	–	
20.4.1.2 Local	750-1000-1500	–	
20.4.2 Consulting Area			
20.4.2.1 General	200-300-500	–	
20.4.2.2 Examiantion	750-1000-1500	–	
20.4.3 Corridors			
20.4.3.1 General	100-150-200	–	
20.4.4 Ward corridors			
20.4.4.1 Day, screened from bays	150-200-300	–	
20.4.4.2 Day, open to natural light	150-200-300	–	
20.4.4.3 Morning/evening	100-150-200	–	
20.4.4.4 Night	5-10	–	
20.4.5 Cubicles			
20.4.5.1 General	200-300-500	–	
20.4.5.2 Treatment	750-1000-1500	–	
20.4.6 Examination			
20.4.6.1 General	200-300-500	–	
20.4.6.2 Local inspection	750-1000-1500	–	
20.4.7 Intensive therapy			
20.4.7.1 Bed head	30-50	–	
20.4.7.2 Circulation between bed ends	50-100-150	–	
20.4.7.3 Observation	200-300-500	–	
20.4.7.4 Local observation	750-1000-1500	–	
20.4.7.5 Staff base (day)	200-300-500	–	
20.4.7.6 Staff base (night)	30	–	
20.4.8 Laboratories			
20.4.8.1 General	200-300-500	–	
20.4.8.2 Examination	300-500-750	–	
20.4.9 Nurses stations			
20.4.9.1 Morning/day/evening	200-300-500	–	

Types of Interior or Activity			*Range of Service Illuminance in Lux*	*Quality Class of Direct Glare Limitation*	*Remarks*
		20.4.9.2 Night desks	30	–	
		20.4.9.3 Night, medical trolleys	50-100-150	–	
	20.4.10	Operating theatres			
		20.4.10.1 General	300-500-750	–	
		20.4.10.2 Local	10000 to 50000	–	Special operating lights are used
	20.4.11	Pathology Department			
		20.4.11.1 General	200-300-500	–	
		20.4.11.2 Examination	300-500-750	–	
		20.4.11.3 Pharmacies	200-300-500	–	
		20.4.11.4 Reception/inquiry	200-300-500	–	
		20.4.11.5 Recovery rooms	200-300-500	–	
	20.4.12	Ward circulation			
		20.4.12.1 Day	50-100-150	–	
		20.4.12.2 Morning/evening	50-100-150	–	
		20.4.12.3 Night	3-5	–	
	20.4.13	Ward bed head			
		20.4.13.1 Morning/Evening	30-50	–	
		20.4.13.2 Reading	100-150-200	–	
	20.4.14	Night			
		20.4.14.1 Adult	0.1-1	–	
		20.4.14.2 Pediatric	1-5	–	
		20.4.14.3 Psychiatric	5	–	
		20.4.14.4 Watch			
	20.4.15	X-ray Areas			
		20.4.15.1 General	150-200-300	–	
		20.4.15.2 Diagnostic	150-200-300	–	
		20.4.15.3 Operative	200-300-500	–	
		20.4.15.4 Process dark room	50	–	
	20.4.16	Surgeries			
		20.4.16.1 General	200-300-500	–	
		20.4.16.2 Waiting rooms	100-150-200	–	
	20.4.17	Dental Surgeries			
		20.4.17.1 Chair	Special lighting	–	
		20.4.17.2 Laboratories	300-500-750	–	
	20.4.18	Consulting rooms			
		20.4.18.1 General	200-300-500	–	
		20.4.18.2 Desk	300-500-750	–	
		20.4.18.3 Examination	300-500-750	–	
		20.4.18.4 Ophthalmic wall & near-vision charts	300-500-750	–	
20.5	Hotels				
	20.5.1	Entrance Halls	50-100-150		
	20.5.2	Reception, cashiers and porters Desks	200-300-500		Localized lighting may be appropriate
	20.5.3	Bars, coffee base, dinning rooms, grill, rooms, restaurants, lounges	50-200		The lighting should be designed to create appropriate atmos-phere
	20.5.4	Cloak room	50-100-150	3	

Types of Interior or Activity			*Range of Service Illuminance in Lux*	*Quality Class of Direct Glare Limitation*	*Remarks*
20.5.5	Bed room		30-50-100	–	Supplementary local lighting at the bed head, writing table should be provided
20.5.6	Bathroom		50-100-150		Supplementary local lighting near the mirror is desirable
20.5.7	Food preparation and stores, cellars, lifts and corridors			–	See General building areas
20.6	Libraries				
20.6.1	Lending libraries				
	20.6.1.1	General	200-300-500	1	
	20.6.1.2	Counters	300-500-750	1	Localized lighting may be appropriate
	20.6.1.3	Bookshelves	100-150-200	2	The service illuminance should be provided on the vertical surface at the bottom of the book shelves
	20.6.1.4	Reading rooms	200-300-500	1	
	20.6.1.5	Reading tables	200-300-500	1	Localized lighting may be appropriate
20.6.2	Catalogues				
	20.6.2.1	Card	100-150-200	2	
	20.6.2.2	Microfiche/visual display units	100-150-200	2	
20.6.3	Reference libraries				
	20.6.3.1	General	200-300-500	1	
	20.6.3.2	Counters	300-500-750	1	Localized lighting may be appropriate
	20.6.3.3	Bookshelves	100-150-200	2	The service illuminance should be provided on the vertical surface at the foot of the book shelves
	20.6.3.4	Study tables, carrels	300-500-750	1	
	20.6.3.5	Map room	200-300-500	1	
20.6.4	Display and exhibition				
	20.6.4.1	Exhibits insensitive to light	200-300-500	–	
	20.6.4.2	Exhibit sensitive to light, for e.g. pictures, prints, rare books in archieves			
20.6.5	Library workrooms				
	20.6.5.1	Book repair and binding	300-500-750	2	
	20.6.5.2	Catalogue and sorting	300-500-750	2	
	20.6.5.3	Remote book stores	100-150-200	3	

Types of Interior or Activity	*Range of Service Illuminance in Lux*	*Quality Class of Direct Glare Limitation*	*Remarks*
20.7 Museums and Art Galleries			
20.7.1 Exhibits insensitive to light	200-300-500	–	
20.7.2 Light sensitive exhibits, for e.g. oil and temper paints, undyed leather, bone, ivory, wood etc.	150	–	This is a maximum illuminance to be provided on the principal plane of the object
20.7.3 Extremely light sensitive exhibits, for e.g. textiles, water colours, prints and drawing, skins, botanical specimens, etc.	50	–	This is a maximum illuminance to be provided on the principal plane of the object
20.7.4 Conservation studies and workshops	300-500-750	1	
20.8 Sports Facilities			
20.8.1 Multi-purpose sports hall	300-750	–	This lighting system should be sufficiently flexible to provide lighting suitable for the variety of sports & activities that take place in sports halls. Higher illuminance of 1000-2000 lux would be required for television coverage
21. EDUCATION			
21.1 Assembly Halls			
21.1.1 General	200-300-500	3	
21.1.2 Platform and stage	–	–	Special lighting to provide emphasis & to facilitate the use of the platform stage is desirable
21.2 Teaching Spaces			
21.2.1 General	200-300-500	1	
21.3 Lecture Theatres			
21.3.1 General	200-300-500	1	
21.3.2 Demonstration benches	300-500-750	1	Localized lighting may be appropriate
21.4 Seminar Rooms	300-500-750	1	
21.5 Art Rooms	300-500-750	1	
21.6 Needlework Rooms	300-500-750	1	
21.7 Laboratories	300-500-750	1	
21.8 Libraries	200-300-500	1	
21.9 Music rooms	200-300-500	1	
21.10 Sport halls	200-300-500	1	
21.11 Workshops	200-300-500	1	
22. TRANSPORT			
22.1 Airports			
22.1.1 Ticket counters, checking, desks and information desks	300-500-750	2	Localized lighting may be appropriate

Types of interior or activity	*Range of service illuminance in lux*	*Quality class of direct glare limitation*	*Remarks*
22.1.2 Departure lounges, other waiting areas	150-200-300	2	
22.1.3 Baggage reclaim	150-200-300	2	
22.1.4 Baggage handling	50-100-150	2	
22.1.5 Customers and immigration halls	300-500-750	2	
22.1.6 Concourse	150-200-300	2	
22.2 Railway Stations			
22.2.1 Ticket office	300-500-750	2	Localized lighting over the counter may be appropriate
22.2.2 Information Office	300-500-750	2	Localized lighting over the counter may be appropriate
22.2.3 Parcels office, left			
22.2.4 Luggage Office			
22.2.4.1 General	50-100-150	2	
22.2.4.2 Counter	150-200-300	2	
22.2.5 Waiting rooms	150-200-300	2	
22.2.6 Concourse	150-200-300	2	
22.2.7 Time table	150-200-300	2	Localized lighting may be appropriate
22.2.8 Ticket Barriers	150-200-300	2	Localized lighting may be appropriate
22.2.9 Platforms (covered)	30-50-100	2	Care should be taken to light and mark the edge of platform clearly
22.2.10 Platforms (open)	20	–	Care should be taken to light and mark the edge of platform clearly
22.3 Coach Stations			
22.3.1 Ticket offices	300-500-750	2	Localized lighting over the counter may be appropriate
22.3.2 Information offices	300-500-750	2	Localized lighting over the counter may be appropriate
22.3.3 Left Luggage office			
22.3.3.1 General	50-100-150	3	
22.3.3.2 Counter	150-200-300	3	Localized lighting is appropriate
22.3.4 Waiting rooms	150-200-300	2	
22.3.5 Concourse	150-200-300	2	
22.3.6 Time Table	150-200-300	2	Local lighting is appropriate
22.3.7 Loading Areas	100-150-200	3	
23. GENERAL BUILDING AREAS			
23.1 Entrance			
23.1.1 Entrance Halls, Lobbies, Waiting Rooms	150-200-300	2	
23.1.2 Inquiry desks	300-500-750	2	Localized lighting may be appropriate

Types of Interior or Activity	*Range of Service Illuminance in Lux*	*Quality Class of Direct Glare Limitation*	*Remarks*
23.1.3 Gatehouses	150-200-300	2	
23.2 Circulation Areas			
23.2.1 Lifts	50-100-150	–	
23.2.2 Corridors, Passageway, stairs	50-100-150	2	
23.2.3 Escalator, travellators	100-150-200	–	
23.3 Medical and First aid Centres			
23.3.1 Consulting Rooms, Treatment Rooms	300-500-750	1	
23.3.2 Rest Rooms	100-150-200	1	
23.3.3 Medical Stores	100-150-200	2	
23.4 Staff Rooms			
23.4.1 Changing, locker and cleaner Rooms, cloakrooms, lavatories	50-100-150	–	
23.4.2 Rest Rooms	100-150-200	1	
23.5 Staff Restaurant			
23.5.1 Canteens, cafeterias, dining rooms Mess rooms	150-200-300	2	
23.5.2 Servery, vegetable preparation, washing-up area	200-300-500	2	
23.5.3 Food preparation and cooking	300-500-750	2	
23.5.4 Food stores, cellars	100-150-200	2	
23.6 Communications			
23.6.1 Switchboard rooms	200-300-500	2	
23.6.2 Telephone apparatus room	100-150-200	2	
23.6.3 Telex room, post room	300-500-750	2	
23.6.4 Reprographic room	200-300-500	2	
23.7 Building Services			
23.7.1 Boiler houses			
23.7.1.1 General	50-100-150	3	
23.7.1.2 Boiler front	100-150-200	3	
23.7.1.3 Boiler control room	200-300-500	2	Localized lighting of the control display and the control desk may be appropriate
23.7.1.4 Control rooms	200-300-500	2	Localized lighting of the control display and the control desk may be appropriate
23.7.1.5 Mechanical plant room	100-150-200	2	
23.7.1.6 Electrical power supply and distribution room	100-150-200	2	
23.7.1.7 Store rooms	50-100-150	3	
23.8 Car Parks			
23.8.1 Covered Car Parks			
23.8.1.1 Floors	5-20	–	
23.8.1.2 Ramps and Corners	30	–	
23.8.1.3 Entrances and Exits	50-100-150	–	
23.8.1.4 Control Booths	150-200-300	–	
23.8.1.5 Outdoor Car Parks	5-20	–	

TABLE 12

Expected Useful Life of Various Electrical Equipments/ Installations Etc.

Sl. No	*Description of Equipment/ Installation*	*Life in Years*
(1)	*(2)*	*(3)*
A.	**Wiring of Electrical Installations**	
1	Conduit wiring non-coastal area	20
2	Conduit wiring coastal area	15
3	Casing and capping wiring	Deleted
4	PVC wiring on batten	Deleted
5	L.S. wiring	Deleted
6	T.R.S. wiring	Deleted
7	Cleat Wiring	Deleted
8	MS Pole	20
9	GI Pole	25
B.	**Fans**	
1	Ceiling Fan AC	15
2	Ceiling Fan DC	Deleted
3	Exhaust Fan AC/DC DC	6 DC may be deleted
4	Table Fan AC/DC	Deleted
5	Pedestal/ Air circulated Fan	Deleted
C.	**External Electrical Lines**	
1	Temporary overhead lines on wooden poles	Deleted
2	Permanent overhead line on steel/ RCC poles	20
3	Underground Cable Lines	20
D.	**Sub-station Equipment**	
1	Switchgear LT/HT	20
2	Transformers	25
3	Servo voltage stabilizer	10

Sl. No	*Description of Equipment/ Installation*	*Life in Years*
(1)	*(2)*	*(3)*
E.	**Lifts**	
1	Electric Lifts	15-20
2	Escalators	15-20
3	Hospital Lifts	10-15
F.	**Electric Motors and Pumps**	
1	Electric Motors single phase	Deleted
2	Electric Motors three phase	15
3	Electric pumps small (3000 RPM) AC/ DC	Deleted
4	Electric pumps medium (11500 RPM) AC/ DC	Deleted
5	(Diesel) Engine pump upto 10 H.P.	10
6	Storm water pump	7
7	Water supply Pump (Centrifugal)	10
8	Sewage Pump	5
9	(Diesel) Engine pump above 10 H.P.	12
10	Diesel Generator upto 50 KW	12
11	Diesel Generator above 50 KW	15 Above 15 KW may be deleted
G.	**Refrigerators, Coolers & Air Conditioners**	
1	Refrigerators	6
2	Cold storage plant with air-cooled condensing unit	8
3	Cold storage plant with water cooled condensing unit	Deleted
4	Desert Coolers [1500-2000 cfm (Evaporative type)]	4
5	Water Coolers	5
6	Room coolers cheap type about 1000 cfm	Deleted
7	Window type/ Split type/ Air-conditioning/ units with air cooled condensers	7
8	Packaged type Air-conditioning units with water cooled condensers	10

Sl. No	*Description of Equipment/ Installation*	*Life in Years*
(1)	*(2)*	*(3)*
9	Packaged type Air-conditioning units with air cooled condensers	8
10	DX type central air-conditioned plant with water cooled condensers	Deleted
11	Central chilled water system of air-conditioning plant with water cooled condensers	20
12	Evaporative type air-cooling plant (upto 25,000 cfm.)	10
13	Evaporative type air-cooling plant above 25,000 cfm.	Deleted
H.	**Mechanical Machinery**	
(a)	***Asphalt Plant***	
1	Hotmix Asphalt Plant (upto 10 TPH)	Deleted
2	Hotmix Asphalt Plant (10 to 30 TPH)	Deleted
3	Hotmix Asphalt Plant (30/45 TPH)	Deleted
4	Tar/Bitumen heater 1000 - 1500 litres capacity	Deleted
5	Cold Asphalt mixer 30 cft.	Deleted
6	Asphalt power finishers	Deleted
(b)	***Compaction Equipment***	
1	Hand Roller 1/2 tonne	Deleted
2	Diesel Steel Wheel roller 8/10 tonne capacity	Deleted
3	Vibratory tandom roller 4 tonne	Deleted
4	Sheep's foot roller single/ double drum.	Deleted
(c)	***Concrete Plants***	
1	Concrete Mixer 3/5 cft. Capacity	Deleted
2	Concrete Mixer 0.28/0.20 and 0.39/0.28 cu.m. capacity	Deleted
3	Electric vibrator capacity 5 HP	Deleted
4	Vibrator Engine Driver , Immersion/ Screed board type above 2 HP - 5 HP	Deleted
(d)	***Earth Moving Machinery***	
1	Dozer	Deleted

Sl. No	*Description of Equipment/ Installation*	*Life in Years*
(1)	*(2)*	*(3)*
2	Earth Rammer	Deleted
3	Front and Boarder 75 B.H.P.	Deleted
4	Front end loader 45 B.H.P.	Deleted
5	Motor Grader 60-80 BHP	Deleted
6	Electric driven portable Swivel Loader	Deleted
(e)	***Miscellaneous***	
1	Air-compressors 108-210 cf m	Deleted
2	Mobile Crane 4 tonne capacity	Deleted
3	Grass Cutter 1.52-1.8 3 m (5'-6") cut mid/rear mounted	Deleted
4	Centrifugal pump upto 10 HP	Deleted
5	Trailer mounted Centrifugal Pump, Engine driven about 10 HP-50 HP	Deleted
6	Spray painting equipment complete	Deleted
7	Welding Transformers	Deleted
8	Pneumatic Rock Drill	Deleted
9	Pneumatic Pavement Breakers	Deleted
10	Generating set upto 50 KW with trolley	Deleted
11	Insulating Oil Dehydration plant upto 500 lit.	Deleted
12	Core Cutting machine	Deleted
13	Water Tank 910 lit. capacity trolley mounted	Deleted
14	Boilers	15
15	Incinerator	15
(f)	***Transport***	
1	Tipper/Truck	Deleted
2	Tractor 25-40 HP	Deleted
3	Tractor above 60-80 BHP	Deleted
4	Motor Car	5
5	Four wheeled trailer	Deleted

Sl. No	*Description of Equipment/ Installation*	*Life in Years*
(1)	*(2)*	*(3)*
(g)	***Fire Fighting Equipment***	
1	Fire Alarm System	15
2	Water based wet riser/ sprinkler system	20

Note: These are general guidelines. Proposal for replacement will be based on actual hours of operation / conditions of use and inspection by the concerned authority. Based on adverse working condition, it may be necessary to replace installations earlier. Similarly replacement can be postponed if the existing condition is found to be satisfactory based on detailed inspection done. But it is necessary to keep close watch, when useful life is going to be over.

TABLE 13

List of T&P to be Held by each Junior Engineer as a Maintenance Unit

1. Earth Tester
2. Insulation Tester LT/HT
3. Tong Tester
4. Multimeter
5. Lux Meter
6. Vernier Caliper
7. Wire Gauge
8. Hand Blower / Vacuum Cleaner
9. Drill Machine
10. Chase Cutting Machine
11. Crimping tool kit
12. Self-supporting ladder - 4 ft. 3 Nos.
13. Ladder - 20 ft. 1 No.
14. Electrical wiring drawing machine
15. Cable fault locator machine
16. One set of hydraulic crimping tool kit

Note: Item No. 15 & 16 will be procured by Superintending Engineer (E) based on the requirement.

