ELECTRICAL INSTALLATION AND ESTIMATING

SEMESTER-6TH

DEPARTMENT OF ELECTRICAL ENGINEERING

Lecture notes

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CHAPTER-1 INDIAN ELECTRICITY RULES ,1956

1. INTRODUCTION

Before actually studying Indian electricity rules (IE Rules) and other precaution , lets us understand why these rules and regulation have been framed.

The rules and regulation have been framed by competent authority to:

1. Safeguard consumers (users) of electrical energy from shock.
2. Minimize fire risk and
3. Ensure ,as far possible ,satisfactory operation of equipments and apparatus used.

1.1 DEFINATIONS

1. AMPERE-It means a unit of electricity current and is the unvarying electric current which when passed through a solution of nitrate in water , in accordance with the specification set out in annexture- 1 , deposits silver at the rate of 0.001118 of a gram per second.

2. ACCESSIBLE- It Means with in physical reach without use of any appliances or special effort:

3. APPARATUS-It means electrical apparatus and includes ,all machines fittings, accessories and appliances in which conductor are used.

4. BARE-It means not covered with insulating materials.

5. CABLE- It means a length of insulated single conductor (solid or stranded) or of two or more such conductor each provided with its own insulation ,which are laid up together. Such insulated conductor or conductor may not be provided with and overall mechanical protective covering.

6. CIRCUIT- It means an arrangement of conductor or conductor for the purpose of conveying energy and forming a system or a branch of a system .

7. CIRCUIT BREAKER- It means a device, capable of making and breaking the circuit under all condition and unless otherwise specified, so designed as to break the current automatically under the abnormal conditions.

8. CONDUCTORS-It means any wire, cable bar, tube, rail or place used for conducting energy and so arranged so as to be electrically connected to a system.

9. CONDUIT-It means rigid or flexible metallic tubing or mechanically strong and fire resisting non-metallic tubing in which a cable or cable may be drawn for the purpose of affording it or them mechanical protection.

10. CONDUCTOR VOLTAGE-It means the difference of electrical potential measured in volt between any two conductor or between any parts of either conductor and the earth as , ensured by a suitable voltmeter and is said to be

(a) LOW VOLTAGE- where the voltage does not exceed 250 volt under normal condition subject , however, to the percentage variation allowed by these rules.

(b) MEDIUM VOLTAGE-where the voltage does not exceed 650 volt fusible cut-out. It under normal condition subject, however, to the percentage variation allowed by these rules.

(c) HIGH VOLTAGE-where the voltage does not exceed 33,000 volt under normal condition subject, however, to the percentage variation allowed by these rules.

(d) EXTRA HIGH VOLTAGE - where the voltage does not exceed 33,000 volt under normal condition subject, however, to the percentage variation allowed by these rules.

11. CUT-OUT –it means any appliance for automatically interrupting the transmission of energy through any conductor when the current raises above predetermined amount and shall also included fusible cut-out.

12. DANGER- it means danger to health of life any part of body from shock burn or other injury to person or property of from fire or explosion ,attendant upon the generation, transmission , transformation ,conversion ,distribution, or use of energy.

13. DEAD - it means at or about earth potential and disconnected from any live system : provided that apparatus separated from a conductor by a spark gap shall not be deemed to be dead.

Note: the term dead is used only with reference to current carrying part when these parts are not alive.

14. LIVE- it means electrically charged.

15. OHMS- it means a unit of electrical resistance and is the resistance offered to an unvarying electric current by a coulomb of mercury at the temperature melting of ie 14.4521 gram in mass of an uniform cross section al area of length of 16.3 centimeters.

16. SWITCHGEAR- It means it denotes switches, breaker, cut-out and other apparatus used for operation ,regulation and control of circuit.

17. VOLT- It means a unit of electromotive force and is the electric pressure which ,when steadily applied to conductor ,the resistance of which is one ohm, will produce a current of one ampere.

18. EARTHING SYSTEM- It means an electrical system in which all conductors are earthed.

19. INSTALLATION- It means any composite electrical units used for the purpose of generating, transforming, transmitting, converting, distributing, or utilizing energy.

20. SPAN- It means the horizontal distance between two adjacent supporting points of an overhead conductor.

1.2 GENERAL SAFETY PRECAUTIONS

Rule 29 (Construction, installation, protection, operation and maintenance of electric supply lines and apparatus)

All electric supply lines and apparatus shall be of sufficient ratings for power, insulation and estimated fault current and of sufficient mechanical strength, for the duty which they may be required to perform under the environmental conditions of installation, and shall be constructed, installed, protected, worked and maintained in such a manner as to ensure safety of human beings, animals and property.

Rule 30 Service lines and apparatus on consumer's premises

(1) The supplier shall ensure that all electric supply lines, wires, fittings and apparatus belonging to him or under his control, which are on a consumer's premises, are in a safe condition and in all respects fit for supplying energy and the supplier shall take due precautions to avoid danger arising on such premises from such supply lines, wires, fittings and apparatus.

(2) Service-lines placed by the supplier on the premises of a consumer which are underground or which are accessible shall be so insulated and protected by the supplier as to be secured under all ordinary conditions against electrical, mechanical, chemical or other injury to the insulation.

(3) The consumer shall, as far as circumstances permit, take precautions for the safe custody of the equipment on his premises belonging to the supplier.

(4) The consumer shall also ensure that the installation under his control is maintained in a safe condition.

Rule 31 Cut-out on consumer's premises

(1) The supplier shall provide a suitable cut-out in each conductor of every service-line other than an earthed or earthed neutral conductor or the earthed external conductor of a concentric cable within a consumer's premises, in an accessible position. Such cut-out shall be contained within an adequately enclosed fireproof receptacle.

Where more than one consumer is supplied through a common service-line, each such consumer shall be provided with an independent cut-out at the point of junction to the common service.

(2) Every electric supply line other than the earth or earthed neutral conductor of any system or the earthed external conductor of a concentric cable shall be protected by a suitable cut-out by its owner.

Rule 32 Identification of earthed and earthed neutral conductors and position of switches and cut-outs therein.

Where the conductors include an earthed conductor of a two-wire system or an earthed neutral conductor of a multi-wire system or a conductor which is to be connected thereto, the following conditions shall be complied with--

(1) An indication of a permanent nature shall be provided by the owner of the earthed or earthed neutral conductor, or the conductor which is to be connected thereto, to enable such conductor to be distinguished from any live conductor. Such indication shall be provided-

(a) Where the earthed or earthed neutral conductor is the property of the supplier, at or near the point of commencement of supply;

(b) Where a conductor forming part of a consumer's system is to be connected to the supplier's earthed or earthed neutral conductor, at the point where such connection is to be made.

(c) In all other cases, at a point corresponding to the point of commencement of supply or at such other points as may be approved by an Inspector or any officer appointed to assist the Inspector .

(2) No cut-out, link or switch other than a linked switch arranged to operate simultaneously on the earthed or earthed neutral conductor and live conductors shall be inserted or remain inserted in any earthed or earthed neutral conductor of a two wire-system or in any earthed or earthed neutral conductor of a multi-wire system or in any conductor connected thereto with the following exceptions:

(d) A link for testing purposes, or

(e) A switch for use in controlling a generator or transformer.

Rule 33 Earthed terminal on consumer's premises

(1) The supplier shall provide and maintain on the consumer's premises for the consumer's use a suitable earthed terminal in an accessible position at or near the point of commencement of supply as defined under rule 58.

Provided that in the case of medium, high or extra-high voltage installation the consumer shall, in addition to the afore mentioned earthing arrangement, provide his own earthing system with an independent electrode.

Provided further that the supplier may not provide any earthed terminal in the case of installations already connected to his system on or before the date to be specified by the State Government in this behalf if he is satisfied that the consumer's earthing arrangement is efficient.

(2) The consumer shall take all reasonable precautions to prevent mechanical damage to the earthed terminal and its lead belonging to the supplier.

(3) The supplier may recover from the consumer the cost of installation on the basis of schedule of charges notified in advance and where such schedule of charges is not notified, the procedure prescribed, in sub-rule (5) of rule 82 will apply

Rule 34 Accessibility of bare conductor

Where bare conductors are used in a building, the owner of such conductors shall-

(a) Ensure that they are inaccessible.

(b) Provide in readily accessible position switches for rendering them dead whenever necessary.

(c) Take such other safety measures as are considered necessary by the Inspector.

Rule 35 Danger Notices

The owner of every medium, high and extra-high voltage installation shall affix permanently in a conspicuous position a danger notice in Hindi or English and the local language of the district, with a sign of skull and bones.