TABLE 14

Values of Performance Characteristics of Energy Efficient Induction Motors

Table 1 – Values of Performance Characteristic of 2 Pole Energy Efficient Induction Motors

(Clauses 1.2, 1.3, 4.1.1, 4.1.2, 14.1, 17.1, 17.1.1 and 17.1.2)

Rated Output	*Frame Designation*	*Full Load Speed*	*Full Load Current*	*Breakaway Torque in Terms of Full Load Torque*	*Breakaway Current in Terms of Full Current, Equal or Below*		*Nominal Efficiency*	
		Min	*Max*	*Min*	*For eff 2*	*For eff 1*	*For eff 2*	*For eff 1*
kW		*Rev/min*	*Amp*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*
0.37	71	2,790	1.2	170.0	600	650	66.0	70.2
0.55	71	2,760	1.6	170.0	600	650	70.0	74.0
0.75	80	2,780	2.0	170.0	600	650	73.0	77.0
1.1	80	2,790	2.8	170.0	600	650	76.2	82.8
1.5	90S	2,800	3.7	170.0	600	650	78.5	84.1
2.2	90L	2,810	5.0	170.0	650	700	81.0	85.6
3.7	100L	2,820	8.0	160.0	650	700	84.0	87.5
5.5	132S	2,830	11.0	160.0	650	700	85.7	88.6
7.5	132S	2,840	15.0	160.0	650	700	87.0	89.5
9.3	160M	2,840	18.5	160.0	650	700	87.7	90.0
11.0	160M	2,860	21.5	160.0	650	700	88.4	90.5
15.0	160M	2,870	29.0	160.0	650	700	89.4	91.3
18.5	160L	2,880	35.0	160.0	650	700	90.0	91.8
22.0	180M	2,890	41.5	160.0	650	700	90.5	92.2
30.0	200L	2,900	54.0	160.0	650	700	91.4	92.9
37.0	200L	2,900	67.0	160.0	650	700	92.0	93.3
45.0	225M	2,955	80.0	160.0	650	700	92.5	93.7
55.0	250M	2,960	95.0	160.0	650	700	93.0	94.0
75.0	280S	2,970	130.0	160.0	650	700	93.6	94.6
90.0	280M	2,970	150.0	160.0	650	700	93.9	95.0
110.0	315S	2,980	185.0	160.0	650	700	94.0	95.0
125.0	315M	2,980	209.0	160.0	650	700	94.5	95.3
132.0*	315M	2,980	220.0	160.0	650	700	94.5	95.3
160.0*	315L	2,980	265.0	160.0	650	700	94.8	95.3

Note: Output to frame size relation is maintained in accordance with IS 1231 for all motors, except those marked as *, wherein the frame size indicated is ‘preferred frame size’.

TABLE 14

Table 2 – Values of Performance Characteristic of 4 Pole Energy Efficient Induction Motors

(Clauses 1.2, 1.3, 4.1.1, 4.1.2, 14.1, 17.1, 17.1.1 and 17.1.2)

Rated Output	*Frame Designation*	*Full Load Speed*	*Full Load Current*	*Breakaway Torque in Terms of Full Load Torque*	*Breakaway Current in Terms of Full Current, Equal or Below*		*Nominal Efficiency*	
		Min	*Max*	*Min*	*For eff 2*	*For eff 1*	*For eff 2*	*For eff 1*
kW		*Rev/min*	*Amp*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*
0.37	71	1,330	1.4	170.0	550	600	66.0	73.0
0.55	80	1,340	1.7	170.0	550	600	70.0	78.0
0.75	80	1,360	2.2	170.0	550	600	73.0	82.5
1.1	90S	1,370	2.9	170.0	550	600	76.2	83.8
1.5	90L	1,380	3.8	170.0	550	600	78.5	85.0
2.2	100L	1,390	5.1	170.0	600	700	81.0	86.4
3.7	112M	1,410	8.1	160.0	600	700	84.0	88.3
5.5	132S	1,420	11.4	160.0	600	700	85.7	89.2
7.5	132M	1,430	15.4	160.0	600	700	87.0	90.1
9.3	160M	1,430	18.5	160.0	600	700	87.7	90.5
11.0	160M	1,440	22.0	160.0	600	700	88.4	91.0
15.0	160L	1,440	30.0	160.0	600	700	89.4	91.8
18.5	180M	1,440	36.0	160.0	600	700	90.0	92.2
22.0	180L	1,440	43.0	160.0	600	700	90.5	92.6
30.0	200L	1,450	56.0	160.0	600	700	91.4	93.2
37.0	225S	1,450	69.0	160.0	650	700	92.0	93.6
45.0	225M	1,460	84.0	160.0	600	700	92.5	93.9
55.0	250M	1,460	99.0	160.0	600	700	93.0	94.2
75.0	280S	1,470	134.0	160.0	600	700	93.6	94.7
90.0	280M	1,470	164.0	160.0	600	700	93.9	95.0
110.0	315S	1,480	204.0	160.0	600	700	94.4	95.2

TABLE 14

Table 3 – Values of Performance Characteristic of 6 Pole Energy Efficient Induction Motors

(Clauses 1.2, 1.3, 4.1.1, 4.1.2, 14.1, 17.1, 17.1.1 and 17.1.2)

Rated Output	*Frame Designation*	*Full Load Speed*	*Full Load Current*	*Breakaway Torque in Terms of Full Load Torque*	*Breakaway Current in Terms of full Current, Equal or Below*		*Nominal Efficiency*	
		Min	*Max*	*Min*	*For eff 2*	*For eff 1*	*For eff 2*	*For eff 1*
kW		*Rev/min*	*Amp*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*
0.37	80	870	1.4	160.0	550	600	65.0	69.4
0.55	80	870	1.9	160.0	550	600	68.0	72.0
0.75	90S	890	2.3	160.0	550	600	71.0	74.6
1.1	90L	900	3.2	160.0	550	600	74.0	77.3
1.5	100L	900	4.0	160.0	550	600	76.0	79.6
2.2	112M	910	5.5	150.0	600	700	79.0	82.2
3.7	132S	920	8.8	150.0	600	700	82.5	85.1
5.5	132M	920	12.7	150.0	600	700	84.5	86.8
7.5	160M	930	16.7	150.0	600	700	86.0	88.1
9.3	160L	930	20.5	140.0	600	700	87.0	89.3
11.0	160L	935	23.0	140.0	600	700	87.5	89.7
15.0	180L	940	30.5	140.0	600	700	88.5	90.5
18.5	200L	940	37.5	140.0	600	700	89.5	91.3
22.0	200L	945	44.0	140.0	600	700	90.0	91.8
30.0	225M	945	59.0	140.0	600	700	91.0	92.6
37.0	250M	950	72.0	140.0	600	700	91.5	93.0
45.0	280S	960	87.0	140.0	600	700	92.0	93.4
55.0	280M	960	107.0	140.0	600	700	92.5	93.8
75.0	315S	970	145.0	140.0	600	700	93.0	94.2
90.0	315M	970	175.0	140.0	600	700	93.3	94.5
110.0*	315M	970	214.0	140.0	600	700	93.5	94.6
132.0*	315L	980	257.0	140.0	600	700	93.8	94.9

Note: Output to frame size relation is maintained in accordance with IS 1231 for all motors, except those marked as *, wherein the frame size indicated is ‘preferred frame size’.

TABLE 14

Table 4 – Values of Performance Characteristic of 8 Pole Energy Efficient Induction Motors

(Clauses 1.2, 1.3, 4.1.1, 4.1.2, 14.1, 17.1, 17.1.1 and 17.1.2)

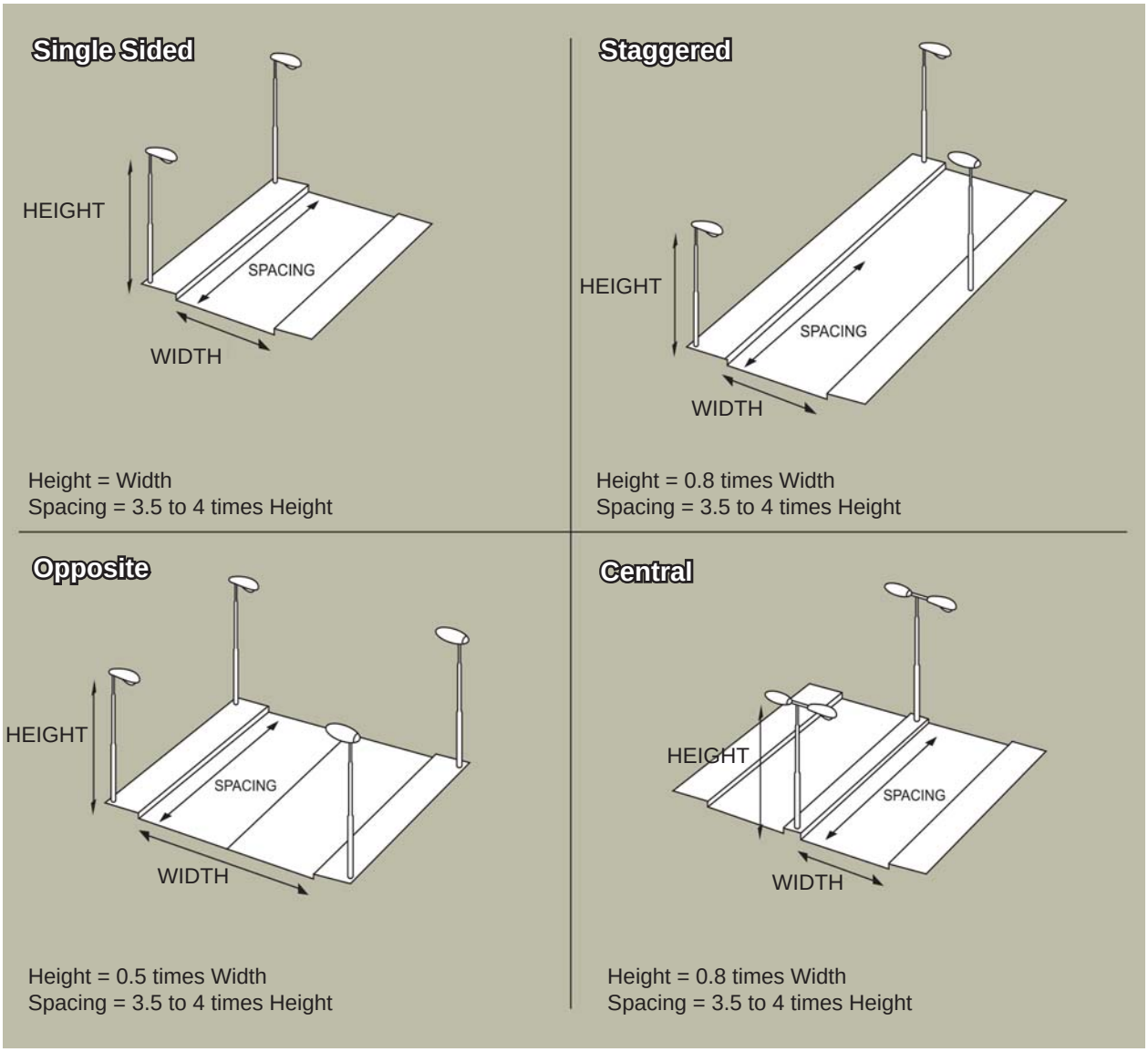
Rated Output	*Frame Designation*	*Full Load Speed*	*Full Load Current*	*Breakaway Torque in Terms of Full Load Torque*	*Breakaway Current in Terms of full Current, Equal or Below*		*Nominal Efficiency*	
		Min	*Max*	*Min*	*For eff 2*	*For eff 1*	*For eff 2*	*For eff 1*
kW		*Rev/min*	*Amp*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*
0.37	90S	640	1.5	150.0	550	600	62.0	66.8
0.55	90L	640	2.1	150.0	550	600	67.0	71.1
0.75	100L	650	2.7	150.0	550	600	70.0	73.8
1.1	100L	660	3.5	150.0	550	600	72.0	76.2
1.5	112M	670	4.5	150.0	550	600	74.0	77.9
2.2	132S	680	6.1	140.0	600	700	77.0	80.5
3.7	160M	690	9.8	140.0	600	700	80.0	83.0
5.5	160M	690	14.2	140.0	600	700	82.5	85.1
7.5	160L	695	19.0	140.0	600	700	84.0	86.4
9.3	180L	700	23.0	140.0	600	700	85.0	87.3
11.0	180L	700	26.0	140.0	600	700	86.0	88.1
15.0	200L	705	35.0	130.0	600	600	87.0	89.0
18.5	225S	705	45.0	130.0	600	700	88.0	89.8
22.0	225M	710	52.0	130.0	600	700	88.5	90.2
30.0	250M	710	70.0	130.0	600	700	90.0	91.5
37.0	280S	710	86.0	130.0	600	700	90.5	91.9
45.0	280M	720	99.0	130.0	600	700	91.0	92.4
55.0	315S	720	118.0	130.0	600	700	91.5	92.8
75.0	315M	730	153.0	130.0	600	700	92.3	93.5
90.0*	315L	730	182.0	130.0	600	700	92.8	93.9
110.0*	315L	730	218.0	130.0	600	700	93.3	94.3

Note: Output to frame size relation is maintained in accordance with IS 1231 for all motors, except those marked as *, wherein the frame size indicated is ‘preferred frame size’.

Fig. 1

Road Lighting

[Clause 2.14]



Basic Lighting Arrangements

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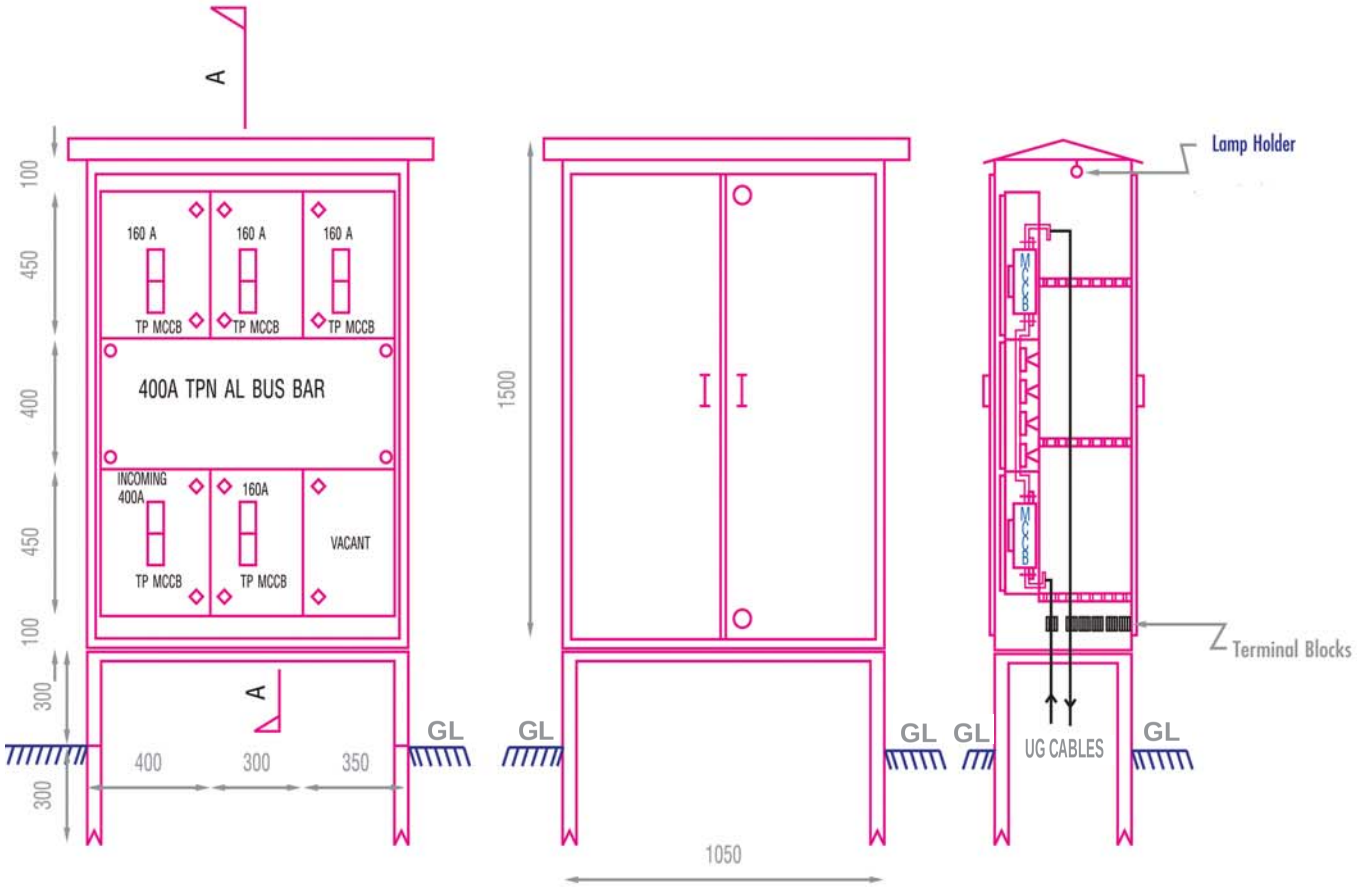
Fig. 2

GA DRG for Feeder Pillar

[Clause 2.14]

NOT TO SCALE



INSIDE VIEW **FRONT/BACK VIEW** **SEC. AT AA**

Note :

(a) The fabrication will be done out of 2 mm thick CRCA sheet with double door and inbuilt locking arrangement.

(b) All connections (incoming and outgoing) will be taken out in cable alley with suitable rated solid copper conductor.

(c) The feeder pillar will have to be supplied with suitable pedastal (MS angle iron frame of MS channel base for grouting in the RCC and proper gland at the bottom.

(d) The feeder pillar will be having one 10 Amp 3 pin socket outlet with 10 amp switch and one brass batten holder fitted in Metering Panel compartment and directly fed from incoming.

(e) The depth of the feeder pillar has been considered as 400 mm

(f) The Bus Bars made of hard drawn Tinned copper are fitted on insulated DMC supports.

(g) Sizes and arrangement are suggestive. Exact size and arrangement will be decided by NIT approving authority.

(h) The feeder pillar should be provided with terminal blocks for incoming & outgoing cables. From MCCB to terminal block wiring will be done with copper conductor/ suitable cable. Incoming / outgoing U.G. cable will be terminated in terminal block. This will very much reduce congestion of cables.

(i) All dimensions in mm.

Fig. 3

Typical Schematic Diagram for Power Distribution from Sub-Station

[Clause 3.1(vi)]

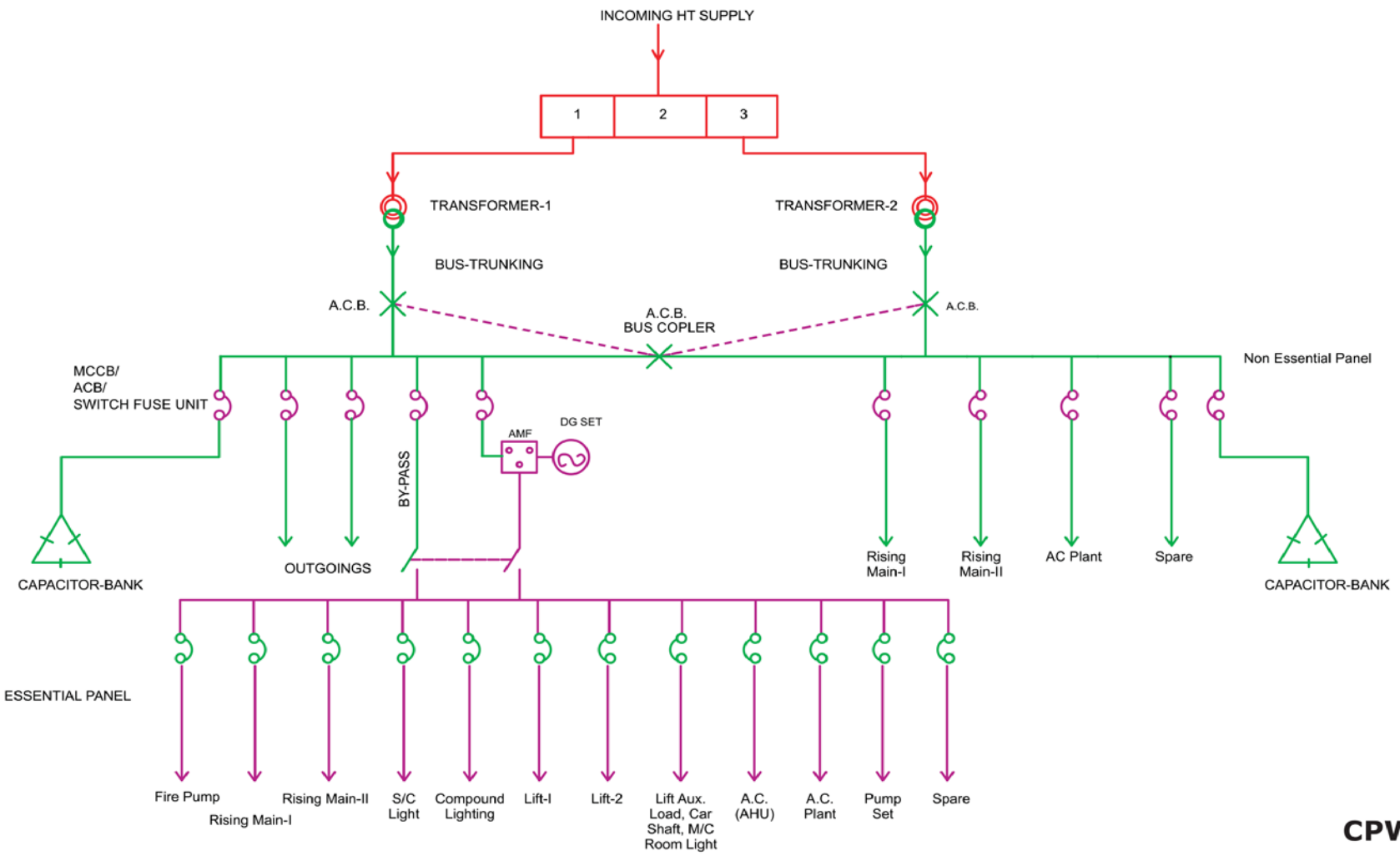


Fig. 4

Typcial Connection Diagram from SDB to Room Switch Board

[Clause 3.5 (v)]

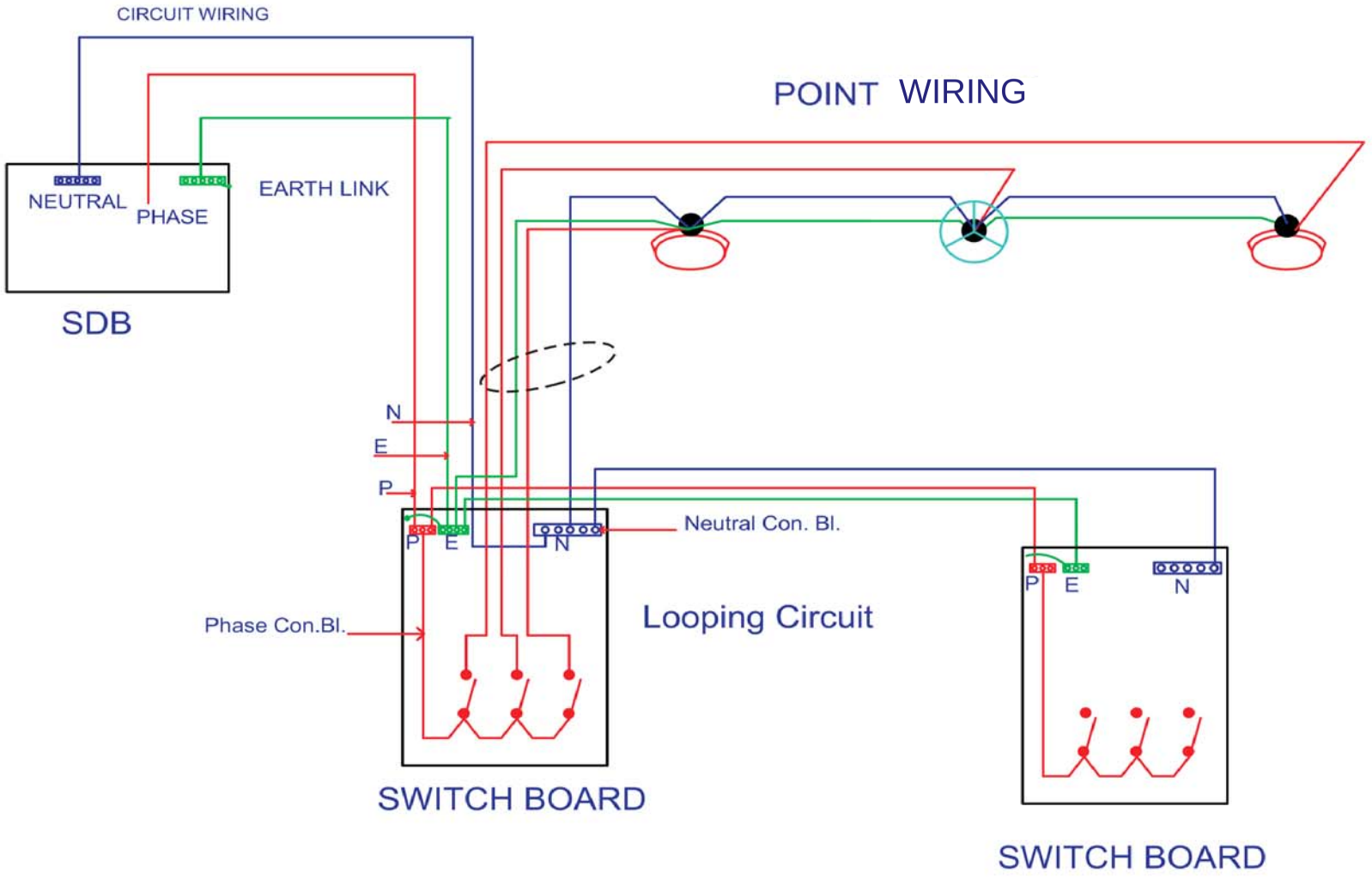
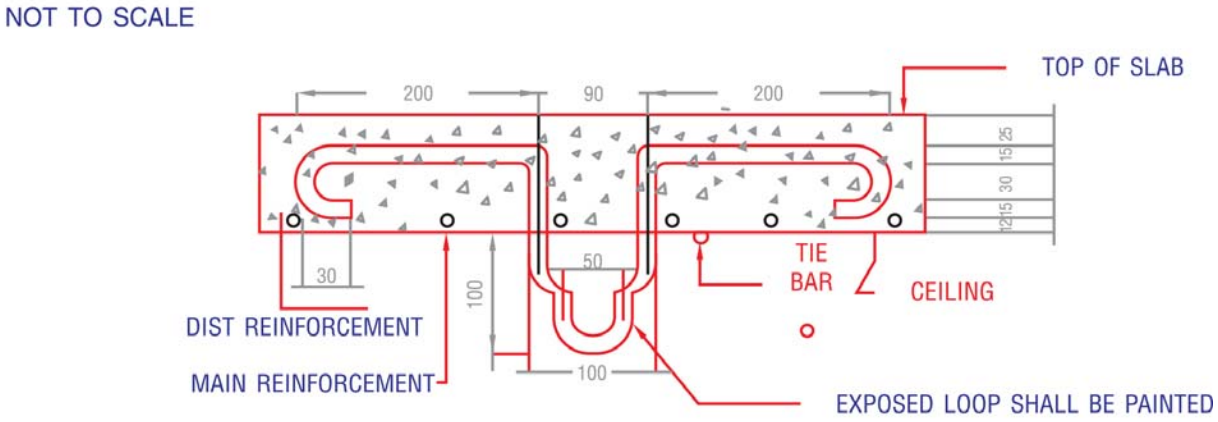


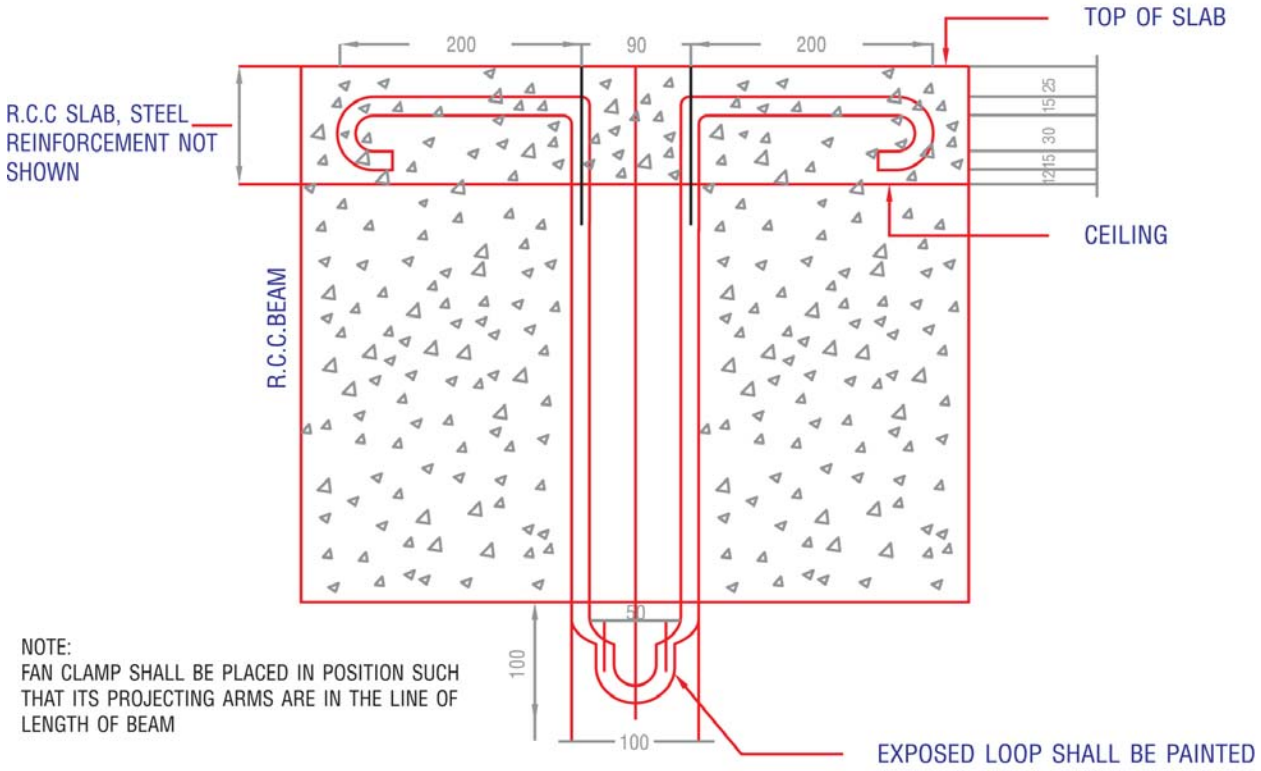
Fig. 5

Typical Design of M.S. Fan Clamps

[Clause 3.16 (v)]



TYPE 1 WHERE FAN CLAMP IS TO BE FIXED DURING LAYING OF R.C.C. SLAB

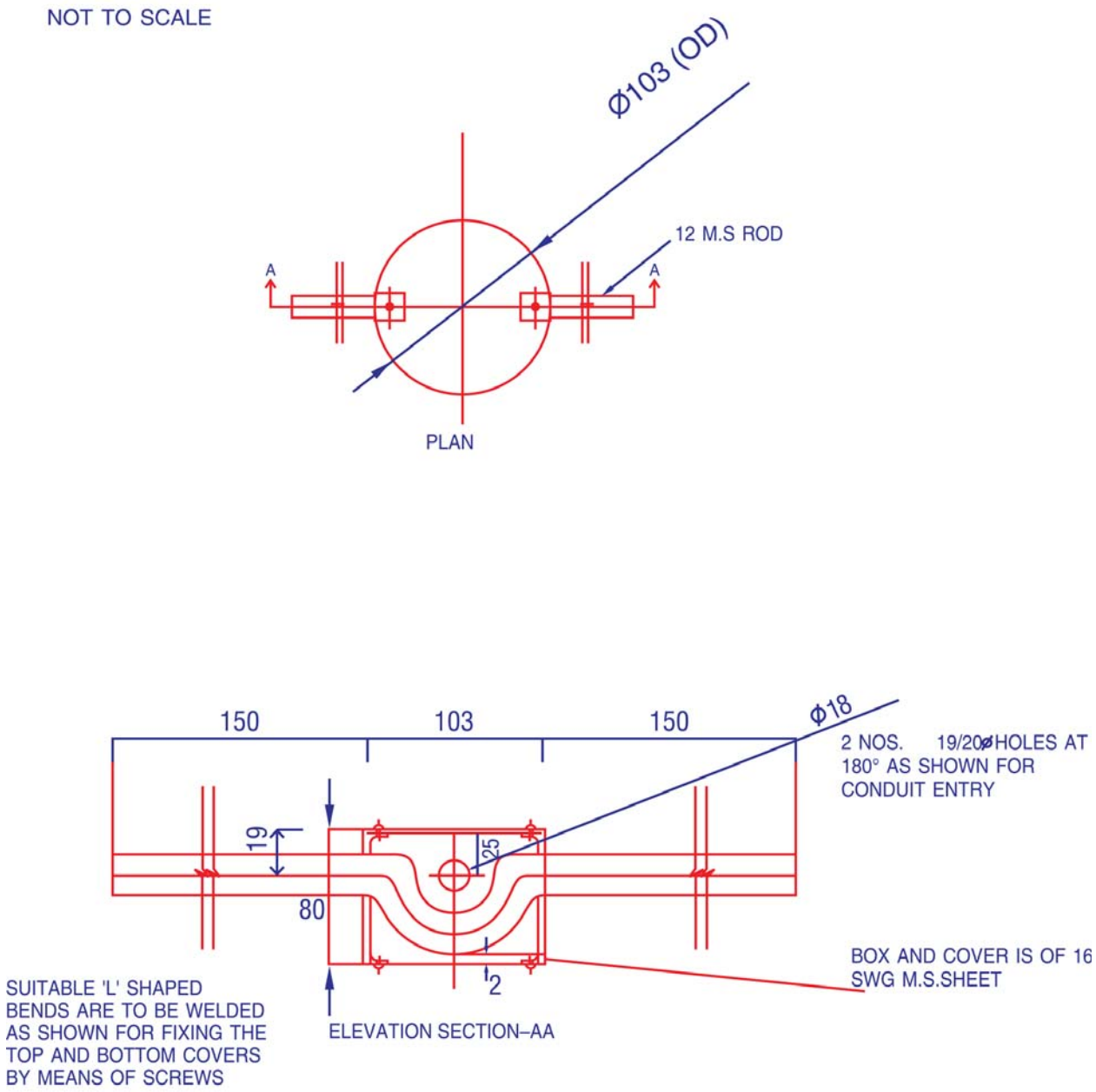


TYPE 2 WHERE FAN CLAMP IS TO BE FIXED DURING LAYING OF R.C.C. BEAM

Fig. 6

Circular Box Type Fan Clamp

[Clause 3.16 (vi)]



All dimensions are in mm.

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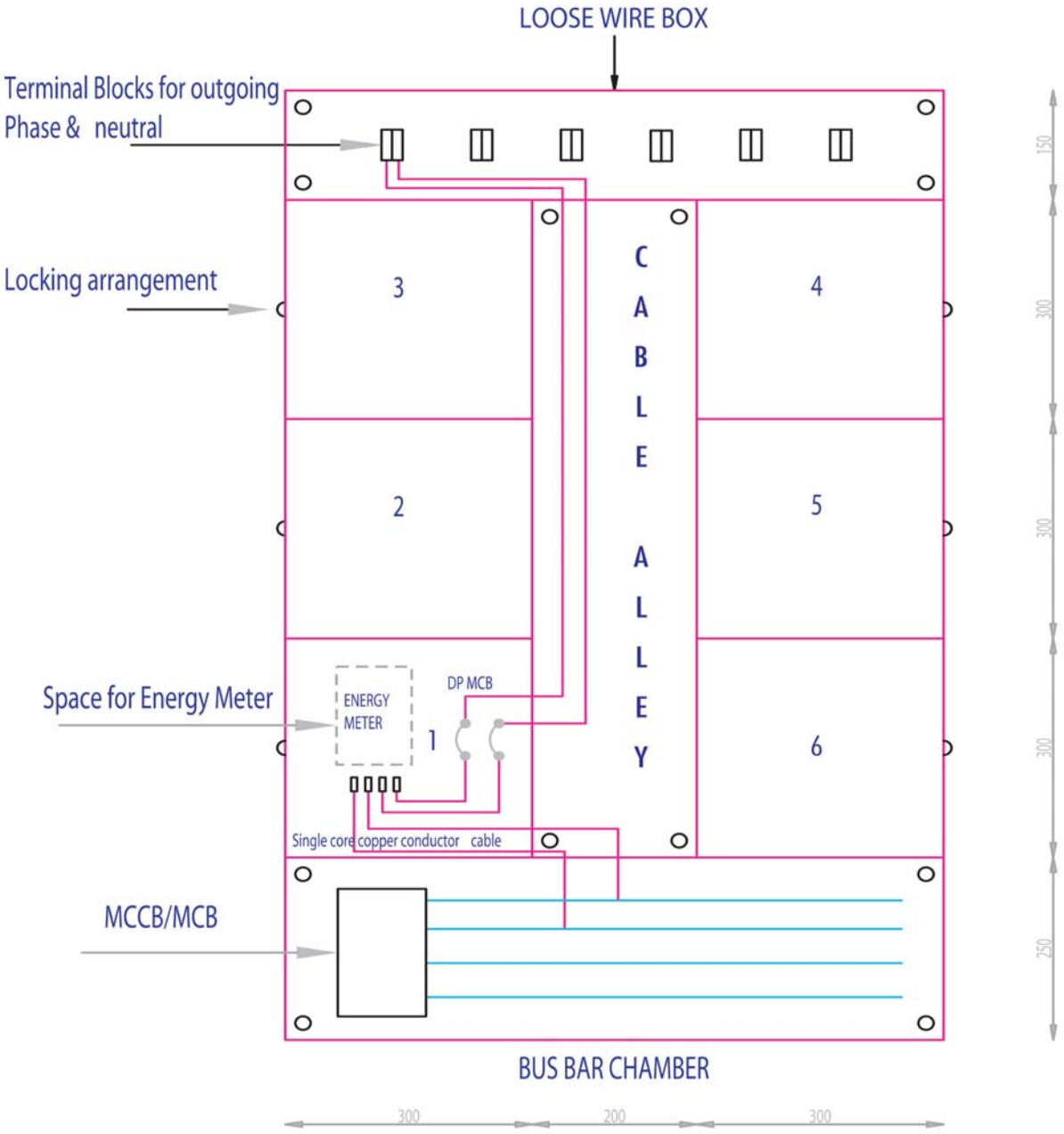
Fig. 7

Typical Cubical Panel for Meter Board

[Clause 3.20 (v)]



- All dimensions in mm.
- Individual Meter box will have locking arrangement
- Loose wire box, Cable Alley and bus bar chamber will have arrangement for sealing.
- Sizes and arrangement are suggestive. Exact size and arrangement will be decided by NIT approving authority.