(a) Every motor, generator, transformer and other electrical plant and equipment together with apparatus used for controlling or regulating the same;

(a) All supports of high and extra-high voltage overhead lines which can be easily climb-upon without the aid of ladder or special appliances;

(b) Luminous tube sign requiring high voltage supply, X-ray and similar high- frequency installations;

Provided that where it is not possible to affix such notices on any generator, motor transformer of other apparatus, they shall be affixed as near as possible thereto; or the word 'danger' and the voltage of the apparatus concerned shall be permanently painted on it.

Provided further that where the generator, motor, transformer of other apparatus is within an enclosure one notice affixed to the said enclosure shall be sufficient for the purposes of this rule.

Rule 36 Handling of electric supply lines and apparatus

(1) Before any conductor or apparatus is handled adequate precautions shall be taken, by earthing or other suitable means, to discharge electrically such conductor or apparatus, and any adjacent conductor or apparatus if there is danger there from, and to prevent any conductor or apparatus from being accidentally or inadvertently electrically charged when persons are working thereon.

(2) No person shall work on any live electric supply line or apparatus and no person shall assist such person on such work, unless he is authorised in that behalf, and takes the safety measures approved by the Inspector.

(3) The supplier shall provide and maintain on the consumer's premises for the consumer's use a suitable earthed terminal in an accessible position at or near the point of commencement of supply as defined under rule 58.

Rule 40 Street boxes

(1) Street boxes shall not contain gas pipes, and precautions shall be taken to prevent, as far as reasonably possible, any influx of water or gas.

(2) Where electric supply lines forming part of different systems pass through the same street box, they shall be readily distinguishable from one another and all electric supply lines at high or extra-high voltage in street boxes shall be adequately supported and protected to as to prevent risk of damage to or danger from adjacent electric supply lines.

(3) All street boxes shall be regularly inspected for the purpose of detecting the presence of gas and if any influx or accumulation is discovered, the owner shall give immediate notice to any authority or company who have gas mains in the neighbourhood of the street box and in cases where a street box is large enough to admit the entrance of a person after the electric supply lines or apparatustherein have been placed in position, ample provision shall be made.

(a) To ensure that any gas which may by accident have obtained access to the box shall escape before a person is allowed to enter; and

(b) For the prevention of danger from sparking.

(4) The owners of all street boxes or pillars containing circuits or apparatus shall ensure that their covers and doors are so provided that they can be opened only by means of a key or a special appliance.

Rule 41 Distinction of different circuits of different voltage

The owner of every generating station, sub- station, junction-box or pillar in which there are any circuits or apparatus, whether intended for operation at different voltages or at the same voltage, shall ensure by means of indication of a permanent nature that the respective circuits are readily distinguishable from one another.

Rule 43 Provisions applicable to protective equipment

(1) Fire buckets filled with clean dry sand and ready for immediate use for extinguishing fires, in addition to fire extinguishers suitable for dealing with electric fires, shall be conspicuously marked and kept in all generating stations, enclosed sub-stations and switch stations in convenient situation.

The fire extinguishes shall be tested for satisfactory operation at least once a year and record of such tests shall be maintained.

(2) First-aid boxes or cupboards, conspicuously marked and equipped with such contents as the State Government may specify, shall be provided and maintained in every generating station, enclosed sub-station and enclosed switch station so as to be readily accessible during all working hours. All such boxes and cupboards shall, except in the case of unattended sub-stations and switch stations, be kept in charge of responsible persons who are trained in first-aid treatment and one of such person shall be available during working hours.

Rule 44 Instructions for restoration of persons suffering from electric shock

(1) Instructions, in English or Hindi and the local language of the district and where Hindi is the local language, in English and Hindi for the restoration of persons suffering from electric shock, shall be affixed by the owner in a conspicuous place in every generating station, enclosed sub-station.

(2) Copies of the instructions shall be supplied on demand by an officer or officers appointed by the Central or the State Government in this behalf at a price to be fixed by the Central or the State Government.

(3) The owner of every generating station, enclosed sub-station, enclosed switch-station and every factory or other premises to which this rule applies, shall ensure that all authorised persons employed by him are acquainted with and are competent to apply the instructions referred to in sub-rule (1)

Rule 45 Precautions to be adopted by consumers [1][owners occupiers], electrical contractors, electrical workmen and suppliers

(1) No electrical installation work, including additions, alterations, repairs and adjustments to existing installations, except such replacement of lamps, fans, fuses, switches, low voltage domestic appliances and fittings as in no way altersits capacity or character, shall be carried out upon the premises of or on behalf of any consumer, supplier, owner or occupier for the purpose of supply to such [2][consumer, supplier, owner or occupier except by an electrical contractor licensed in this behalf by the State Government and under the direct supervision ofa person holding a certificate of competency and by a person holding a permit issued or recognized by the State Government.

Central Government and in the case of installations in mines, oil fields and railways, the Central Government and in other cases the State Government may, by notification in the Official Gazette, exempt, on such conditions as it may impose, any such work described therein either generally or in the case of any specified class of consumers, suppliers, owners or occupiers] from so much of this sub-rule as requires such work to be carried out by an electrical contractor licensed by the State Government in this behalf.

(2) No electrical installation work which has been carried out in contravention of sub-rule (1) shall either be energised or connected to the works of any supplier.

Rule 46 Periodical inspection and testing of consumer, installation

(1).

(a) Where an installation is already connected to the supply system of the supplier, every such installation shall be periodically inspected and tested at intervals not exceeding five years either by the Inspector or any officer appointed to assist the Inspector or by the supplier as may be directed by the State Government in this behalf or in the case of installations belonging to, or under the control of the Central Government, and in the case of installation in mines, oilfieldsand railways by the Central Government.

(b) Where the supplier is directed by the Central or the State Government as the case may be to inspect and test the installation he shall report on the condition of the installation to the consumer concerned in a form approved by the Inspector and shall submit a copy of such report to the Inspector or to any officer appointed to assist the Inspector and authorised under sub-rule (2) of rule 4A.

(c) Subject to the approval of the Inspector, the forms of inspection report contained in Annexure IX-A may, with such variations as the circumstances of each case require, be used for the purposes of this sub-rule.

(2) (a) The fees for such inspection and test shall be determined by the Central or the State Government, as the case may be, in the case of each class of consumers and shall be payable by the consumer in advance.

(b) In the event of the failure of any consumer to pay the fees on or before the date specified in the fee-notice, supply to the installation of such consumer shall be liable to be disconnected under the direction of the Inspector.
Such disconnection, however, shall not be made by the supplier without giving to the consumer seven clear days' notice in writing of his intention so to do.
(3) Notwithstanding the provisions of this rule, the consumer shall at all times be solely responsible for the maintenance of his installation in such condition as to be free from danger.

1.3 GENERAL CONDITIONS RELATING TO SUPPLY AND USE OF ENERGY

Rule 47. Testing of consumer's installation

(1) Upon receipt of an application for a new or additional supply of energy and before connecting the supply or reconnecting the same after a period of six months, the supplier shall inspect and test the applicants' installation.

The supplier shall maintain a record of test results obtained at each supply point toa consumer, in a form to be approved by the Inspector.

(2) If as a result of such inspection and test, the supplier is satisfied that the installation is likely to constitute danger, he shall serve on the applicant a notice in writing requiring him to make such modifications as are necessary to render the installation safe. The supplier may refuse to connect or reconnect the supply until the required modifications have been completed and he has been notified by the applicant.

Rule 48.Precautions against leakage before connection

The supplier shall not connect with his works the installation or apparatus on the premises of any applicant for supply unless he is reasonably satisfied that the connection will not at the time of making the connection cause a leakage from that installation or apparatus of a magnitude detrimental to safety. Compliance with this rule shall be checked by measuring the insulation resistance as provided below:

(i) High Voltage Equipments installations-

(a) High Voltage equipments shall have the IR value as stipulated in therelevant Indian Standard.

(b) At a pressure of 1000 V applied between each live conductor and earth for a period of one minute the insulation resistance of HV installations shall be at least 1 Mega ohm or as specified by the [1][Bureau of Indian Standards] from time to time.

(ii) Medium and Low Voltage Installations- At a pressure of 500 V applied between each live conductor and earth for a period of one minute, the insulation resistance of medium and low voltage installations shall be at least 1 Mega ohm or as specified by the [2][Bureau of Indian Standards] from time to time.]

(3) If the supplier declines to make a connection under the provisions of sub- rule (1), he shall serve upon the applicant a notice in writing stating his reason for so declining.