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Fig. 8

Layout of Electrical Panel

[Clause 7.1]

NOT TO SCALE

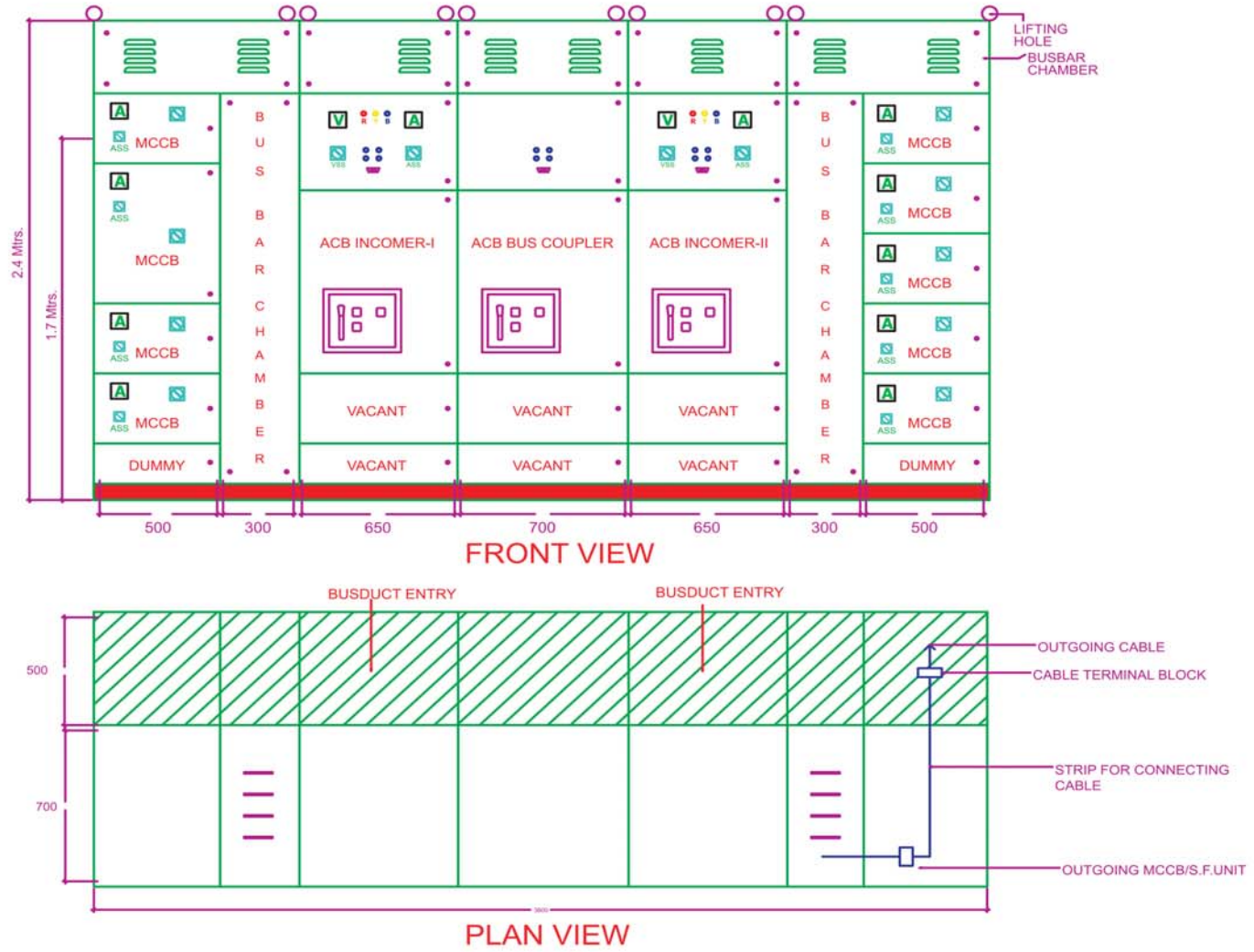
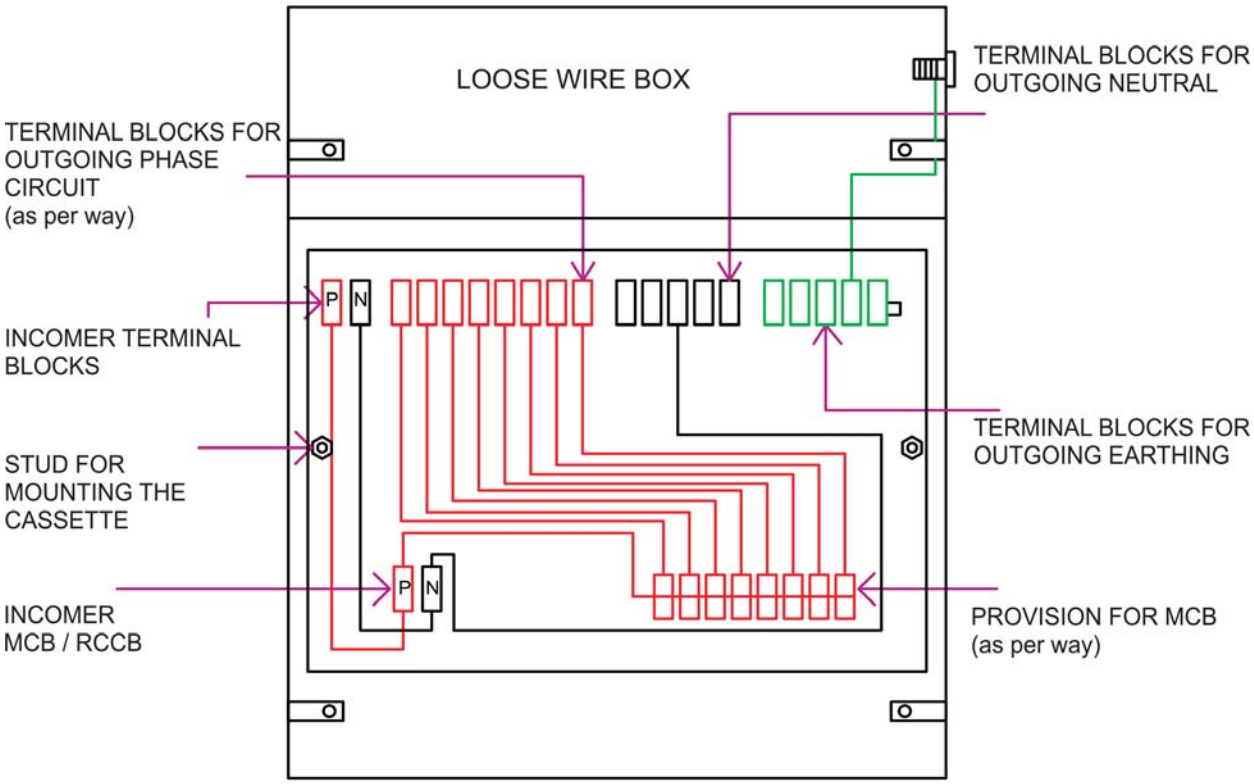


Fig. 9

Pre-wired MCB Distribution Board (Single Phase)

[Clause 7.1.2]



Schematic Line Diagram

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Fig. 10

Schematic Diagram For Power Distribution System

[Clause 7.2]

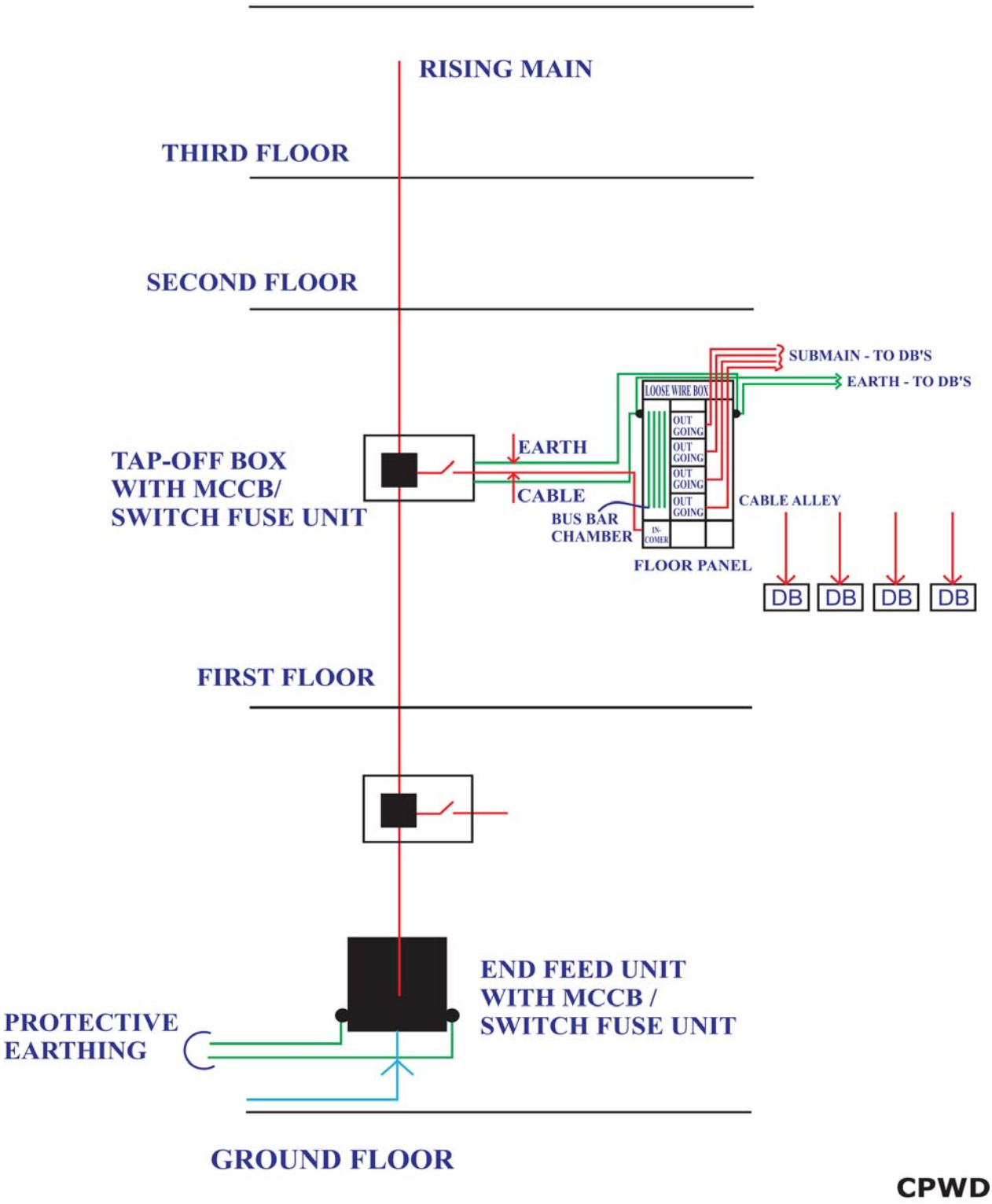

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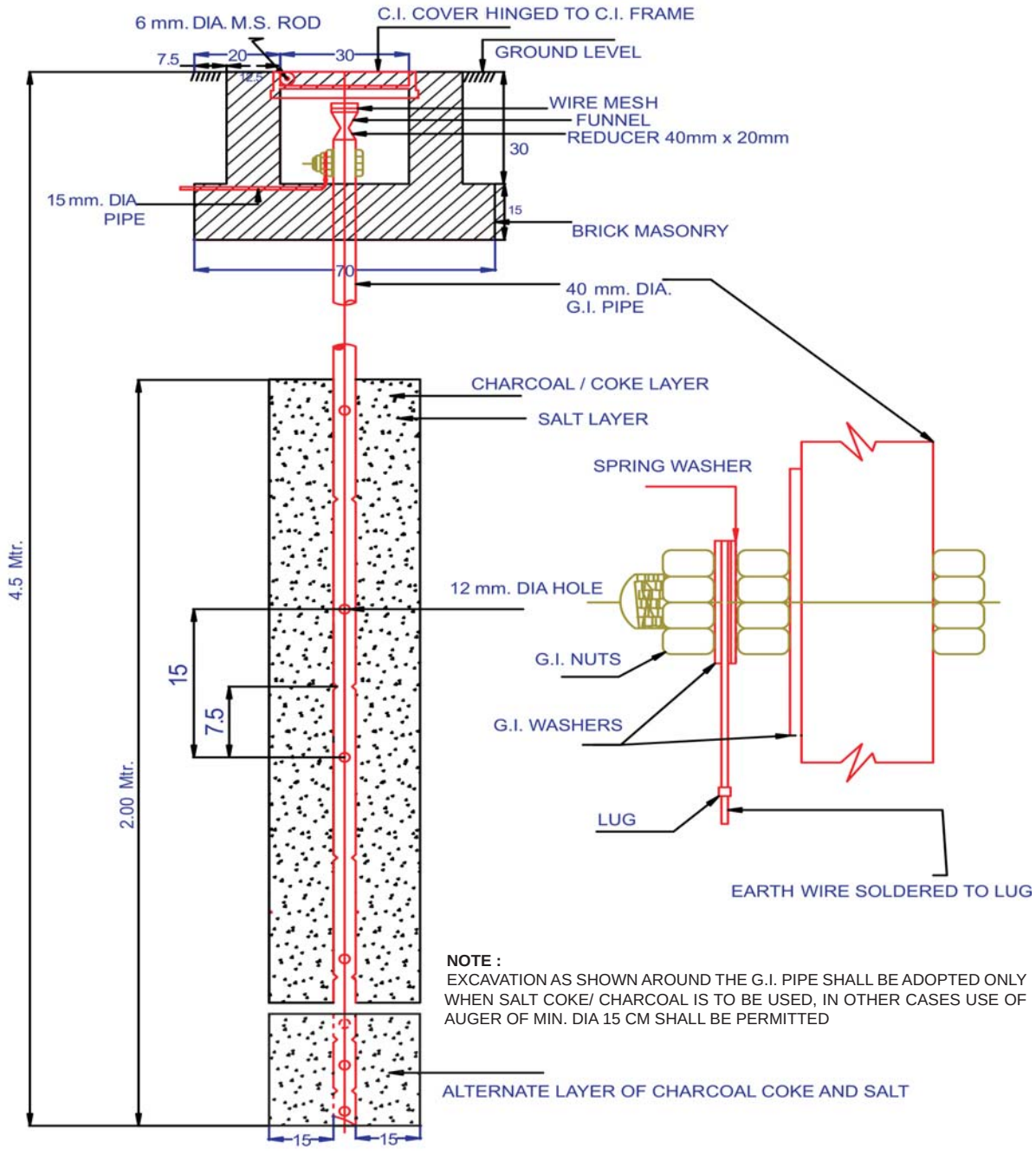
Fig. 11

Method of Pipe Earthing

[Clause 8.4.1.1(i)]

NOT TO SCALE



NOTE :
EXCAVATION AS SHOWN AROUND THE G.I. PIPE SHALL BE ADOPTED ONLY WHEN SALT COKE/ CHARCOAL IS TO BE USED, IN OTHER CASES USE OF AUGER OF MIN. DIA 15 CM SHALL BE PERMITTED

ALL DIMENSIONS ARE IN CM (OTHER DIMENSIONS SHOWN)

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Fig. 12 (Revised)

Method of Plate Earthing

[Clause 8.4.1.1(ii)]

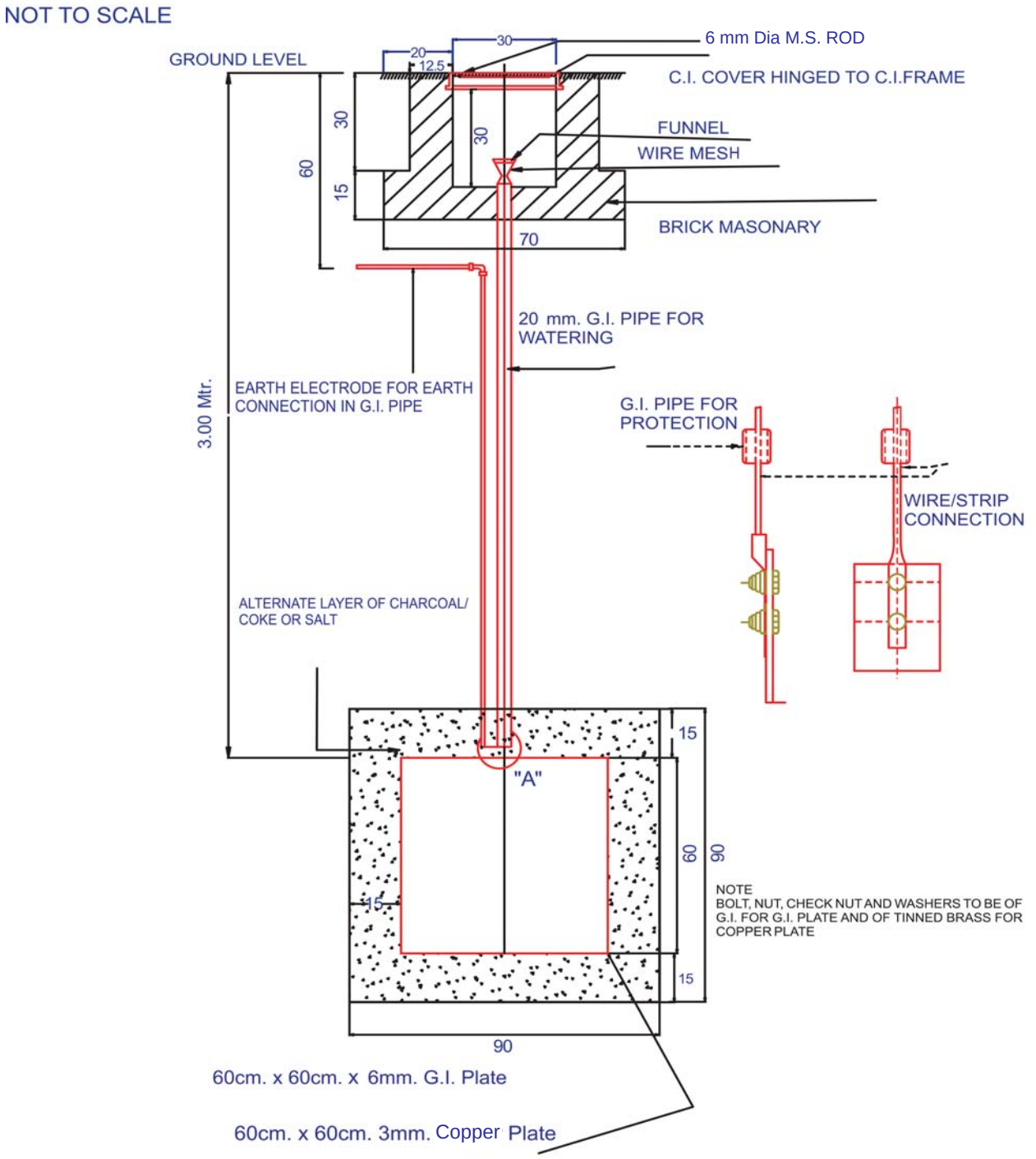


Fig. 13

Earth Testing

[Clause 16.5.1]