Rule 49 Leakage on consumer's premises

If the Inspector or any officer appointed to assist the Inspector and authorised under sub-rule (2) of rule 4A or the supplier had reason to believe that there is in the system of a consumer leakage which is likely to affect injuriously the use of energy by the supplier or by other persons, or which is likely to cause danger, he may give the consumer reasonable notice in writing that he desires to Inspect and test the consumers' installation.

Rule 51 Provision Application to Medium ,High or Extra High voltage installations

Provisions applicable to medium, high or extra-high voltage installations. The following provisions shall be observed where energy at medium, high or extra- high voltage is supplied, converted, transformed or used :

(1) (a) All conductors (other than those of overhead lines) shall be completely enclosed in mechanically strong metal casting or metallic covering which is electrically and mechanically continuous and adequately protected against mechanical damage unless the said conductors are accessible only to an authorised person or are installed and protected to the satisfaction of the Inspectorso as to prevent danger.

(b) All metal works, enclosing, supporting or associated with the installation, other than that designed to serve as a conductor shall be connected with an earthing system as per standards laid down in the Indian Standards in this regard and in also accordance with rule 61(4).]

(c) Every switchboard shall comply with the following provisions, namely: -

(i) A clear space of not less than 1 metre in width shall be provided in front of the switchboard;

(ii) If there are any attachments or bare connections at the back of the switchboard, the space (if any) behind the switchboard shall be either less than 20 centimetres or more than 75 centimetres in width, measured from the farthest outstanding part of any attachment or conductor;

(iii) If the space behind the switchboard exceeds 75 centimetres in width, there shall be a passage way from either end of the switchboard clear to a eight. of 1.83 mt.(6 ft).

Rule 54 Declared voltage of supply to consumer

Except with the written consent of the consumer or with the previous sanction of the State Government a supplier shall not permit the voltage at the point of commencement of supply as defined under rule 58 to vary from the declared voltage-

(i) In the case of low or medium voltage, by more than 6 per cent, or;

(ii) In the case of high voltage, by more than 6 per cent on the higher side or by more than 9 per cent on the lower side, or;

(iii) In the case of extra-high voltage, by more than 10 per cent on the higher side or by more than 12.5 per cent on the lower side.

Rule 55 Declared frequency of supply to consumer

Except with the written consent of the consumer or with the previous sanction of the State Government a supplier shall not permit the frequency of an alternating current supply to vary from the declared frequency by more than 3 per cent.

Rule 56 Sealing of meters, and cut-outs

(1) A supplier may affix one or more seals to any cut-out and to any meter, maximum demand indicator, or other apparatus placed upon a consumer's premises in accordance with section 26, and no person other than the supplier shall break any such seal.

(2) The consumer shall use all reasonable means in his power to ensure that no such seal is broken otherwise than by the supplier.

(3) The word 'supplier' shall for the purpose of this rule include a State Government when any meter, maximum demand indicator or other apparatus is placed upon a consumer's premises by such Government.

Rule 57 Meters, maximum demand indicators and other apparatus on consumer's premises

(1) Any meter or maximum demand indicator or other apparatus placed upon a consumer's premises in accordance with section 26 shall be of appropriate capacity and shall be deemed to be correct if its limits of error are within the limits specified in the relevant Indian Standard Specification and where no such specification exists, the limits of error do not exceed 3 per cent above or below absolute accuracy at all loads in excess of one tenth of full load and up to full load.

(2) No meter shall register at no load.

(3) Every supplier shall provide and maintain in proper condition such suitable apparatus as may be prescribed or approved by the Inspector for the examination, testing and regulation of meters used or intended to be used in connection with thesupply of energy.

Provided that the supplier may with the approval of the Inspector and shall, if required by the Inspector, enter into a joint arrangement with any other supplier for the purpose aforesaid.

(4) Every supplier shall examine, test and regulate all meters, maximum demand indicators and other apparatus for ascertaining the amount of energy supplied before their first installation at the consumer's premises and at such other intervals as may be directed by the State Government in this behalf.

(5) Every supplier shall maintain a register of meters showing the date of the last test, the error recorded at the time of the test, the limit of accuracy after adjustment and final test, the date of installation, withdrawal, reinstallation, etc., for the examination of the Inspector or his authorised representative.

Rule 58. Point of commencement of supply

The point of commencement of supply of energy to a consumer shall be deemed to be the point at the incoming terminal of the cut-outs installed by the consumer under rule 50.

Rule 59. Precautions against failure of supply: Notice of failures

(1) The layout of the electric supply lines of the supplier for the supply of energy throughout his area of supply shall under normal working conditions be sectionalised and so arranged, and provided with cut-outs or circuit-breakers so located, as to restrict within reasonable limits the extent of the portion of thesystem affected by any failure of supply.

(2) The, supplier shall take all reasonable precautions to avoid any accidental interruptions of supply, and also to avoid danger to the public or to any employee or authorised person when engaged on any operation during and in connection with the installation, extension, replacement, repair and maintenance of any works.

(3) The supplier shall send to the Inspector [1][or any officer of a specified rank and class appointed to assist the Inspector] notice of failure of supply of such kind as the Inspector [1][or any officer of specified rank and class to assist the Inspector] may from time to time require to be notified to him, and such notice shall be sent by the earliest practicable post after the failure occurs or after the failure becomes known to the supplier and shall be in such form and contain such particulars as Inspector may from time to time specify

(4) For the purpose of testing or for any other purpose connected with the efficient working of the undertaking, the supply of energy may be discontinued by the supplier for such period as may be necessary, subject (except in cases of emergency) to not less than 24 hours notice being given by the supplier to all consumers likely to be affected by such discontinuance:

Provided that the supply of energy shall be discontinued during such hours as are likely to interfere the least with the use of energy by consumers and the energy shall not be discontinued if the Inspector so directs.

Rule 60 Test for resistance of insulation

(1) Where any electric supply line for use at low or medium voltage has been disconnected from a system for the purpose of addition, alteration or repair, such electric supply line shall not be reconnected to the system until the supplier or the owner has applied the test prescribed under rule 48.

The provision of sub-rule (1) shall not apply to overhead lines except, overhead insulated cables unless the Inspector otherwise directs in any particular case.

Rule 61 Connection with earth

(1) The following provisions shall apply to the connection with earth of systems at low voltage in cases where the voltage normally exceeds 125 volts and of systems at medium voltage: -

(a) Neutral conductor of a phase, 4 wire system and the middle conductor of a 2 phase, 3-wire system shall be earthed by not less than two separate and distinct connections with a minimum of two different earth electrodes of such large number as may be necessary to bring

the earth resistance to a satisfactory value both at the generating station and at the sub-station. The earth electrodes so provided, may be interconnected to reduce earth resistance. It may also be earthed at one or more points along the distribution system or service line in addition to any connection with earth which may be at the consumer's premises.

(b) In the case of a system comprising electric supply lines having concentric cables, the external conductor of such cables shall be earthed by two separate and distinct connections with earth.

(c) The connection with earth may include a link by means of which the connection may be temporarily interrupted for the purpose of testing or for locatinga fault.

(d) (i) In a direct current three wire system the middle conductor shall be earthed at the generating station only, and the current from the middle conductor to earth shall be continuously recorded by means of a recording ammeter, and if any time the current exceeds one-thousandth part of the maximum supply-current immediate steps shall be taken to improve the insulation of the system.

(ii) Where the middle conductor is earthed by means of a circuit breaker with a resistance connected in parallel, the resistance shall not exceed 10 ohms and on the opening of the circuit breaker, immediate steps shall be taken to improve the insulation of the system, and the circuit-breaker shall be reclosed as soon as possible.

(iii) The resistance shall be used only as a protection for the ammeter in case of earths on the system and until such earths are removed. Immediate steps shall be taken to locate and remove the earth.

(e) In the case of an alternating current system, there shall not be inserted in the connected with earth any impedance (other than that required solely for the operation of switch-gear of instruments), cut-out or circuit-breaker, and the result of any test made to ascertain whether the current (if any) passing through the connection with earth is normal shall be duly recorded by the supplier.

(f) No person shall make connection with earth by the aid of, nor shall be keep it in contact with, any water main not belonging to him except with the consent of the owner thereof and of the Inspector.

(g) Alternating current systems which are connected with earth as aforesaid may be electrically interconnected.

Provided that each connection with earth is bonded to the metal sheathing and metallic armouring (if any) of the electric supply lines concerned.

(2) The frame of every generator, stationary motor, portable motor, and the metallic parts (not intended as conductors) of all transformers and any other apparatus used for regulating or controlling energy and all medium voltage energy consuming apparatus shall be earthed by the owner by two separate and distinct connections with earth.

(3) All metal castings or metallic coverings containing or protecting any electric supply-line or apparatus shall be connected with earth and shall be so joined and connected across all junction boxes and other openings as to make good mechanical and electrical connection throughout their whole length.

(4) All earthing systems belonging to the supplier shall in addition, be tested for resistance on dry day during the dry season not less than once every two years.

(5) A record of every earth test made and the result thereof shall be kept by the supplier for a period of not less than two years after the day of testing and shall be available to the Inspector or any officer appointed to assist the Inspector and authorised under sub-rule (2) of rule 4A when required.

Rule 62 Systems at medium voltage

Where a medium voltage supply system is employed, the voltage between earth and any conductor forming part of the same system shall not, under normal conditions, exceed low voltage.

Rule 63 Approval by Inspector

(1) Before making an application to the Inspector for permission [1][to commence or recommence supply after an installation has been disconnected for one year and above] at high or extra-high voltage to any person, the supplier shall ensure that the high or extra-high voltage electric supply lines or apparatus belonging to him are placed in position, properly joined and duly completed and examined. The supply of energy shall not be commenced by the supplier unless and until the Inspector is satisfied that the provisions of rules 65 to 69 both inclusive have been complied with and the approval in writing of the Inspector have been obtained by him.

Provided that the supplier may exercise the aforesaid electric supply lines or apparatus for the purpose of tests specified in rule 65.

(2) The owner of any high or extra-high voltage installation shall, before making application to the Inspector for approval of his installation or additions thereto, test every high or ext.-a-high voltage circuit or additions thereto, other than an overhead line, and satisfy himself that they withstand the application of the testing voltage set out in sub-rule (1) of rule 65 and shall duly record the results of such tests and forward them to the Inspector.

Provided that an Inspector may direct such owner to carry out such tests as he deems necessary or, if he thinks fit, accept the manufacturer's certified tests in respect of any particular apparatus in place of the tests required by this sub-rule.

(3) The owner of any high or extra-high voltage installation who makes any additions or alterations to his installation shall not connect to the supply his apparatus or electric supply lines, comprising the said alterations or additions unless and until such alterations or additions have been approved in writing by the Inspector.

Rule 64 Use of energy at high and extra-high voltage

(1) The Inspector shall not authorise the supplier to commence supply or where the supply has been discontinued for a period of one year and above, to commence the supply at high or extra-high voltage to any consumer unless.

(a) All conductors and apparatus situated on the premises of the consumer are so placed as to be inaccessible except to an authorised person and all operations in connection with the said conductors and apparatus are carried out by anauthorised person;

(b) The consumer has provided and agrees to maintain a separate building or a locked weather-proof and fire-proof enclosure of agreed design and location, to which the supplier at all times have access for the purpose of housing his apparatus and metering equipment, or where the provision for a separate building or enclosure is impracticable, the consumer has segregated the aforesaid apparatus of the supplier from any other part of his own apparatus;

Provided that such segregation shall be by the provision of fire proof walls, if the Inspector considers it to be necessary;

Provided further that in the case of an out-door installation consumer shall suitably segregate the aforesaid apparatus belonging to the supplier from his own to the satisfaction of the Inspector;

(c) All pole type sub-stations are constructed and maintained in accordance with rule 69.

(2) The following provisions shall be observed where energy at high or extra- high voltage is supplied, converted, transformed or used: -

(a) (i) Clearances as per Indian Standard Code shall be provided for electrical apparatus so that sufficient space is available for easy operation and maintenance without any hazard to the operating and maintenance personnel working near the equipment and for ensuring adequate ventilation.

(iii) The following minimum clearances shall be maintained for bare conductors or live parts of any apparatus in out-door substations, excluding overhead lines, of HV and EHV installations: -

Volt Class age	**Voltage**	Ground clearance (Metres)	Sectional clearance (Metres)
Not exceeding	11KV	2.75	2.6
	33KV	3.7	2.8
-do-	66KV	4.0	3.0
-do-	132KV	4.6	3.5
-do-		5.5	4.3
-do-	22OKV	8.0	6.5]
-do-	40OKV		

(b) The windings of motors or other apparatus within reach from any position in which a person may require to be shall be suitably protected so as to prevent danger.

(c) Where transformer or transformers are used, suitable provision shall be made, either by connecting with earth a point of the circuit at the lower voltage or otherwise, to guard against danger by reason of the said circuit becoming accidentally charged above its normal voltage by leakage from or contact with the circuit at the higher voltage.

(d) A sub-station or a switch station with apparatus having more than 2000 litres of oil shall not be located in the basement where proper oil draining arrangement cannot be provided.

Rule 65 Testing, Operation and Maintenance

(1) Before approval is accorded by the Inspector under rule 63, the manufacturer's test certificates shall, if required, be produced for all the routine tests as required under the relevant Indian Standard.

(2) No new HV or EHV apparatus, cable or supply line shall be commissioned unless such apparatus, cable or supply line are subjected to site tests as per relevant code of practice of the [1][Bureau of Indian Standards].

(3) No HV of EHV apparatus, cable or supply line which has been kept disconnected, for a period of 6 months or more, from the system for alterations or repair shall be corrected to the system until such apparatus, cable or supply line are subjected to the relevant tests as per code of practice of [1][Bureau of Indian Standards.]

(4) Notwithstanding the provisions of sub-rules (1) to (3) (both inclusive) the Inspector may require certain additional tests to be carried out before charging the installations or subsequently.

(5) All apparatus, cables and supply lines shall be maintained in healthy conditions and tests shall be carried out periodically as per the relevant codes of practice of the [Bureau of Indian Standards].

Rule 66 Metal sheathed electric supply lines. Precautions against excess leakage

(1) The following provisions shall apply to electric supply lines (other than overhead lines for use at high or extra-high voltage: -

(a) The conductors shall be enclosed in metal sheathing which shall be electrically continuous and connected with earth, and the conductivity of the metal sheathing shall be maintained and reasonable precautions taken where necessary to avoid corrosion of the sheathing.

(b) The resistance of the earth connection with metallic sheath shall be kept low enough to permit the controlling circuit breaker or cut-out to operate in the event of any failure of insulation between the metallic sheath and the conductor.]

(c) Where an electric supply-line as aforesaid has concentric cables and the external conductor is insulated from an outer metal sheathing and connected with earth, the external conductor may be regarded as the metal sheathing for the purposes of this rule provided that the foregoing provisions as to conductivity are complied with.

(2) Nothing in the provisions of sub-rule (1) shall preclude the employment in generating stations, sub-stations and switch-stations (including outdoor substations and outdoor switch-stations) of conductors for use at high or extra- high voltages which are not enclosed in metal sheathing or preclude the use of electric supply lines laid before the prescribed date to which the provisions ofthese rules apply

Rule 67 Connection with earth

(1) All non-current carrying metal parts associated with HV/EHV installation shall be effectively earthed to a grounding system or mat which will

(a) Limit the touch and step potential to tolerable values;

(b) Limit the ground potential rise to tolerable values so as to prevent danger due to transfer of potential through ground, earth wires, cables sheath fences, pipelines, etc.;

(c) Maintain the resistance of the earth connection to such a value as to make operation of the protective device effective.

(lA) In the case of star-connected system with earthed neutrals or delta connected system with earthed artificial neutral point: -

(a) The neutral point of every generator and transformer shall be earthed by connecting it to the earthing system as defined in rule 61 and hereinabove by not less than two separate and distinct connections;

Provided that the neutral point of a generator may be connected to the earthing system through an impedance to limit the fault current to the earth;

Provided further that in the case of multi-machine system neutral switching may be resorted to, for limiting the injurious effect of harmonic current circulation in the system;

(b) In the event of an appreciable harmonic current flowing in the neutral connection so as to cause interference, with communication circuits, the generator or transformer neutral, shall be earthed through a suitable impedance;

(2) Single-phase high or extra-high voltage systems shall be earthed in a manner approved by the Inspector

(3) In the case of a system comprising electric supply lines having concentric cables, the external conductor shall be the one to be connected with earth.

(4) Where a supplier proposes to connected with earth an existing system for use at high or extra-high voltage which has not hitherto been so connected with earth he shall give not less than fourteen days' notice in writing together with particulars to the telegraph-authority of the proposed connection with earth.

(5) Where the earthing lead and earth connection are used only in connection with earthing guards erected under high or extra-high voltage overheadlines where they cross a telecommunication line or a railway line, and where such lines are equipped with earth leakage relays of a type and setting approved by the Inspector, the resistance shall not exceed 25 ohms.