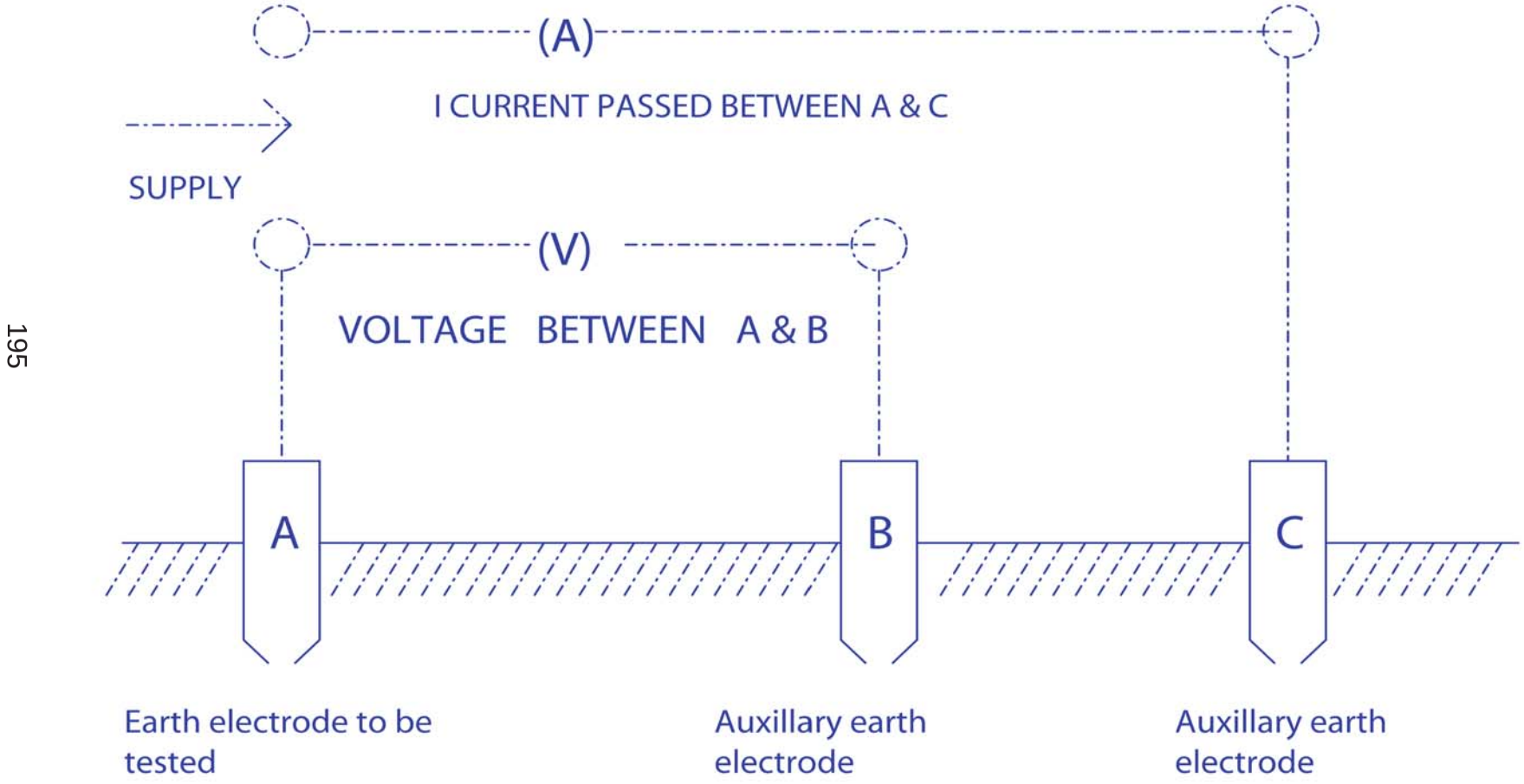
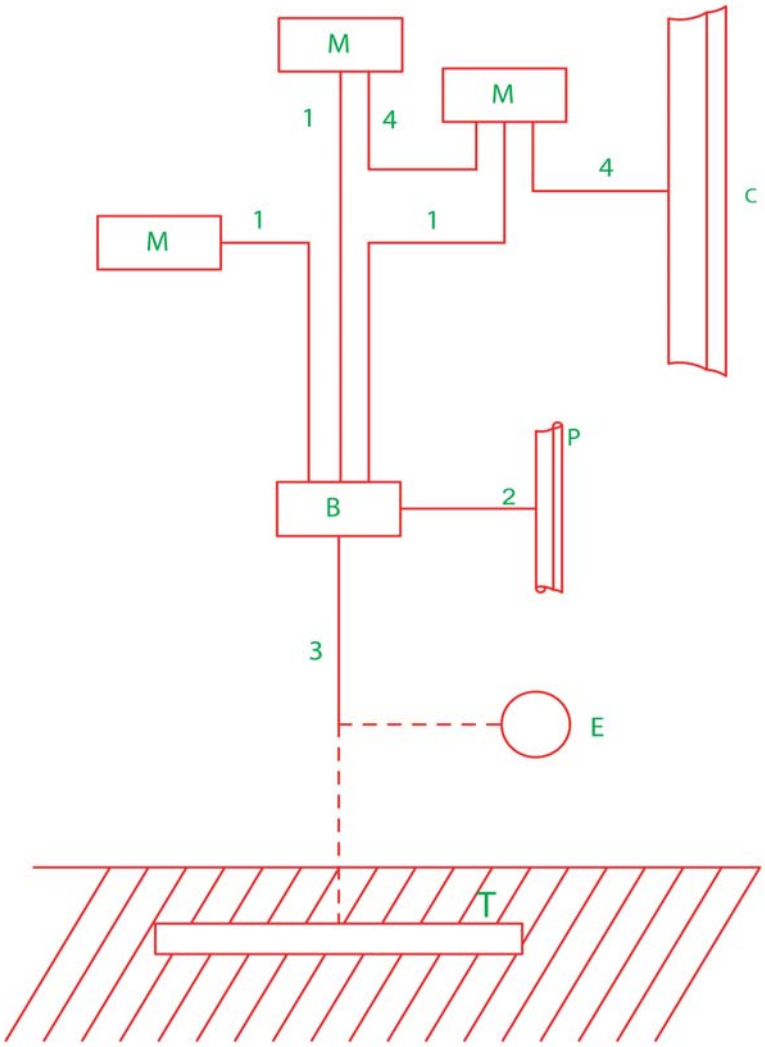


Fig. 14

Earthing Concept

[Clause F.3.2.2]



1, 2, 3, 4	=	Protective conductors
1.	=	Circuit Protective conductors
2.	=	Main equipotential bonding conductor
3.	=	Earthing conductor
4.	=	Supplementary equipotential bonding conductor (where required)
B	=	Main earthing terminal
M	=	Exposed conductive part
C	=	Extraneous conductive part
P	=	Main metallic water pipe
T	=	Earth electrode (TT & IT system)
E	=	Other means of earthign (TN system)

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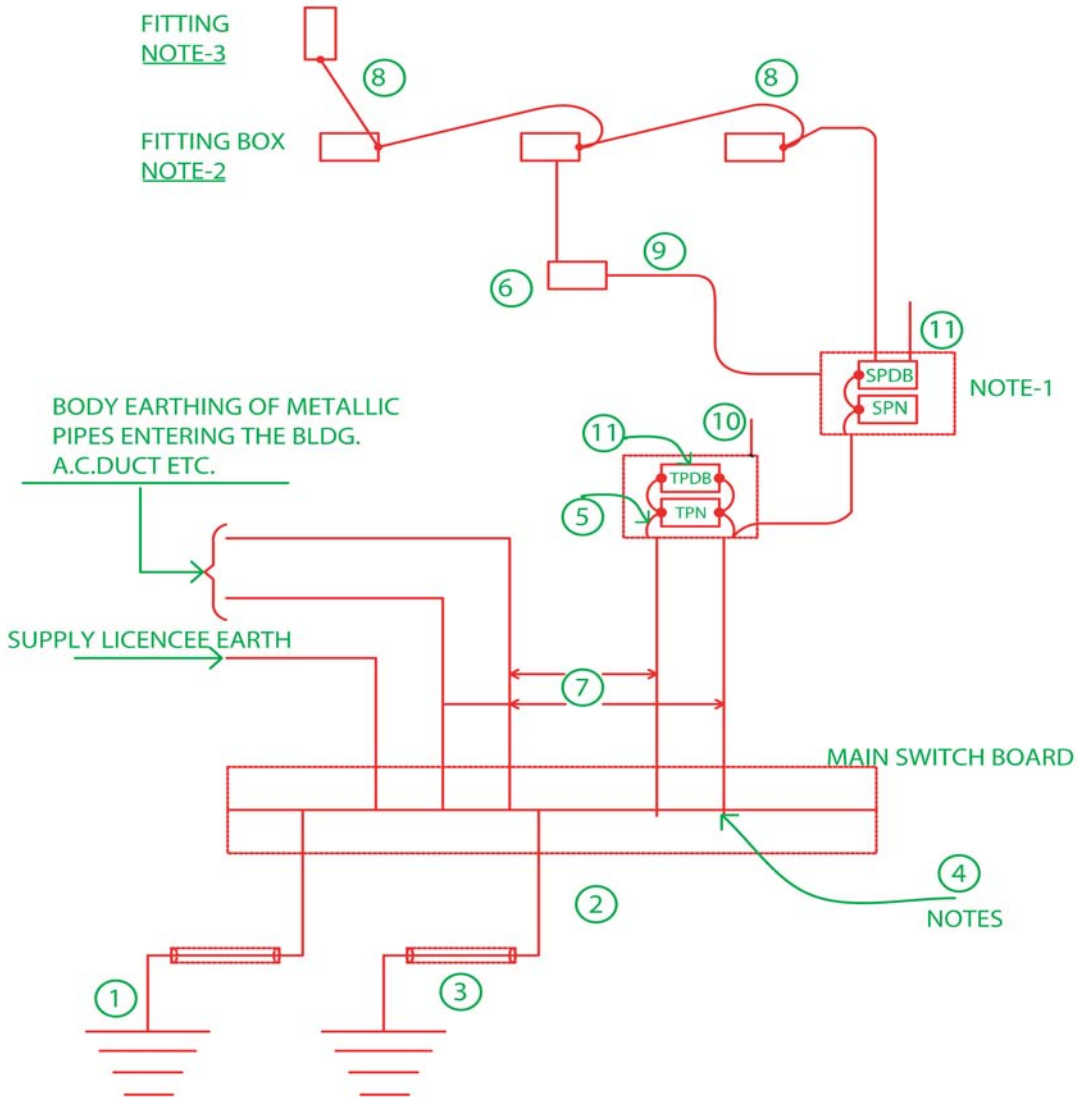
Fig. 15

Typical Earthing Schematic For Internal E.I.

[Clause F.3.2.2]



LEGEND
1. Earth electrode
2. Earthing conductor
3. Protection pipe earthing conductor
4. Main earthing terminal or earth bus
5. Earth bus

⏚ Earthing terminal
6. Extraneous protective parts.
7. Protective conductor
8. Protective (loop earthing) conductor
9. Main bonding conductor
10. Supplementary bonding conductor
11. Independent earth connection block

NOTE 1. (8) Should be terminated to (11) by screws.
2. Earth pin of socket outlet and metallic part of fan regulators should be connected to ° in switch boxes.
3. Fittings with earthing terminals may be connected to ° in metallics boxes.
4. When distribution is by U.G. cable protective conductors should be provided in addition to the cable armouring.
5. All earthing terminal & earth bus shall be marked as (E)⏚or . The main earthing terminal shall be marked as SAFETY EARTH - DO NOT DISCONNECT

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DETAILED REFERENCES TO CLAUSES

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1.6 Taxes and duties
1.7 Mobilisation advance
1.8 Completeness of tender
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4.3.2 (i) Painting before erection

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4.3.3 Additional requirements for recessed conduit work

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सत्यमेव जयते

SPACE FOR ELECTRICAL AND MECHANICAL SERVICES IN BUILDINGS

COMPANION VOLUME OF GENERAL SPECIFICATIONS FOR ELECTRICAL WORKS

PART - I (INTERNAL)

2013

CPWD

PUBLISHED UNDER THE AUTHORITY
OF
DIRECTOR GENERAL, CPWD, NEW DELHI

FOREWORD

1. It is important to provide proper space for various E&M services at preliminary stage itself in coordination with the architect. However, it is seen in many cases, space provided for various E&M services are inadequate and in few cases they are in excess. Sometimes, some services have been left out. Based on feedback received from a number of projects, a uniform standard has been prepared.

2. The enclosed norms are intended only to serve as guidelines, and should not come in the way of modifications / improvements or different approach as required for specific applications as per the judgement of planning engineers.

3. Suggestions / comments will be gratefully received.

4. I appreciate the efforts put in by Shri J. K. Choudhury, Chief Engineer (E) for preparation of this Booklet.

5. This has been approved by 38th Specification Committee held on 9th/10th October, 2002 vide agenda Item 30.0.5.

C. K. VARMA

CHIEF ENGINEER (E) CSQ

INDEX

ANNEXURES

SPACE FOR ELECTRICAL AND MECHANICAL SERVICES IN BUILDINGS

1. INTRODUCTION

E&M services generally provided in a building:

(a) Electric sub-station, power distribution system.

(b) Generating sets.

(c) Lifts.

(d) AC plant including central plant, package plant, split /window AC units.

(e) Ventilation system.

(f) U.P.S. / Voltage stabilizer.

(g) Water supply pumps.

(h) Wet riser system for fire protection.

(i) Fire detection, alarm, PA system for fire protection.

(j) Communication system.

(k) Computer cabling and allied works.

(l) Building security system including CCTV, access control, burglar alarm system.

(m) Building automation system.

(n) External lighting, road lighting, compound lighting, garden lighting, area lighting, high mast lighting and other specialised lighting.

(o) Auditorium lighting, acoustics, stage lighting and sound system.

(p) Swimming pool equipments etc.

All these services require close coordination between civil, architectural and electrical wings right from conceptual stage. Unless proper space is provided for these services, they can't be provided at construction stage without adversely affecting the aesthetics of the building and functional efficiency of the services. Many services can't be provided at all in absence of proper planning of space for various E&M services.

2. ELECTRICAL SUB-STATION

(a) **Space for:**

HT panel (both supply and CPWD).

Transformers.

L.T. panel.

Essential L.T. panel.

Power factor correction panel.

Generating sets.

P.O.L. Store / other store.

Supervisor room, toilet, workers rest room.

HT voltage correctors.

Voltage stabilizers.

UPS system including battery room.

Other equipments as required.

(b) Ventilation.

(c) Approach road around Sub-station.

(d) **Extract of Table A & B of Appendix IV of CPWD Electrical Specification Part IV (Sub-station) 2013**

Area for Sub-Station

The minimum sub-station and transformer room area required for different capacities are tabulated for general guidance. Actual area will however depend upon the particular layout and site constraints.

The clear height required for Sub-station equipments shall be a minimum of 3.6 m.

TABLE 1

Sub-Station with transformer capacity of	*Total transformer room area required*	*Total sub-station area required i/c HVMV panel transformers but without generators*	*Suggested minimum face width*
2*500 kVA	36.00 sqm	130.00 sqm	14.5 m
3*500 kVA	54.00 sqm	172.00 sqm	19.0 m
2*800 kVA	39.00 sqm	135.00 sqm	14.5 m
3*800 kVA	58.00 sqm	181.00 sqm	19.0 m
2*1000 kVA	39.00 sqm	149.00 sqm	14.5 m
3*1000 kVA	58.00 sqm	197.00 sqm	19.0 m

Area for Generating Sets

Additional area that is required for one generator is given below:

TABLE 2

Capacity	*Area*
25 kW	56.00 sqm
48 kW	56.00 sqm
100 kW	65.00 sqm
150 kW	72.00 sqm
248 kW	100.00 sqm

The clear height required for the generating set room shall be a minimum of 3.6 m upto 100 kW capacity and 4.57 m for higher capacities.

(e) **Location of Sub-station:**

(i) Avoid basement due to likely flooding during rains (there is hardly any basement sub-station/ AC plant, which is not affected by substantial damage due to flooding).

(ii) No parking in front of transformer and other equipments.

(iii) Easy approach to equipments.

(iv) Closer to the electrical load center and preferably in the ground floor.

(f) **Future Expansion:**

The sub-station design should take into account reasonable augmentation of equipments in future.

(g) **Security Precaution:**

Sub-station is the heart of electrical system. Wherever required, security measures like boundary wall and lockable gate may be provided so that unauthorized entry to sub-station can be prohibited.

Annexure I, II & III for Sub-Station may be seen.

3. WET RISER & WATER SUPPLY PUMP HOUSE

Preferable to have underground pump house by the side of U.G. water reservoir to ensure flooded suction. Water supply pump sets to be combined. Provide suitable ramp approach 1.5 m wide with suitable slope for easy access of heavy equipments and inspection personnel.

Roof slab may be 500 mm above ground level with ventilators. Provide suitable water proofing to prevent seepage of water into pump house.

Preventive measures to be taken so that during heavy rains, rainwater does not get into pump house.

Extract of Para 1.3.3 of CPWD Specifications Part V: Wet Riser System for Fire Fighting:

Location and Requirements

(a) *Under Ground Static Storage Tank and Pump House:*

Following aspects shall be considered in deciding the location of the underground static water storage tank and the wet riser pump house :

(i) Easy accessibility for fire fighting operations.

(ii) Proximity of fire pump house to the static tank.

(iii) Ease in bringing and removing equipments.

(iv) Pump house not being prone to flooding by rainwater, subsoil water.

(v) Protection of the pump house from any falling masonry and the like occasioned by fire.

(vi) Adequate ventilation for engine aspiration and to limit the temperature rise in pump house on continuous operation.

(vii) Aesthetics.

To protect the pump house, it should preferably be located atleast 6 m away from the building. Where this is not possible, this shall be enclosed with suitable masonry structure as a part of the building to prevent spread of fire into the pump room and provide safe operation.

The fire pump house should be located such that the suction for the pump is flooded. Where this is not practical, the pump house may be constructed with negative suction for pump, with suitable automatic priming arrangement. The size of the fire pump house should be 5.5 m x 8 m x 3.5 m, where engine driven fire pump, electric motor driven fire pump and pressurization pump are installed.

The capacity and design of the static tank shall be in accordance with the provisions of National Building Code Part IV - Fire Protection and the local Bylaws as applicable. (See Appendix -II of CPWD Specification Part-V).

Annexure IV, V & VI for Pump House & Tank may be seen.

(b) *External Piping and Hydrants:*

External hydrants shall be located within 2 m to 15 m from the building to be protected such that they are accessible and may not be damaged by vehicles. A spacing of about 45 m between hydrants is generally adopted.

(c) *Internal Riser and Hydrants:*

Normally one wet riser is required for every 1000 sqm of covered area. However, the maximum distance that can be served shall be 30 m from the riser.

4. LIFTS

Check Sizes As Per B.I.S.

(a) Capacity & number of lifts.

(A minimum capacity of 13 passenger lift for office bldg. and 8 passenger lift for residential building). Ensure provision of goods lift.

(b) Lift well size.

(c) Pit depth.

(d) Machine room size.

(e) Over head.

(f) The floor of lift machine room shall be designed for a uniform load of 1000 kg/sqm.

(g) Lift pit to be water proofed.

(h) No structural member intrusions into lift well, like column, beam projections which compromise lift well dimensions.

Annexure VII-a, VII-b, VII-c, VII-d may be seen.

5. FIRE CONTROL ROOM / TELEPHONE ROOM

(a) Telephone room: 4 m x 3 m.

(b) Fire control room: 4 m x 3 m preferable location near entrance lobby.

Note: Fire control room is a statutory requirement as per national building code.

Annexure IX may be seen.

6. AIR CONDITIONING

(a) Air-conditioning is maintenance of specified inside conditions: temperature, relative humidity, air changes and air quality.

Air-conditioning also includes winter heating and clean air system.

(b) Depending upon specific requirements, following systems of air-conditioning are followed:

(i) Window type AC Units.

(ii) Split type AC Units.

(iii) Package type AC Units.

(iv) Central AC System.

(c) Their brief applications are as below:

(i) *Window type Units:* Suitable for individual isolated rooms. Consumes very high amount of power. No relative humidity control. Very little control over air quality. Suitable for area upto 100 Sqm.

(ii) *Split Units:* They are same as window type units, except that the compressor units are located away from evaporator (fan) units. The noise of compressor is kept away. Energy wasteful.

(iii) *Package type:* They are mini and compact central plants available up to 10-Ton capacity. This system is suitable for areas between 100 to 1000 sqm.

(iv) *Central AC Plants:* They are suitable for large areas. Excellent control over temperature, humidity, clean air, air changes, noise control, uniform distribution and have energy efficiency. A properly designed central AC system will be reliable, effective and efficient. Hence for air-conditioning areas in excess of 1000 sqm, central AC plant is preferred.

(d) Comparison of Systems

TABLE 3

	Normal Life	*Energy Consumption Index*	*Humidity Control*	*Air Changes*
Central AC Plant	20 Yrs	100	Yes	Yes
Package Plant	10 Yrs	130	Yes	Yes
Split/ Window AC Unit	7 Yrs	150	No	No

The central plants are designed with suitable standby systems to give reliable service. Properly designed buildings also will reduce ingress of heat, hence the heat load also is reduced by as much as 25%, in case of central plant.

For example, a properly designed building with 200 ton AC load, working 8 hr/day, 250 days/ year will consume approximately 4 Lac units of electricity per year which comes to Rs.16 Lac/year. If the same building is air-conditioned with window type AC units/ split type units, without proper insulation of the building, the energy cost is likely to be 60% more.

(e) The space & structural requirements for air-conditioning works vary considerably with the systems adopted. It is therefore advisable to study individual cases and decide accordingly in consultation with the manufacturers, if necessary. However, a general guideline is given in Annexure XIV for the purpose of preliminary design/ drawing.

(i) Space for:

A/C plant room, cooling tower, make up water tank, air handling units, shaft for chilled water lines.

(ii) Shaft, space, false ceiling for ducts, air tightness of doors & windows in air-conditioned areas & AHU rooms.

(iii) Clear height of 3.4 m in corridor/ air conditioned space, as the case may be to accommodate supply air duct and return air path.

(iv) Thermal insulation of ceiling and walls of air-conditioned area/ AHU rooms wherever necessary.

(v) Acoustic insulation for AHU rooms.

(vi) Co-ordination of false ceiling work.

(vii) Availability of water supply for cooling towers.

(viii) Ventilation of AC plant room.

(ix) Approach road around plant room.

(x) Drainage of AHU room, fresh air opening in AHU room.

(xi) Opening for WT AC units. (Annexure Xlll).

(xii) Space for split AC condensing units and route and entry for inter-connection of indoor & outdoor units.

7. SHAFTS

(a) **Shaft Details:**

(i) ***Electrical rising main shaft:*** 2.2 x 0.8 m for accommodating normal & essential supply rising mains.

(ii) ***Wet riser shaft:*** 1.2 m * 0.8 m.

(iii) ***Telephone shaft:*** 0.6 m * 0.3 m

(iv) ***Fire alarm shaft:*** 0.6 m * 0.3 m.