(6) In so far as the provisions of rule 61 are consistent with the provisions ofthis rule, all connections with earth shall also comply with the provisions of that rule.

Rule 68 General conditions as to transformation and control of energy

(1) Where energy at high or extra-high voltage is transformed, converted, regulated or otherwise controlled in sub-stations or switch-stations (including outdoor substations and out-door switch-stations) or in street boxes constructed underground, the following provisions shall have effect: -

Sub-stations and switch-stations shall preferably be erected above ground, but where necessarily constructed underground due provisions for ventilation and drainage shall be made and any space housing switchgear shall not be used for storage of any materials especially inflammable and combustible materials or refuse.]

(b) Outdoor sub-station is except pole type sub-stations and. outdoor switch- stations shall (unless the apparatus is completely enclosed in a metal covering connected with earth, the said apparatus also being connected with the system by armoured cables) be efficiently protected by fencing not less than 1.8 metres in height or other means so as to prevent access to the electric-supply lines and apparatus therein by an unauthorised person.

(c) Underground street boxes (other than sub-stations) which contain transformers shall not contain switches or other apparatus, and switches, cut-outs or other apparatus required for controlling or other purposes shall be fixed in separate receptacles above ground wherever practicable.

(2) Where energy is transformed, suitable provisions shall be made either by connecting with earth a point of the system at the lower voltage or otherwise to guard against danger by reason of the said system becoming accidentally charged above its normal voltage by leakage from a contact with the system at the higher voltage.

Rule 70 Condensers

Suitable provision shall be made for immediate and automatic discharge of ever static condenser on disconnection of supply.

1.4 Over Head Line

Rule 74 Material and strength

(1) All conductors of overhead lines other than those specified in sub-rule (1) of rule 86 shall have a breaking strength of not less than 350 kg.

(2) Where the voltage is low and the span is of less than 15 metres and is on the owner's or consumer's premises, a conductor having an actual breaking strength of not less than 150 kg may be used.

Rule 75 Joints

Joints between conductors of overhead lines shall be mechanically and electrically secure under the conditions of operation. The ultimate strength of the joint shall not be less than 95 per cent of that of the conductor, and the electrical conductivity not less than that of the conductor.

Rule 76 Maximum stresses: Factors of safety

(1) (a) The owner of every overhead line shall ensure that it has the following minimum factors of safety:-

1. For metal supports	2.0
2. For mechanically processed concrete supports	2.5
3. For hand-moulded concrete supports	3.0
4. For wood supports	3.5

(b) The minimum factor of safety for stay-wires, guard-wires or bearer wires shall be 2.5 based on the ultimate tensile strength of the wire.

(c) The minimum factor of safety for conductors shall be 2, based on their ultimate tensile strength. In addition, the conductors tension at 32^0C, without external load, shall not exceed the following percentages of the ultimate tensile strength of the conductor: -

Initial unloaded tension 35 per cent

Final unloaded tension 25 per cent.

Provided that in the case of conductors having a cross section of a generally triangular shape, such as conductors composed of 3-wires, the final unloaded tension at 32'C shall not exceed 30 per cent of the ultimate tensile strength of suchconductor.

(2) For the purpose of calculating the factors of safety prescribed in sub-rule (l)-

(a) The maximum wind pressure shall be such as the State Government may specify in each case;

(b) For cylindrical bodies the effective area shall be taken as two-thirds of the projected area exposed to wind pressure;

(c) For latticed steel or other compound structures the wind pressure on the lee side members shall be taken as one-half of the wind pressure on the windward side members and the factors of safety shall be calculated on the crippling load of struts and upon the elastic limit of tension members;

(d) The maximum and minimum temperatures shall be such as the State Government may specify in each case.

(3) Notwithstanding anything contained in sub-rules (1) and (2), in localities where overhead lines are liable to accumulations of ice or snow the State Government may, by order in writing, specify the loading conditions for the purpose of calculating the factor of safety.

Rule 77.Clearance above ground of the lowest conductor

(1) No conductor of an overhead line, including service lines, erected across a street shall at any part thereof be at a height of less than-

(a) For low and medium voltage lines 5.8 mt (19ft)

(b) For high voltage lines 6.0 mt (20ft)

(2) No conductor of an overhead line, including service lines, erected along any street shall at any part thereof be at a height less than-

(a) For low and medium voltage lines 5.49 mt (18 ft)

(b) For high voltage lines 5.8 mt (19ft)

(3) No conductor of in overhead line including service lines, erected elsewhere than along or across any street shall be at a height less than-

(a) For low, medium and high voltages lines up to and including 11,000 volts, if bare	4.57 mt (15ft)
(b) For low, medium and high voltage lines up to and including 11,000 volts, if insulated	3.96mt (13ft)
(c) For high voltage lines above 11,000 volts	5.18 mt (17ft)

(4) For extra-high voltage lines the clearance above ground shall not be less than 5.18mt (17ft) metres plus 0.3 mt (1ft) for every 33,000 volts or part thereof by which thevoltage of the line exceeds 33,000 volts.

Provided that the minimum clearance along or across any street shall not be lessthan 6.0 mt (20ft).

Rule 78 Clearance between conductors and trolley wires

No conductor of an overhead line crossing a tramway or trolley bus route using trolley wires shall have less than the following clearances above and trolleywire

(a) Low and medium voltage lines 1.2 metres.

Provided that where an insulated conductor suspended from a bearer wire crosses over a trolley wire the minimum clearance for such insulated conductor shall be 0.6 metre.

(b) High voltage lines up to and including 11,000 volts	1.83 mt (6ft)
(b) High voltage lines above 11,000 volts	2.44 mt (8ft)
(c) Extra-high voltage lines	3.05 mt (10ft)

Rule 79 Clearances from buildings of low and medium voltage lines and service lines

(1) Where a low or medium voltage, overhead line passes above or adjacent to or terminates on any building, the following minimum clearances from any accessible point, on the basis of maximum sag, shall be observed.

(a) For any flat roof, open balcony, verandah roof and lean-to-roof-

(i) When the line passes above the building a vertical clearance of 2.5metres from the highest point, and

(ii) When the line passes adjacent to the building a horizontal clearance of 1.2 metres from the nearest point, and

(b) For pitched roof-

(i) When the line passes above the building a vertical clearance of 2.5metres immediately under the lines, and

(ii) When the line passes adjacent to the building a horizontal clearance of 1.2metres.

(2) Any conductor so situated as to have a clearance less than that specified in sub-rule (1) shall be adequately insulated and shall be attached at suitable intervals to a bare earthed bearer wire having a breaking strength of not lessthan 350 kg.

(3) The horizontal clearance shall be measured when the line is at a maximum deflection from the vertical due to wind pressure.

Rule 80. Clearances from buildings of high and extra-high voltage lines

(1) Where a high or extra-high voltage overhead line passes above or adjacent to any building or part of a building it shall have on the basis of maximum sag a vertical clearance above the highest part of the building immediately under such line, of not less than

(a) For high voltage lines upto andincluding 33,000 volts	3.7 metres
(b) For extra-high voltage lines	3.7 metres plus 0.30 metre for every additional 33,000 volts or part thereof.

(2) The horizontal clearance between the nearest conductor and any part of such building shall, on the basis of maximum deflection due to wind pressure, be not less than-

(a) For high voltage lines up to andincluding 11,000 volts	1.22 mt (4ft)
(b) For high voltage lines above11,000 volts and up to and including 33,000 volts	1.83 mt (6ft)
(c) For extra-high voltage lines	1.83 mt (6ft) plus 0.3mt (1ft) for every additional 33,000 volts for partthereof.

Rule 86 Conditions to apply where telecommunication lines and power lines are carried on same supports

(1) Every overhead telecommunication line erected on supports carrying a power line shall consist of conductors each having a breaking strength of not lessthan 270 kg.

(2) Every telephone used on a telecommunication line erected on supports carrying a power line shall be suitably guarded against lightning and shall be protected by cutouts.

(3) Where a telecommunication line is erected on supports carrying a high or extra-high voltage power line arrangement shall be made to safeguard any person using the telephone against injury resulting from contact, leakage or induction between such power and telecommunication lines.

Rule 87 Lines crossing or approaching each other

(1) Where an overhead line crosses or is in proximity to any telecommunication line, either the owner of the overhead line or the telecommunication line, whoever lays his line later, shall arrange to provide for protective devices or guarding arrangements, in a manner laid down in the Code of Practice or the guidelines prepared by the Power and Telecommunication Coordination Committee and subject to the provisions of the following sub-rules:-

(2) When it is intended to erect a telecommunication line or an overhead line which will cross or be in proximity to an overhead line or a telecommunication line, as the case may be, the person proposing to erect such line shall give one month's notice of his intention so to do along with the relevant details of protection and drawings to the owner of the existing line.

Where an overhead line crosses or is in proximity to another overhead line, guarding arrangements shall be provided so as to guard against the possibility of their coming into contact with each other.

Where an overhead line crosses another overhead line, clearances shall be as under: -

Minimum clearances in metres between lines crossing each other.

Sl. No.	Nominal System Voltage	11-66 KV	110-132 KV	220 KV	400 KV	800 KV
1.	Low & Medium	2.44	3.05	4.58	5.49	7.94
2.		2.44	3.05	4.58	5.49	7.94
3.	11-66 KV	3.05	3.05	4.58	5.49	7.94
4.		4.58	4.58	4.58	5.49	7.94
5.	110-132 KV	5.49	5.49	5.49	5.49	7.94
6.	220 KV	7.94	7.94	7.94	7.94	7.94
	400 KV					
	800 KV					

Provided that no guardings are required when an extra high voltage line crosses over another extra-high voltage, high voltage, medium or low voltage line or a road or a tram subject to the condition that adequate clearances are provided between the lowest conductor of the extra-high voltage line and the top most conductor of the overhead line crossing underneath the extra-high voltage line and the clearances as stipulated in rule 77 from the topmost surface of the roadis maintained.]

(4) A person erecting or proposing to erect a line which may cross or be in proximity with an

existing line, may normally provide guarding arrangements on his own line or require the owner of the other overhead line to provide guarding arrangements as referred to in sub-rule, (3).

(5) In all cases referred to in the preceding sub-rules the expenses of providing the guarding arrangements or protective devices shall be borne by the person whose line was last erected.

(6) Where two lines cross, the crossing shall be made as nearly at right angles the nature of the case admits and as near the support of the line as practicable, and the support of the lower line shall not be erected below the upper line.

(7) The guarding arrangements shall ordinarily be carried out by the owner of the supports on which it is made and he shall be responsible for its efficient Maintenance.

(8) All work required to be done by or under this rule shall be carried out to the satisfaction of the Inspector.

Rule 88 Guarding

(1) Where guarding is required under these rules the provisions of sub-rules (2) to (4) shall apply.

(2) Every guard-wire shall be connected with earth at each point at which its electrical continuity is broken.

(3) Every guard-wire shall have an actual breaking strength of not less than 635 kg and if made of iron or steel, shall be galvanised.

(5) Lines crossing trolley-wires- In the case of a crossing over a trolley-wire the guarding shall fulfil the following conditions, namely:-

(a) Where there is only one trolley-wire, two guard-wires shall be erected asin diagram A;

(b) Where there are two trolley-wires and the distance between them does not exceed 40 cms, two guard-wires shall be erected as in diagram B;

(c) Where there are two trolley wires and the distance between them exceeds 40 cms but does not exceed 1.2 metres, three guard-wires shall be erected as in diagram C;

(d) Where there are two trolley--wires and the distance between them exceeds 1.2 metres, each trolley-wire shall be separately guarded as in diagram D;

(e) The rise of the trolley boom shall be so limited that the trolley leaves the trolley-wire, it shall not foul the guard-wires; and

(f) Where a telegraph-line is liable to fall or be blown down upon an arm, stay-wire or span-wire and so slide down upon a trolley-wire, guard hooks shall be provided to prevent such sliding.

Rule 89 Service-lines from Overhead lines- No Service-line or tapping shall be taken off an overhead line except at a point of support.

Rule 90 Earthing

(1) All metal supports and all reinforced and prestressed cement concrete supports of overhead lines and metallic fittings attached thereto, shall be permanently and efficiently earthed. For this purpose a continuous earth wire shall be provided and securely fastened to each pole and connected with earth ordinarily at three points in every 1.609 km., the spacing between the points being as nearly equidistance as possible. Alternatively, each support and the metallic fitting attached thereto shall be efficiently earthed.

(2) Each stay-wire shall be similarly earthed unless insulator has been placed in it at a height not less than 3.0 metres from the ground.

Rule 91 Safety and protective devices

(1) Every overhead line, (not being suspended from a dead bearer wire and not being covered with insulating material and not being a trolley-wire) erected over any part of street or other public place or in any factory or mine or on any consumers' premises shall be protected with a device approved by the Inspector for rendering the line electrically harmless in case it breaks.

(2) An Inspector may by notice in writing require the owner of any such overhead line wherever it may be erected to protect it in the manner specified in sub-rule(l).

(3) The owner of every high and extra-high voltage overhead line shall make adequate arrangements to the satisfaction of the Inspector to prevent unauthorised persons from ascending any of the supports of such overhead lines without the aid of a ladder or special appliances.

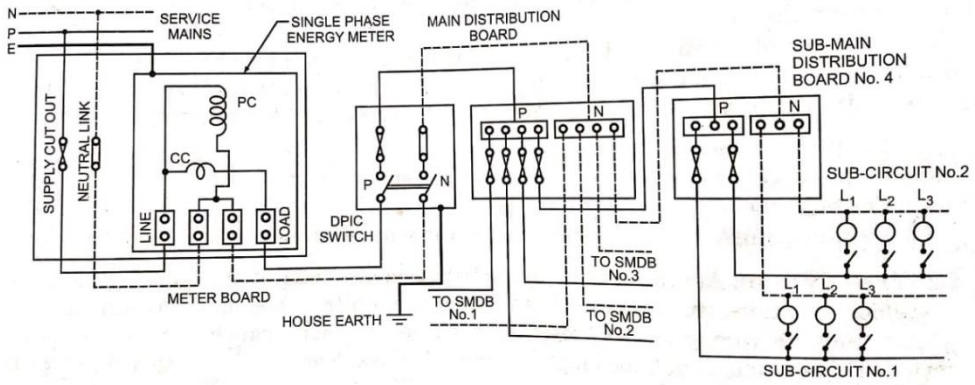
CHAPTER-2 ELECTRICAL INSTALLATIONS

2.1

❖ WIRING SYSTEM

A network of wires connecting various accessories for distribution of electrical energy from the supply meter board to the numerous electrical energy consuming device such as lamps & fan and other domestic appliances through controlling & safety device is known as wiring system.

❖ TYPICAL HOUSE WIRING SYSTEM



Typical House-Wiring Circuit

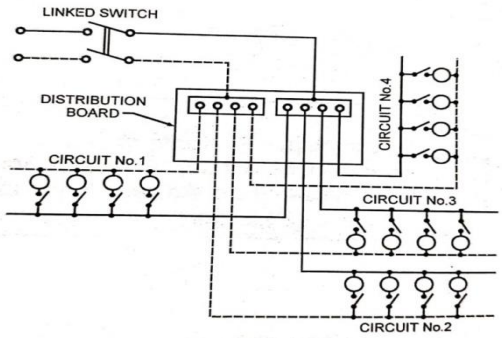
❖ SYSTEM OF DISTRIBUTION OF ELCTRICAL ENERGY

As per recommendation of Indian standard, the maximum number of points of light, fan and 5A sockets outlet that can be connected in one circuit is 10and the maximum load that can be connected in such circuit is 800 watt, in case more load or points are required to be connected to the supply, then it is to be done by having more than one circuit.

The system of distribution of electrical energy is two types

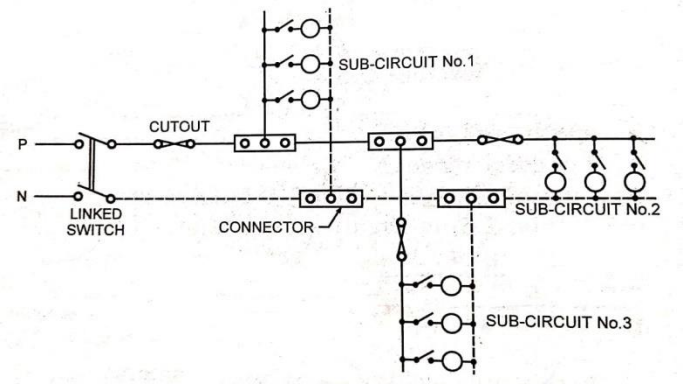
a) Distribution board system
b) Tee system

a) DISTRIBUTION BOARD SYSTEM



Distribution Board System

b) TREE SYSTEM

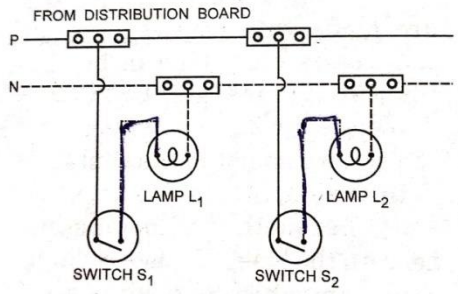


Tree System

❖ METHODS OF WIRING

There are two methods of wirings known as joints box system (tee system) and loop in system wiring.