(v) ***Computer cabling shaft:*** 0.6 m * 0.3 m.

Please see Annexure VIII & IX.

(b) **Door for Shafts:**

Door for Wet riser shaft may be provided as per Annexure XI. Provide steel door frame & steel doors with locking arrangement for other shafts. Doors to open towards corridor.

Please see Annexure XI & Annexure XII.

Note: No wooden doors shall be used since they pose fire risk.

(c) **Location of Shafts:**

(i) ***Fire Alarm Shaft:*** It shall be located in the lift lobby/common area and preferably can start from fire control room.

(ii) ***Telephone Shaft:*** Preferable to start from telephone room.

(iii) Shaft shall be in common area and not inside any room, so that they are accessible to service personnel even after office hours.

(iv) Away from water/ drainage shafts. Not to be exposed to rains etc.

8. CABLE ENTRY PIPES

Provide For:

(a) Cable entry into sub-station.

(b) Sub-station to rising main shafts.

(c) Cable entry into telephone room.

(d) Wet riser pump to wet riser shafts.

9. S.D.Bs

Shall be recessed in walls nearest to load and nitches for the same are not required.

10. FALSE CEILING IN CORRIDOR

When services like telephone/ computer/ electrical cables have to be taken in the corridor, it is better to provide false ceiling, so that the service cables are properly covered and don't present a shabby look. Also it helps in laying additional cables in later years.

11. FALSE CEILING IN ROOMS

Light fittings, AC diffusers, fire detectors, P.A. speakers will be fixed on false ceiling. Therefore it is necessary to locate all these fixtures to give a symmetrical and aesthetic look. False ceiling materials should be of fire resistance type.

12. CHECKLIST

(a) Electrical sub-station.

(b) Wet riser pump house.

Water supply pump house.

(c) Lift:

(i) Number.

(ii) Capacity.

(iii) Shaft dimensions.

(iv) M/c. Room dimensions.

(v) Pit depth.

(vI) Overhead.

(vii) No intrusion of structural members into lift shaft /pitch etc.

(viii) Water proofing of lift pit.

(d) Fire control room and telephone room.

(e) Shafts:
    (i) Electrical rising main shaft.
    (ii) Wet riser shaft.
    (iii) Telephone shaft.
    (iv) Fire alarm shaft.
    (v) Computer cabling.

(f) Doors for shafts.

(g) Location of shafts.

(h) Service-entry pipes.

(i) Central air-conditioning:
    (i) AC plant room.
    (ii) Cooling tower location.
    (iii) AHU room.
    (iv) AHU room drainage, fresh air opening.
    (v) Chiller pipes shaft, chiller pipe entry into building.
    (vi) False ceiling co-ordination.
    (vii) Ceiling height to accommodate ducting.
    (viii) Water requirement.
    (ix) Routes of piping/cable.
    (x) Thermal/acoustic insulation.
    (xi) Airtightness of windows/ doors. It is proper to provide double glazed window panes for insulation.

(j) Split AC Units:
    (i) Location of condensing units.
    (ii) Interconnection of condensing and indoor units finalisation of route.

(k) Window Type AC Units: Window frames compatible with opening for window type AC units.

(l) Corridor false ceiling to cover service cables.

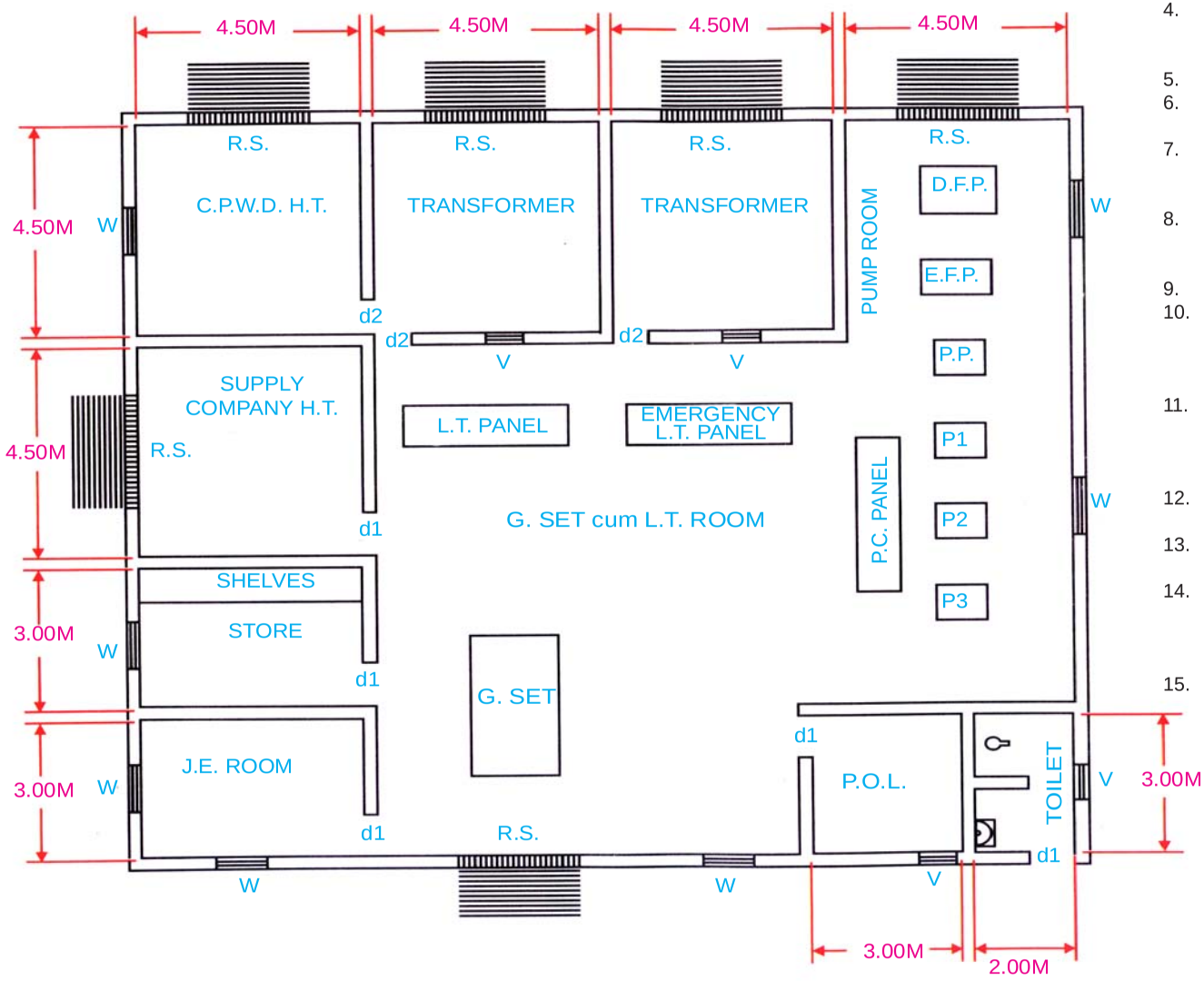
(m) False ceiling to symmetrically provide for AC diffuser, fire detectors, light fittings and P.A. speakers. False ceiling material should be fire resistant.

(n) Water supply co-ordination: Drinking water, toilet water, horticulture, fire fighting, air-conditioning, assessment of water requirements, location of tanks, O.H. tanks and pumping arrangements.

(o) Co-ordination of various service pipe/ cable routes: Coordination of water supply, storm water, drain water, sewerage, electricity, telephone, computer, wet riser pipes, air-conditioning cables/ pipes fixing their routes, so that the service/ cable pipes are co-ordinated and various executing agencies don't clash over routes.

ANNEXURE I

Electric Sub-Station Cum Fire Pump House
(where Sub-station is a Separate Building)



NOTE :

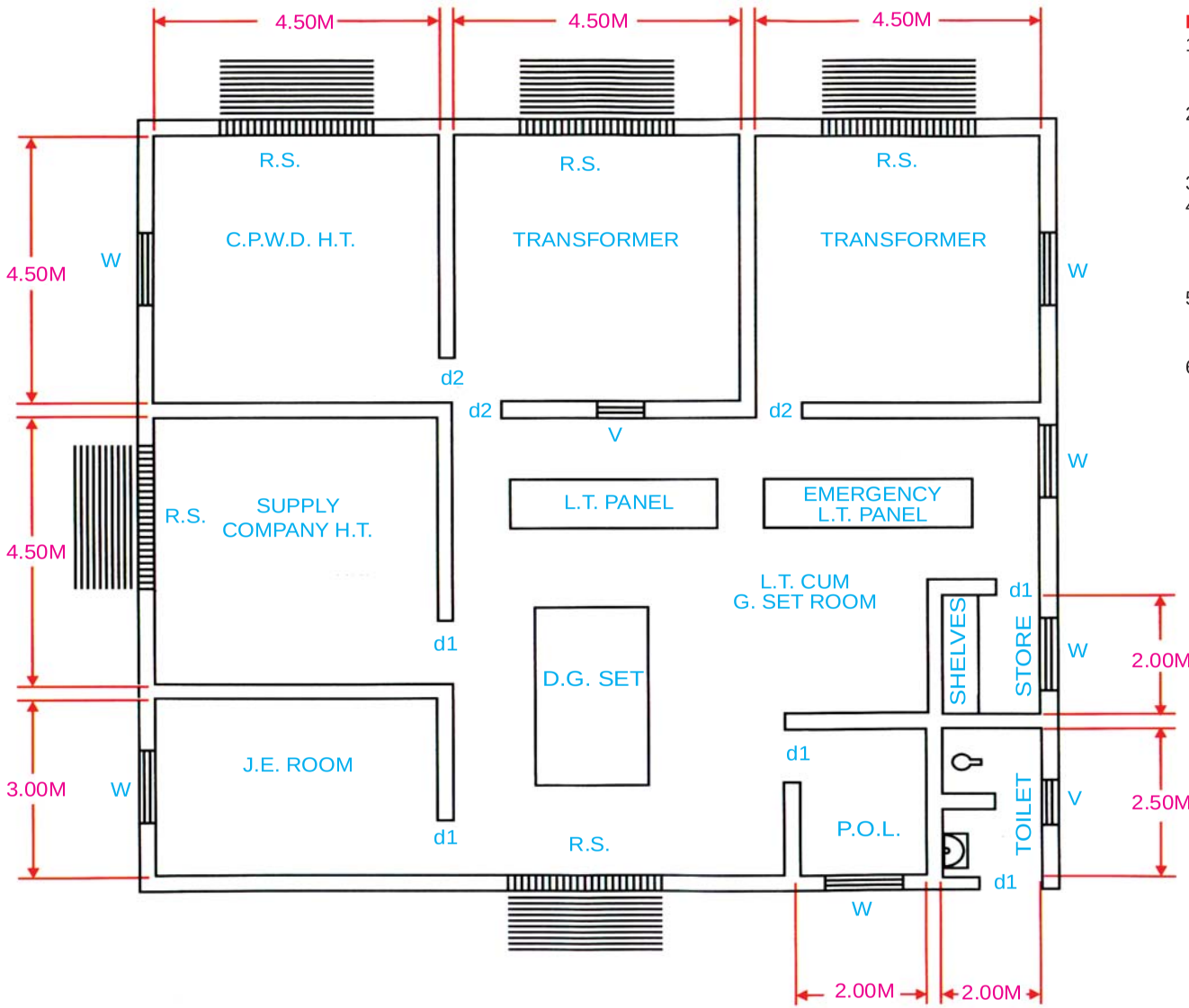
1. Floor to ceiling height - 4.5 m
   Floor level - 30 cm above ground level.
2. Motorable concrete approach road all-round.
3. Partition walls - 30 cm thick brick.
4. Heavy-duty steel ladder with side railing upto sub-station roof for roof drainage maintenance.
5. 1 m wide chajja projection all around.
6. Underground water tank as near as possible to pump room.
7. Rolling shutter 2.5 m wide - 3 m height as per Annexure X and with ventilation grills.
8. All doors of steel for fire protection.
   d1 - 1 m wide - 2 m height
   d 2 - .75 m wide - 1.8 m height
9. W - window - normal size with grill.
10. V - ventilator. Size 75 cm wide - 50 cm height. made of steel frame with heavy wire mesh. 50 cm below ceiling.
11. D.F.P. - Diesel fire pump.
    E.F.P. - Electrical fire pump.
    P.P. - Jockey pump.
    P1, P2, P3 - Water supply pumps.
12. Cable entry pipes - Executive Eng. will give location and details.
13. Cable trenches - Executive Eng. will give details.
14. Protection boundary wall with gate - if sub-station is a protected premise, suitable boundary walls with gates to be provided.
15. Store shelves - .75 m deep, RCC, 1 m, 2 m, 3 m above ground level.

NOTE :

1. Transformer/ HT Panel shall be 'Dry' type when sub-station is housed with main building. (It is not a separate building away from main building).
2. Room with wall enclosure, in case of 'Dry' transformer, is not essential.

ANNEXURE II

Electrical Sub-Station Building



NOTE :

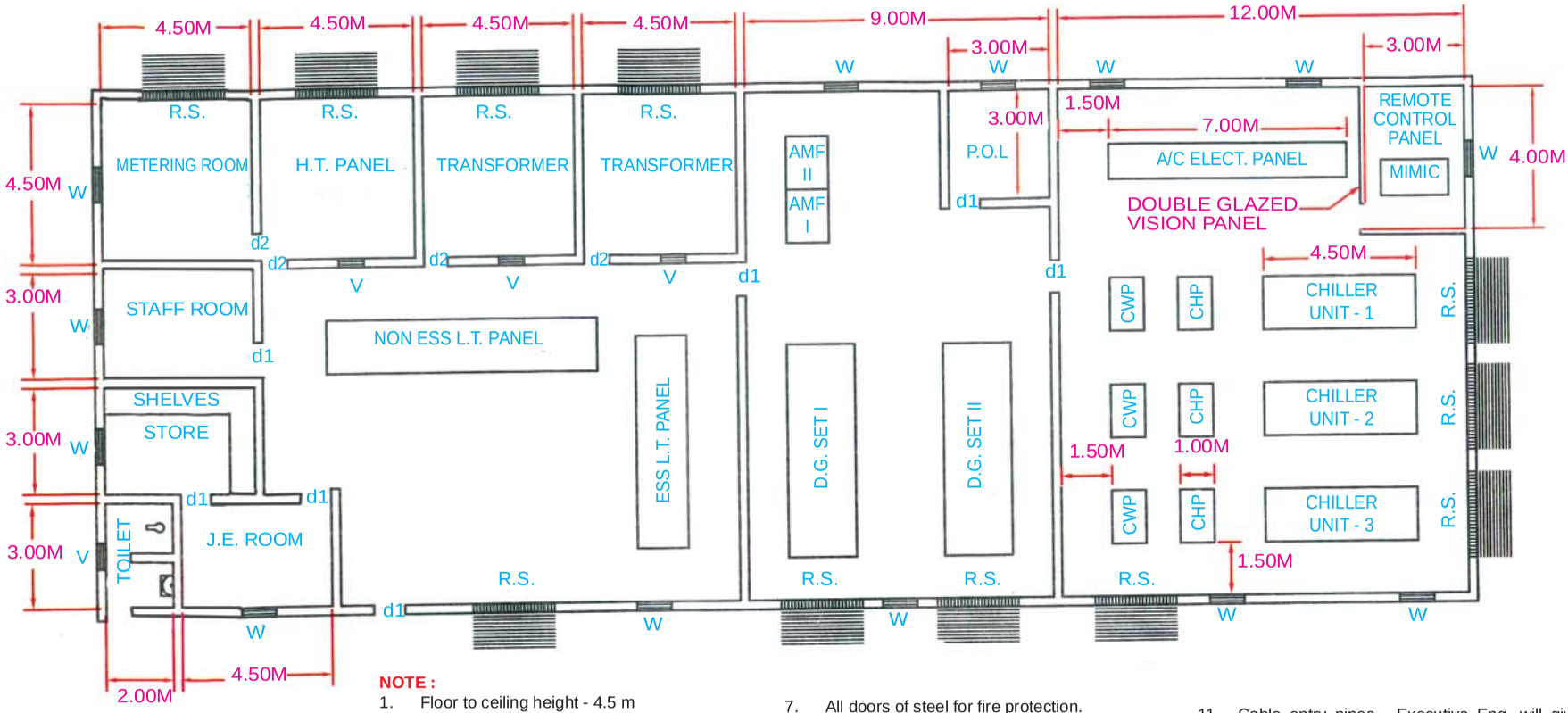
1. Rolling shutter 2.5 m wide - 3 m height as per Annexure X and with ventilation grills.
2. All doors of steel for fire protection.
   d1 - 1 m wide - 2 m height
   d2 - .75 m wide - 1.8 m height
3. W - window - normal size with grill.
4. V - ventilator. Size 75 cm wide - 50 cm height made of steel frame with heavy wire mesh 50 cm below ceiling.
5. No toilet is required where sub-station is located in the main building itself.
6. Store shelves - .75 m deep, RCC, 1 m, 2 m, 3 m above ground level.

NOTE :

1. Transformer/ HT Panel shall be 'Dry' type when sub-station is housed with main building. (It is not a separate building away from main building).
2. Room with wall enclosure, in case of 'Dry' transformer, is not essential.

ANNEXURE III

Typical Layout of D.G. Sets, Sub-Station Equipment and A.C. Plant Room
2*1000 KVA Transformer 2*500 KVA D.G. Set 300 TR*3 A.C. Plant



NOTE :

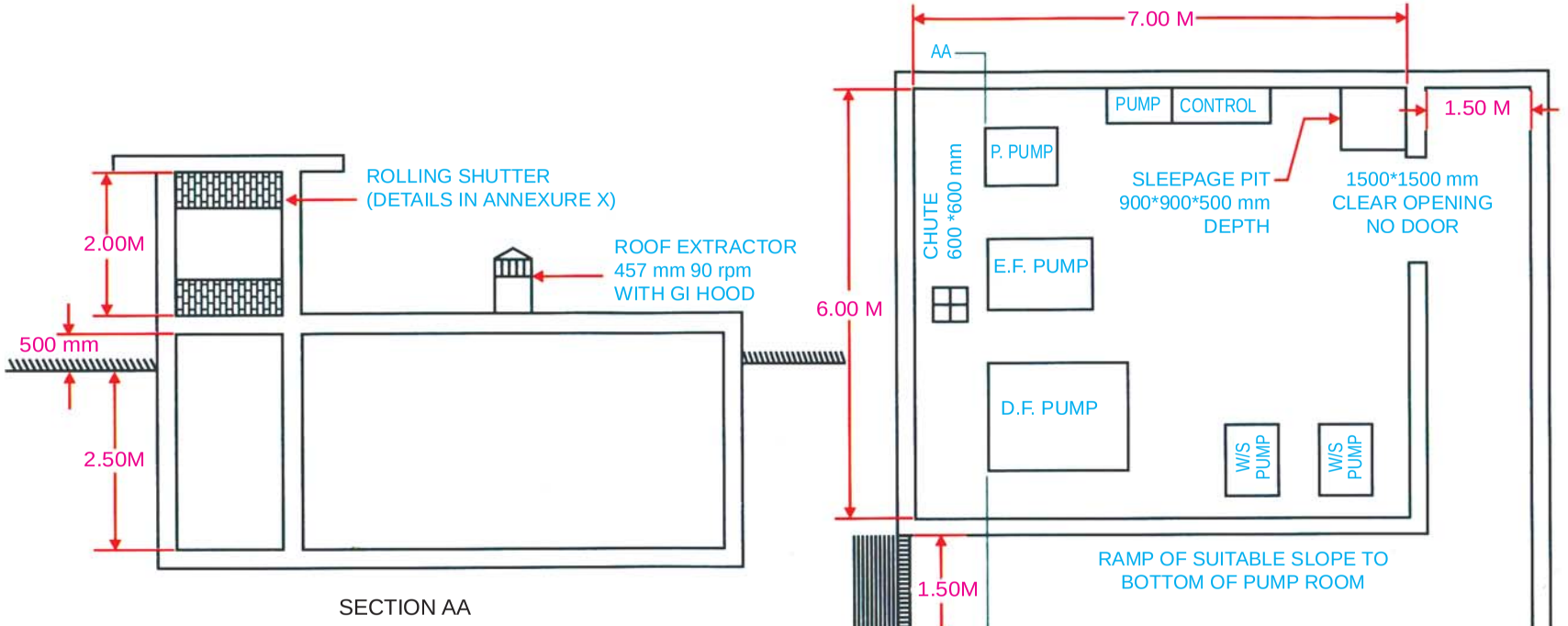
1. Decide cooling tower location.
2. Transformer/ HT Panel shall be 'Dry' type when sub-station is housed with main building. (It is not a separate building away from main building). Room with sall enclosure.

NOTE :

1. Floor to ceiling height - 4.5 m
   Floor level - 30 cm above ground level.
2. Motorable concrete approach road all-round.
3. Partition walls - 30 cm thick brick.
4. Heavy-duty steel ladder with side railing upto sub-station roof for roof drainage maintenance.
5. 1 m wide chajja projection all around.
6. Rolling shutter 2.5 m wide - 3 m height as per Annexure X and with ventilation grills.
7. All doors of steel for fire protection.
   d1 - 1 m wide - 2 m height
   d 2 - .75 m wide - 1.8 m height
8. W - window - normal size with grill.
9. V - ventilator. Size 75 cm wide - 50 cm height. made of steel frame with heavy wire mesh. 50 cm below ceiling.
10. C.H.P. - Chiller water pump
    C.W.P. - Condenser water pump
    A.M.F. - Automatic main failure panel.
11. Cable entry pipes - Executive Eng. will give location and details.
12. Cable trenches - Executive Eng. will give details.
13. Protection boundary wall with gate - if sub-station is a protected premise, suitable boundary walls with gates to be provided.
14. Store shelves - .75 m deep, RCC, 1 m, 2 m, 3 m above ground level.

ANNEXURE IV

Under Ground Wet Riser Pump Room for Positive Suction

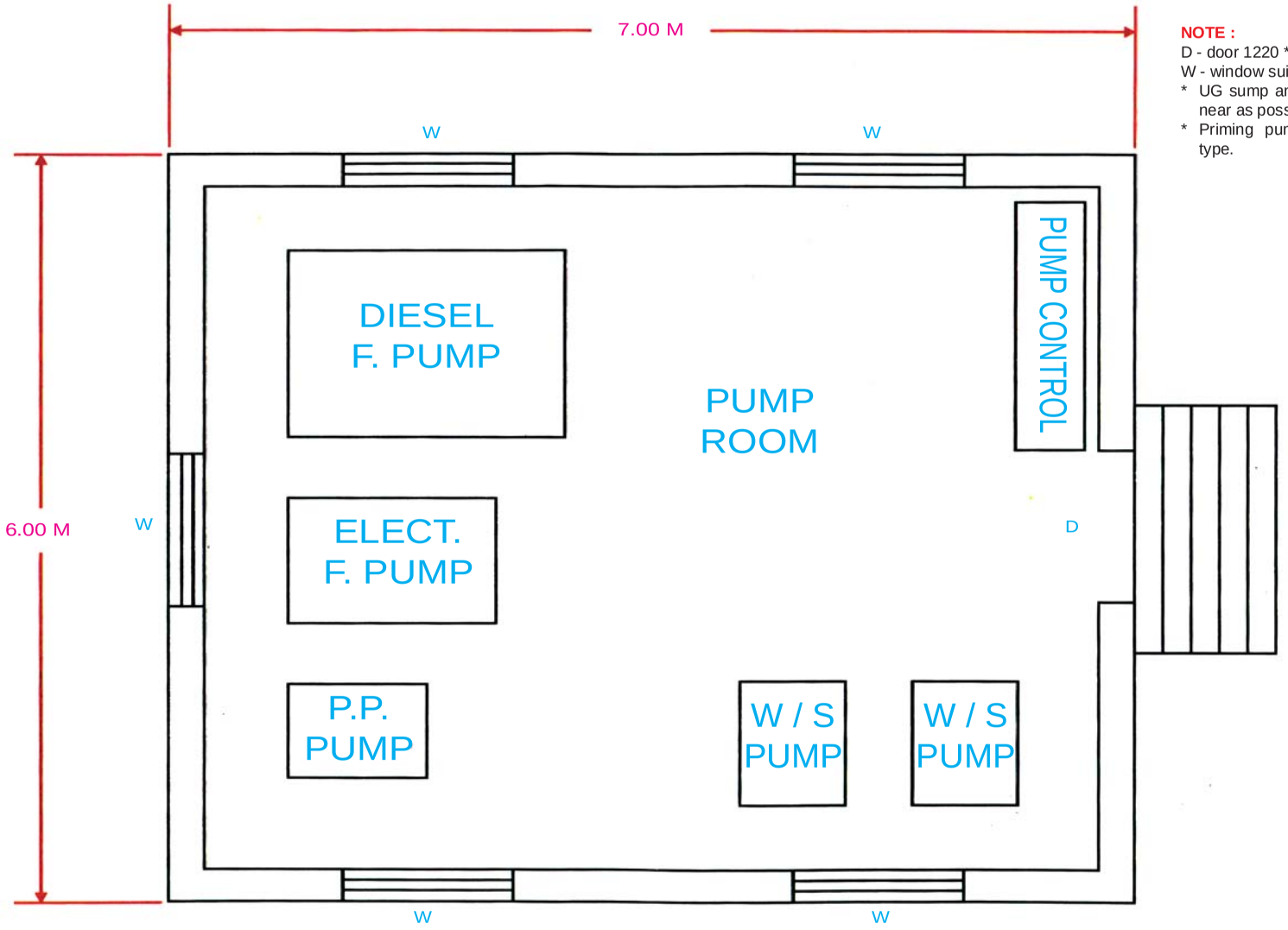


SECTION AA

NOTE :
ROOF EXTRACTOR SHALL BE CONNECTED TO FIRE PUMP CONTROL FOR AUTOMATIC OPERATION WHEN THE FIRE PUMP STARTS

ANNEXURE V

Pump Room for Wet Riser Cum Water Supply



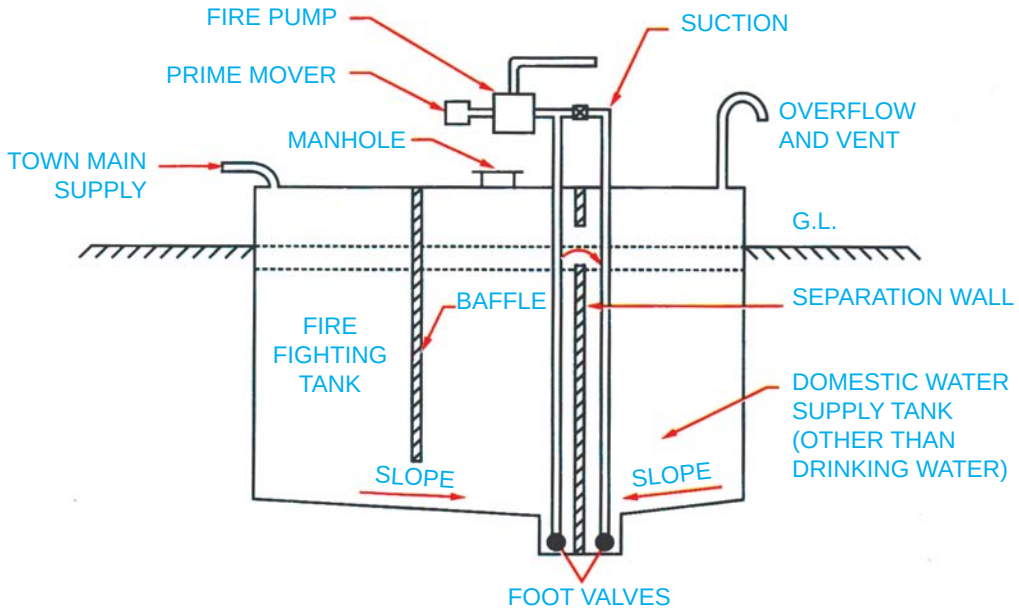
NOTE :

D - door 1220 * 2000 mm with double leaf.
W - window suitable size.

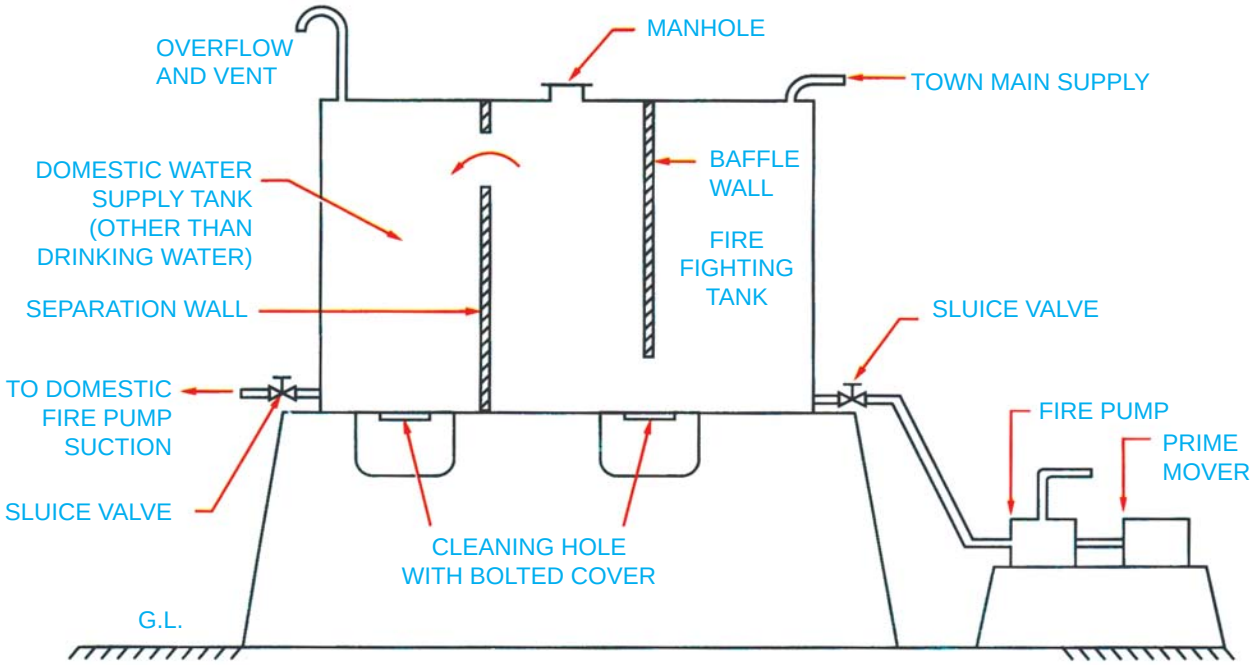
* UG sump and pump room should be as near as possible.
* Priming pump should be submersible type.

ANNEXURE VI

Typical Arrangement for Providing Combined Fire Fighting and Domestic Water Storage Tank
Part IV : Fire Protection National Building Code