JOINTS BOX/ TEE SYSTEM:-



Joint Box System

- In joint box system, the connection to electrical points are given through joint made in joint boxes by means of suitable connectors or joint cut-out.

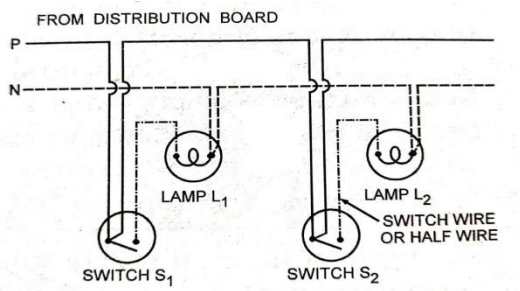
Advantages:-

- Saving of wire due to use of joint box

Disadvantages:-

- Extra cost due to use of joint box.
- Location of fault is difficult.
- Skill labour is required .
- It is not good looking.

LOOP -IN SYSTEM:-



Loop-in System

The phase wire is looped-in from one switch to the other (from one load to other load) and neutral are looped -in from one point to another within the same sub-ckt.

Advantages:-

- No junction boxes are required.
- Inspection and fault location is easy.

Disadvantages:-

- Requirments of cable is more.
- Hence voltage drop and copper losses are comparatively more.

❖ SYSTEMS OF WIRING

The type of internal wiring usually employed in our country are:-

1. Cleat wiring
2. Wooden casing & capping wiring
3. C.T.S/T.R.S wiring
4. Lead sheathed or metal sheathed wiring
5. Conduit wiring
    a) Surface or open type
    b) Concealed of underground type

❖ WIRE AND CABLE

WIRE:- single core strand may be bare or cover with insulations known as wire.
CABLE:-Several wire stranded together is known as cable. (Cover with insulation)

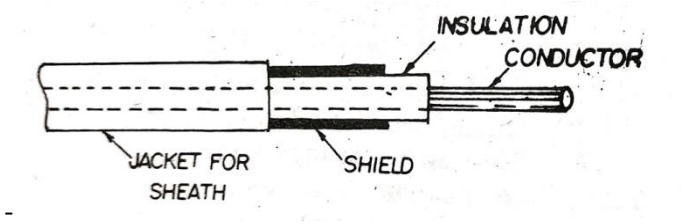
NECESSITY IN A CONDUCTOR/WIRE/CORE:-

- Good conductor of electricity (low resistivity)
- Cheaper in cost.
- Safety (not provide leakage current)
- Easily available.
- High mechanical strength, durable.
- Melting point should be high.
- High resistivity to corrosion, oxidation, withstand dampness.
- High resistivity towards chemical reaction.

PARTS OF CABLE:-

Cable consists of three parts

a) Conductor/Wire/Core
b) Insulation/Dielectric
c) Cable jacket



a) Conductor/core:-It carries current.
b) Insulation/Dielectric:-covering part is used to avoid leakage current from the conductor.
c) Cable jacket;-The protective covering for protection of insulation from mechanical damage.

❖ **CONDUCTOR MATERIAL USED IN CABLES:-**

1. COPPER
2. ALUMINIUM
3. SILVER
4. GOLD
5. LEAD & TIN
6. STEEL
7. GALVANISED STEEL

1.COPPER:-

- It has high conductivity.
- Less resistivity, durable and ductile.
- Mechanically strong, hard
- High resistivity to corrosion, oxidation, high temperature.
- Welded easily, soldered.
- Cheaper in cost.

2.ALUMINIUM

- Cheaper in cost
- Long distance power distribution (use in place of copper for bare electric cable)

Aluminium	copper
1. Less conductivity than copper (60% of copper). 2. required Aluminium is 1.61times that of copper in volume.	1. More conductivity than aluminium.

❖ INSULATING MATERIALS:-

It is used to prevent the leakage current from conductor.

Properties of insulating material:-

- High resistivity.
- High flexibility.
- High dielectric strength.
- Non-inflammable (not catching fire easily/not inflammable).
- Non-hygroscopic (it does not absorb water and moisture from atmosphere).
- High resistive to moisture, acid, or alkalis.
- Capabilities to withstand high rupturing voltage and high temperature.
- Capability withstand wind, force, Iceland.

TYPES OF INSULATING MATERIALS:-

1.RUBBER

Advantages:-

- It has good dielectric strength(30KV/MM)
- It has high insulating properties.
- High relative permittivity.

Disadvantages:-

- It absorbed moisture.
- Often when heated to a temperature of 60 to 70℃
- Ages when expose to light.
- Deform when warm and brittle when cold.
- It is sticky in nature.
- So, hat pure rubber is not used for insulation.

2. VIR (VULCANISED INDIAN RUBBER)

Advantages:-

- It has great mechanical strength.
- It has good dielectric strength (60KV/MM)
- It has good insulating properties.
- It does not absorb moisture from atmosphere.
- It is Durable

VULCANISATION

- It is a chemical process for converting natural rubber to more durable material by adding of sulphur.
- Sulphur reacts with copper and corroded the copper surface. So this can be avoided by providing a tinned layers over the copper surface.
- It may be used in internal wiring and other low voltage insulation. (decoration)

3. SILK& COTTON:-

- This is used in low voltage cable.
- Conductors may have a single layer or double layer covering depending upon the requirements of service.
- Silk of cotton covered wires are usually used for instruments and motor windings

4. IMPREGNATED PAPER

Advantages:-

- It has high dielectric strength. (30 kv/ mm)
- It has good insulation resistance.
- It has low cost.

Disadvantages:-

- It absorbed moisture (hygroscopic in nature).So that it always provided with some protective covering and never left unshield.
- To make it noninflammable paper, impregnated with some compound like paraffin, napthenic and resin.

5. POLYVINYLE CHLORIDE (PVC)

- It has good dielectric strength.
- It has good insulating properties.
- Good mechanical strength.
- It does not absorb moisture.
- It does not reacts with acid & alkali (used in house wiring ,cable factories)
- It is used for low & medium voltage domestic & industrial light and power installation.
- It is low cost.

❖ MECHANICAL PROTECTION:-

- Insulating materials are mechanically weak so protection against mechanical injury is required.
- Protection is provided by steel, aluminium on PVC covering.
- Protection against damage & moisture.

❖ TYPES OF CABLES USED IN INTERNAL WIRING:-

The wire employed for internal wiring of building may be divided into different groups according to:-

1. Conductors used (according to the conductors material used in cable:-

a) Copper conductor
b) Aluminium conductor

2. According to the numbers of core in cables:-

a) Single core cable
b) Twin core cable
c) Three core cable
d) Four core cable

3. According to voltage grading, the cables are 2 types:-

a) 250/500 volt cable
b) 660/1100 volt cable

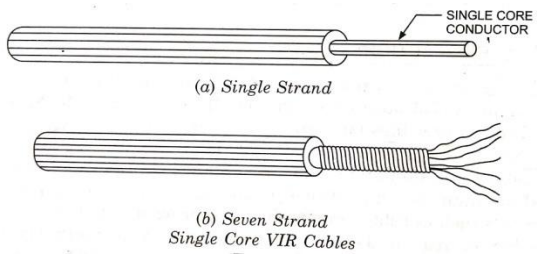
4. According to types of insulation the cables are:-

a) VIR insulated cables
b) TRS/CTS cables
c) Lead sheath cable
d) PVC Cable
e) Waterproof cable/weather proof
f) Flexible cord & cables

TRS-Tough rubber sheath
CTS-Cab tyre sheath

1. VIR INSULATED CABLE

- The cables are available in 250/500 volt and 660/1100 volt.
- It consists of tin & copper conductor covered with a layer of VIR Insulation.
- Over the rubber insulation cotton tap sheath covering with moisture resistance compound bitumen wax to make the cable moisture proof.
- Conductor reacts with VIR insulation therefore to prevent the reaction a tin layer is given in the conductor.
- VIR is used to protect the conductor from mechanical injury.
- Bitumen & cotton tap are used to protect the insulation from weather & moisture.