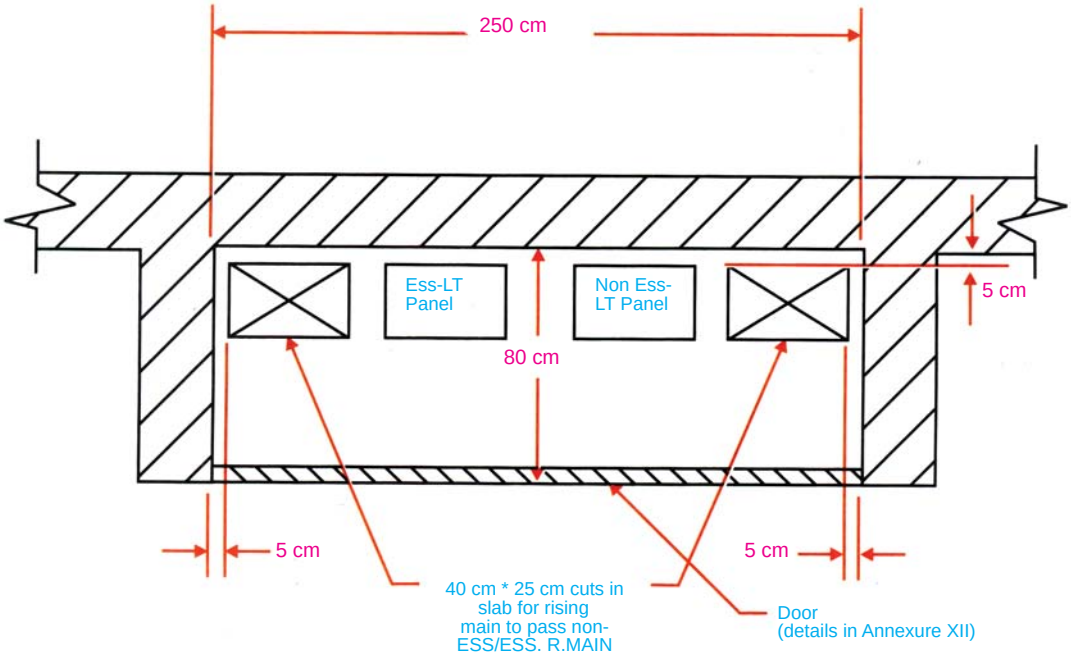
3A WITH NEGATIVE SUCTION



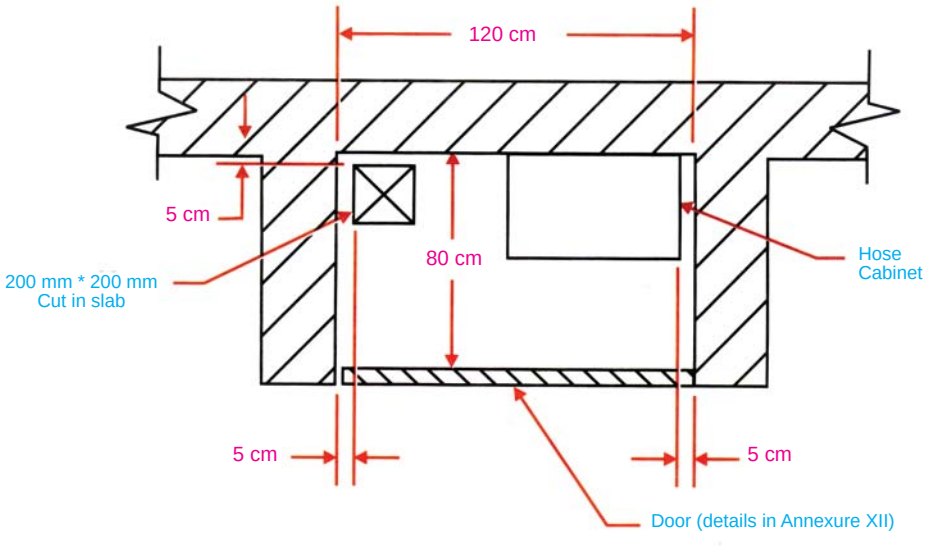
3B WITH POSITIVE SUCTION

ANNEXURE VIII

Electrical Rising Main and Wet Riser Shaft



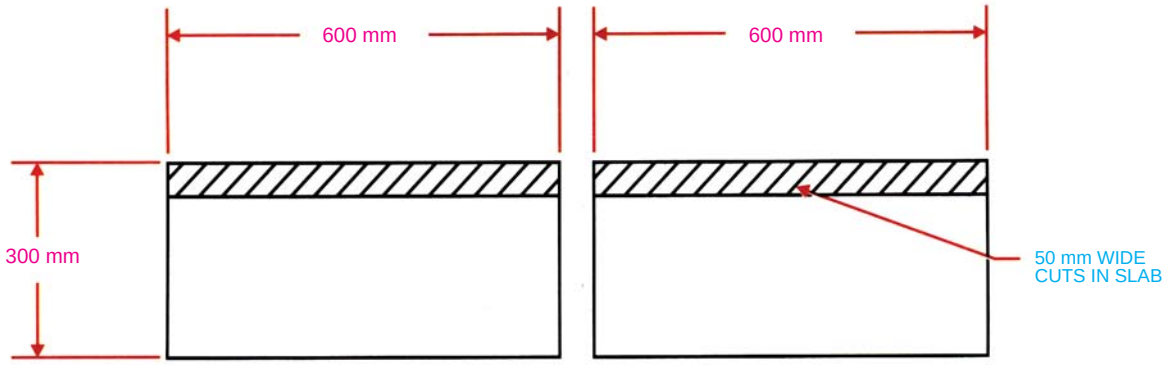
ELECTRICAL RISING MAIN SHAFT



WET RISER SHAFT
one for 1000 sq.mtrs Floor Area

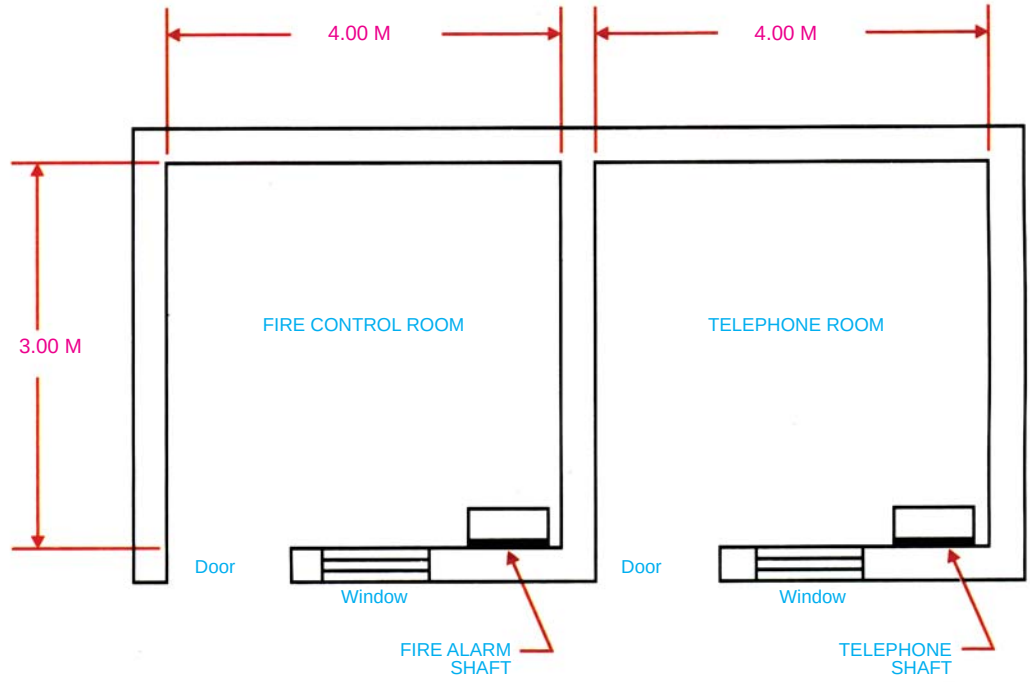
ANNEXURE IX

Telephone & Fire Control Room



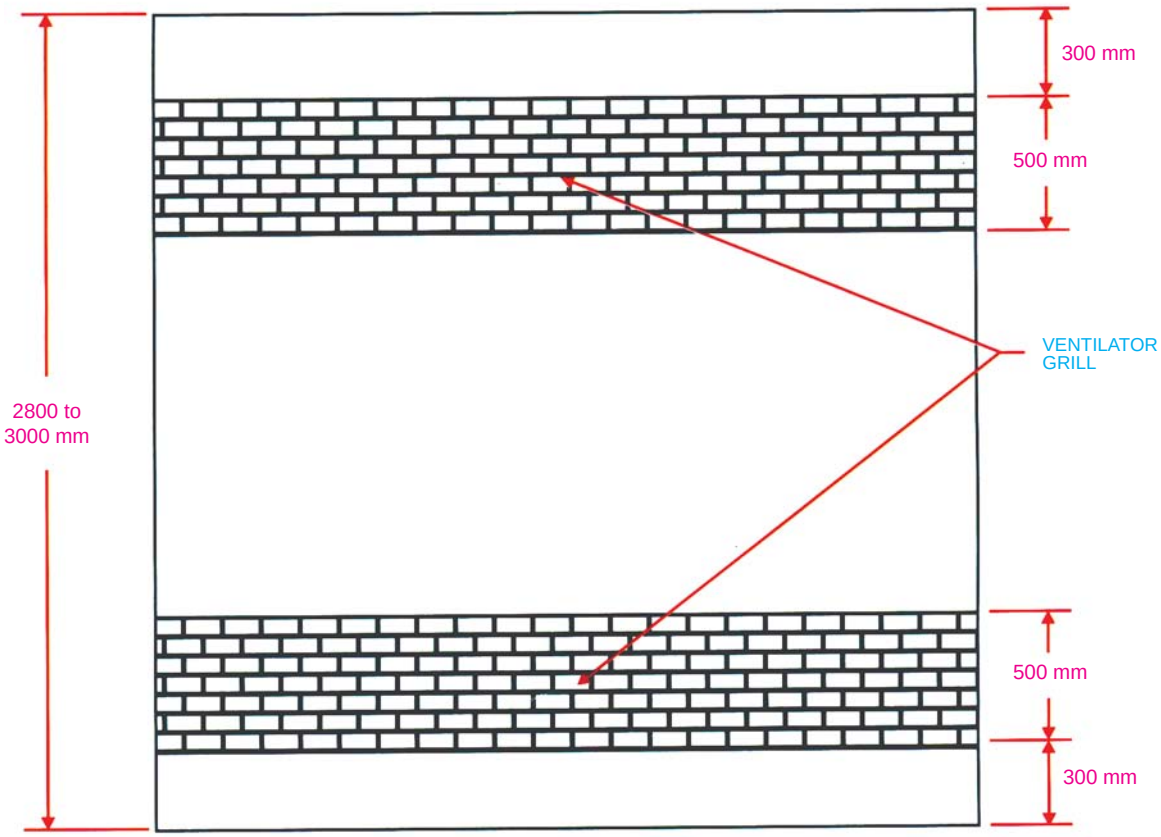
FIRE ALARM SHAFT DETAILS

TELEPHONE SHAFT DETAILS



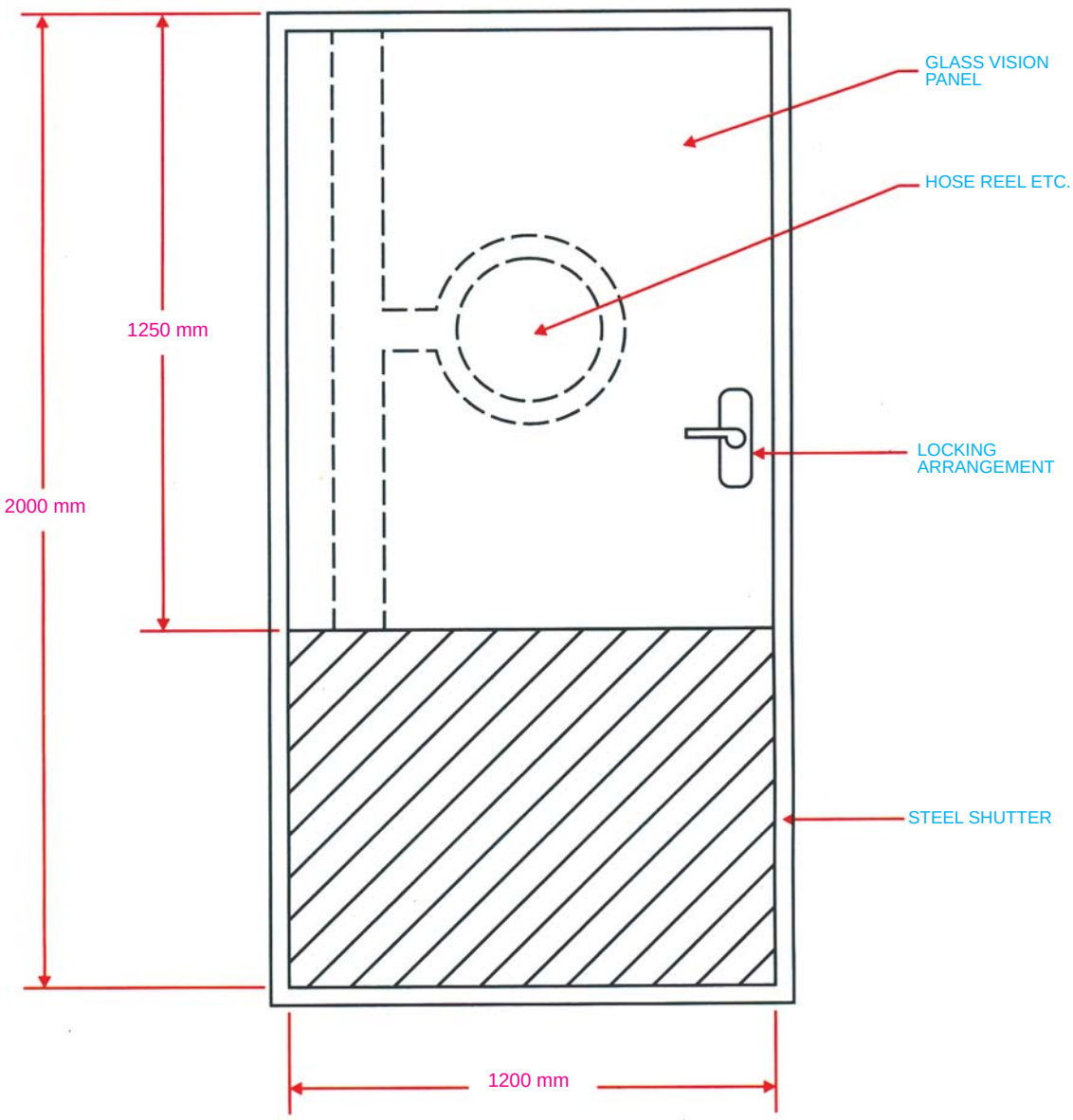
ANNEXURE X

Rolling Shutter for Sub-Station



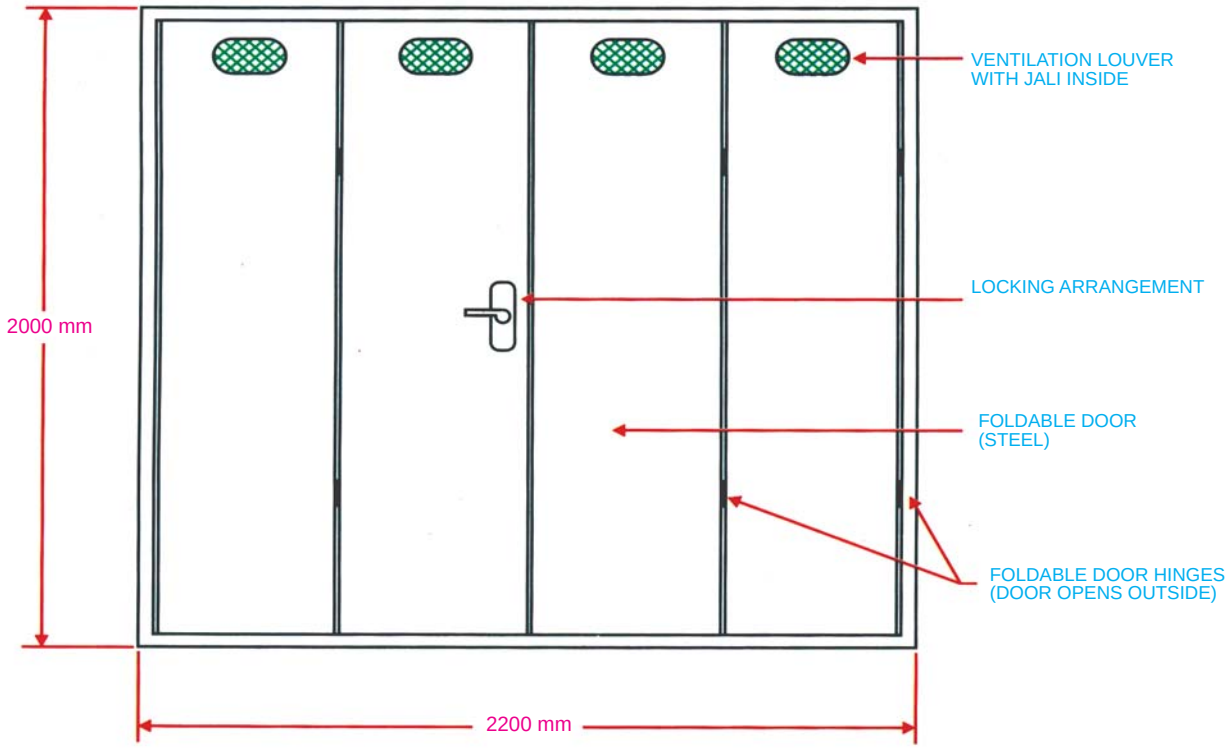
ANNEXURE XI

Wet Riser Shaft Door Details

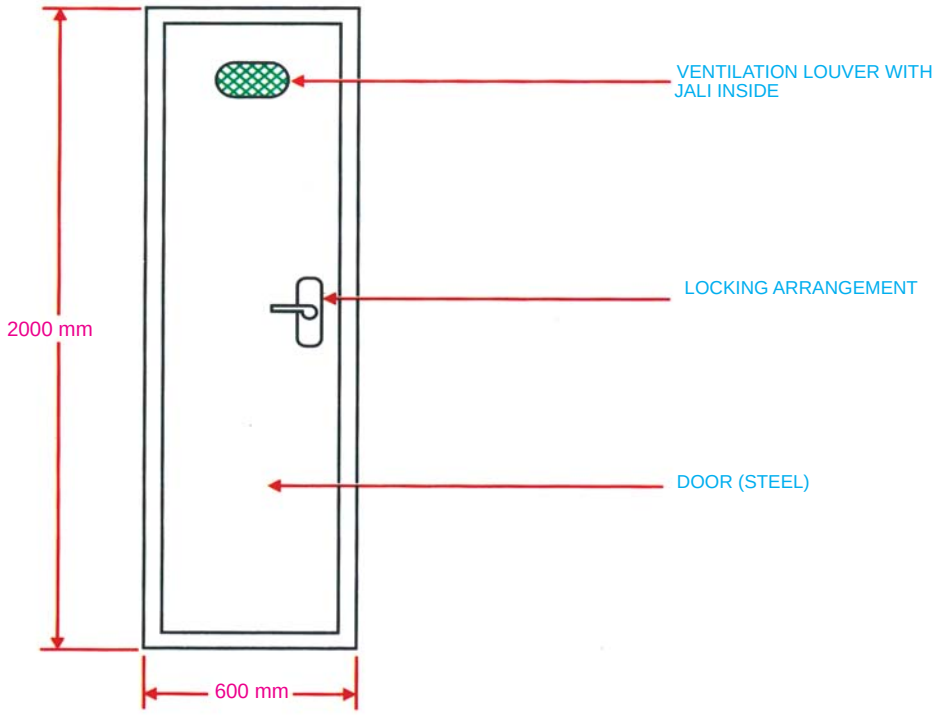


ANNEXURE XII

Electrical Shaft Door and Telephone Fire Alarm Shaft Door



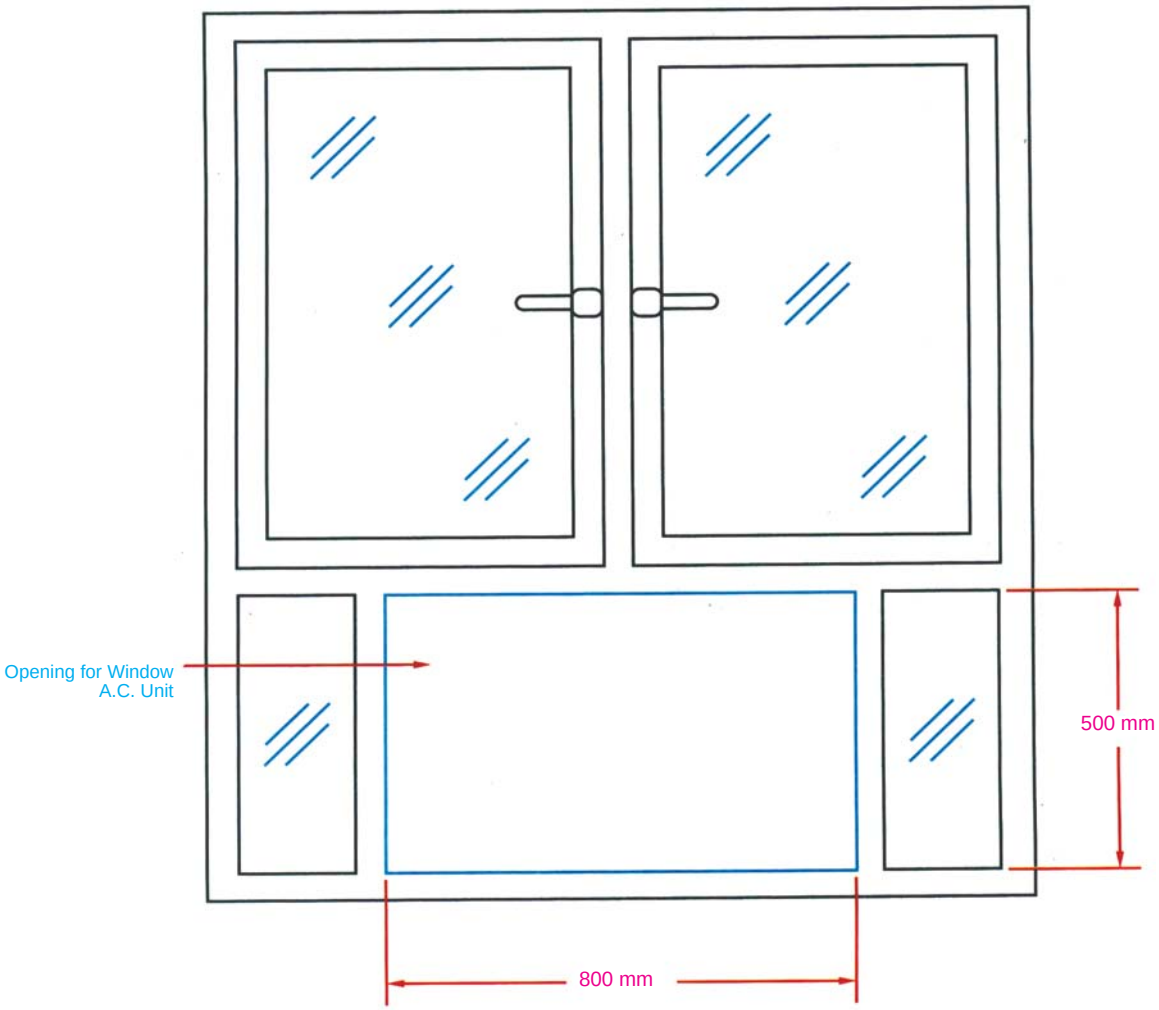
ELECTRICAL SHAFT DOOR DETAILS



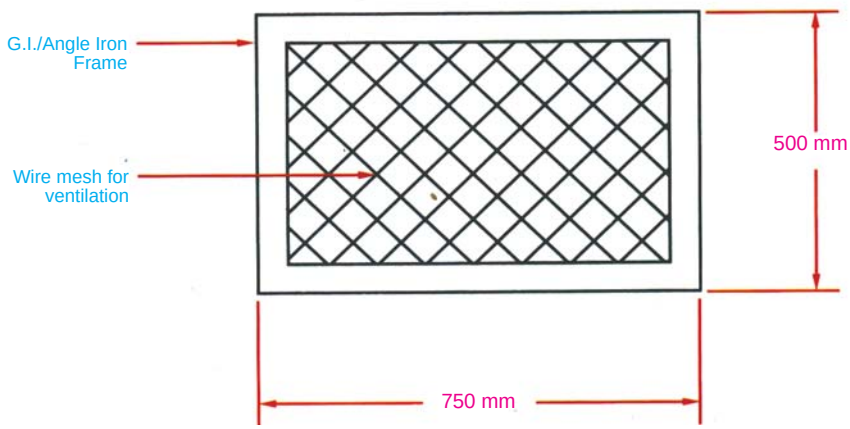
TELEPHONE / FIRE ALARM SHAFT DOOR DETAILS

ANNEXURE XIII

Window and Ventilator Design



WINDOW DESIGN COMPATIBLE WITH INSTALLATION OF WINDOW AC UNIT



VENTILATOR DESIGN

ANNEXURE XIV

Structural Details for Air-conditioning Plants in Office Buildings

(For Preliminary Drawing/Design only)

A	*Capacity of AC Plant (in MS office Building)*	
	Basement	90 Cu Meter/ton
	Ground Floor	75 Cu Meter/ton
	Intermediate Floors	70 Cu Meter/ton
	Top Floor	60 Cu Meter/ton

B	*Central Plant*	
	(i) Size of central plant room including weather maker	10 sqm + 0.8 sqm per ton (Clear height not less than 3.75 m below soffit of beam)
	(ii) Size of central plant room excluding weather maker	5 sqm + 0.5 sqm per ton
	(iii) Size of weather maker room	5 sqm + 0.3 sqm per ton (Clear height not less than 3 m below soffit of beam) (above 150 tons : 0.5 sqm per ton)
	(iv) Fresh Air opening in weather maker room	0.03 sqm per ton
	(v) (a) Main supply and return duct (Taken together)	0.10 sqm per ton
	(b) Supply grills (height 20 cm to 25 cm)	0.10 sqm per ton
	(c) Return grills (height 20 cm to 25 cm)	0.12 sqm per ton
	(vi) (a) Cooling tower : natural draft	0.40 sqm per ton
	(b) Cooling tower : induced draft	0.15 sqm per ton
	(vii) Cooling pond (depth 1.5 m)	1.0 sqm per ton
	(viii) Water consumption	20 litre per tone per hour
	(ix) Make up water tank	12 hrs./ 8 hrs. storage capacity for 24 hrs./ 12 hrs. operation respectively. Bottom level shall be 2 m above the cooling tower sump.

C	*Window type units*	
	Size of the opening in wall	80 cm wide * 50 cm high (see annexure XIII)

D	*E.T.A.C. Plant*	
	(i) Plant room	20 sqm + 0.6 sqm for every 100 cum of space to be cooled
	(ii) Fresh air shaft	0.25 sqm for 100 cum of space to be cooled
	(iii) Duct (masonry)	0.05 sqm for 100 cum of space to be cooled
	(iv) Duct (Metal)	0.10 sqm for 100 cum of space to be cooled

E	*Floor Loading (Assumed Uniformly Distributed Over Entire Area of the Room)*	
	1. Plant room (central)	3000 kg / sqm
	2. Plant room for package type unit (excluding pump sets & weather maker room)	1200 kg / sqm
	3. Pump room & weather maker room	1200 kg / sqm
	4. Cooling tower	
	(a) Natural draft	300 kg / ton
	(b) Masonry shell induced draft cooling tower (usually above 100 ton)	400 kg / ton
	(c) Wooden package wooden shell/ FRP type induced type cooling tower (usually above 100 tons)	100 kg / ton

ANNEXURE XV

Water Requirement for Fire Protection with Wet Riser/Down Corner System

As per N.B. Code

TABLE 4

Residential Buildings		
	U.G. Water Storage Tank Static	*Terrace Tank*
Above 15 m upto 30 m	50,000 lts	10,000 lts
Above 30 m upto 45 m	1,00,000 lts	20,000 lts
Above 45 m	2,00,000 lts	40,000 lts

TABLE 5

Business Building		
	U.G. Water Storage Tank Static	*Terrace Tank*
Above 15 m upto 30 m	1,00,000 lts (50,000 lts if covered area in G.F. is less than 300 sq. m.)	20,000 lts
Above 30 m upto 45 m	2,00,000 lts	20,000 lts
Above 45 m	2,50,000 lts	50,000 lts

ANNEXURE XVI

12 minimum Fire Safety Measures as per National Building Code

1.	Means of acess
2.	Underground / overhead water static tanks
3.	Automatic Sprinklers system
4.	First-aid Hose Reels
5.	Fire extinguishers of ISI certification marks
6.	Compartmentation
7.	Automatic fire detection and alarm system/ manually operated electrical fire alarm system
8.	Public address system
9.	Illuminated exit way marking signs
10.	Alternate source of electric supply
11.	Fire lift with fireman switch
12.	Wet rise/down corner system.