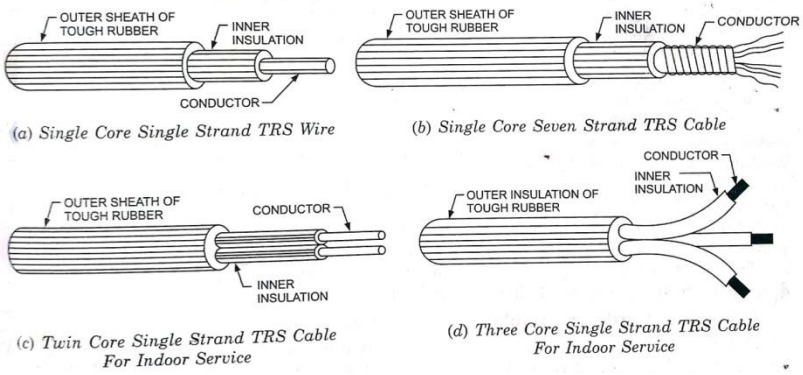


(a) Single Strand

(b) Seven Strand
Single Core VIR Cables

2. TRS/CTS CABLE

- These cables are available in 250/500 volt and 660/1100.
- TRS/CTS cable is vulcanized rubber, insulated conductor with an outer protective covering of tough rubber which provides additional insulation and protection against wear & tear.
- These cables are water proof and hence can be used in wet condition.
- This cable is available in single core, twin core, three cores etc.
- The cores are insulated from each other and covered with a common sheathing.



(a) Single Core Single Strand TRS Wire

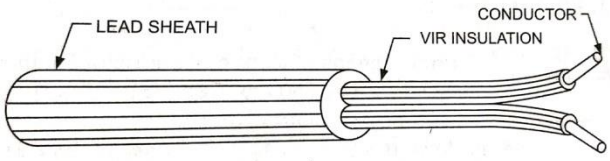
(b) Single Core Seven Strand TRS Cable

(c) Twin Core Single Strand TRS Cable
For Indoor Service

(d) Three Core Single Strand TRS Cable
For Indoor Service

3. LEAD SHEATH CABLE

- This cable is available in 250/500 volt.
- It consists of vulcanized rubber insulated conductors cover with a sheath of lead.
- The lead sheath provides a very good protection against the moisture and mechanical injury. So this can be used without casing or conduit system.
- This cable is available in single core, twin core, three cores etc.



2-Core Lead Sheathed Cable

4. POLYVINYL CABLE (PVC)

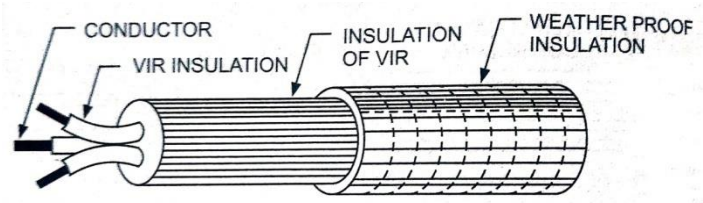
- These cables are available in 250/500 volt & 660/1100 volt grade.
- It is used incasing-capping, batten& conduit wiring system.
- Since PVC is harder than rubber it does not require cotton tapping over it for mechanical and moisture protection.
- These type cable conductors are insulated with PVC insulation.

ADVANTAGES

- Better insulating properties.
- Low cost
- Better flexibilities.
- No chemical effect on metal of the wire.

5. WEATHER PROOF CABLE

- These cables are available in 250/600 volt and 660/1100 volt grade.
- These cables are either PVC or VIR insulated conductors and then compounded with weather resisting material.
- These cables are not affected by heat, sunlight, rain.
- It is used for outdoor wiring, power supply or industrial supply.



3-Core Weather Proof Cable

6. FLEXIBLE CORD & CABLE

- It consist of wire silk, cotton, plastic covering.
- Flexible cord have tin-copper conductor.
- Flexibilities and strength is obtained by using conductors having large no. of strand.
- This wire or cable are used as connecting wires for such purpose as from ceiling rose to lamp holder ,socket outlet to portable apparatus such as fan ,lamp, heater ,etc.

❖ **MULTISTRAND CABLES:-**

- Advantages of multi strand cables w.r.t single solid conductors.
- Multi strand cables are more flexible and durable and therefore can be handle conveniently.
- The surface area of multi strand cable is more as compare to the surface area of equivalent single solid conductor .so heat radiating capacity is more in multi strand cable because of its large area.
- Skin effect is better as conductors are tubular, specially in case of high frequency.
- The no. of strand is stranded cable must be 3,7, 19, 37, 61, 91 etc.

❖ **VOLTAGE GRADING OF CABLES:-**

- This specifies the safe voltage which the insulation of the cable can withstand.
- The cables employed for domestic wiring are graded as 250/500 volt & 660/1100 volt grade.

❖ **GENERAL SPECIFICATION OF CABLES:-**

1. Size of the cable in metric system (e.g 19/2.24, 7/1.70, 7/2.24,7/2.50 etc)

For 19/24

19-No. of strand in cable 2.24-diameter of each strand in mm

2. Types of conductors used in cable (Co & Al)
3. The no.of core that cable consists of (single core, twin core ,three core ,four core)
4. Voltage grading (250/500 volt & 660/1100 volt grade)
5. Types of cable with clear description regarding insulation, shielding etc.(PVC etc.)

2.2 ACCESSORIES

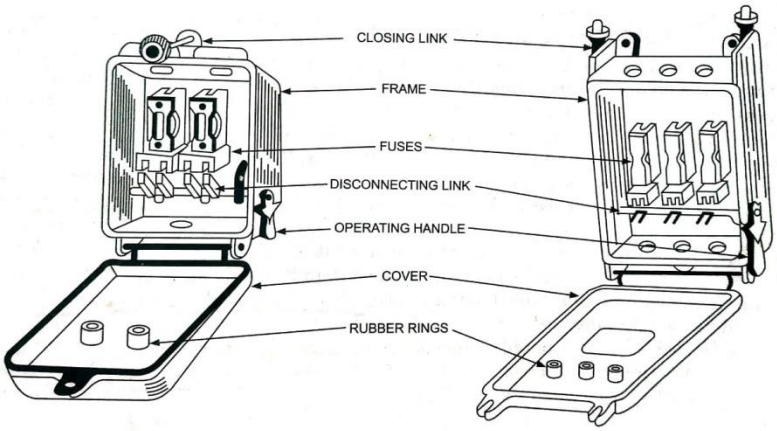
❖ MAIN SWITCH AND DISTRIBUTION BOARD

- Main switch is provided immediately after the meter board. The link main switch and fuse unit may be provided as one unit or as separate unit.
- Switch, fuse is a combined unit and is known as iron clad switch, being made of iron.
  - I. DPIC- Double pole iron clad switch(1 phase,2 wires)
  - II. TPIC-Triple pole iron clad switch (3phase,3 wires)
  - III. TPNIC-Triple pole with neutral link iron clad switch (3phase ,4 wires)

Ratings

DPIC	TPIC	TPNIC
240V, 16A	450V, 32A	450V, 32A
240V, 32A	450V, 63A	450V, 63A
240V, 63A	450V, 100A	450V, 100A
240V, 100A	450V, 150A	450V, 150A
240V, 150A		

- Since no fuse is to be provided in neutral in DPIC switch fuses,where provision is made for fuses in both the wires , one fuse carrier is furnished with fuse elements and the other a thick copper wire.

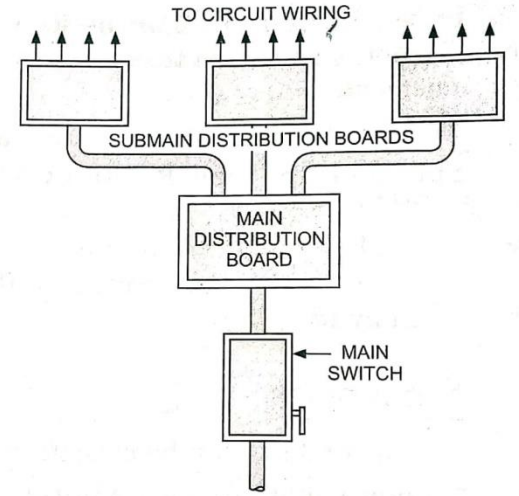


(a) DPIC Switch (b) TPIC Switch

SWITCH FUSE REQUIREMENT GENERAL

- The switches & fuse shall be enclosed in a strong metallic enclosure.
- It should be dust free and weather proof and have a mounting arrangements on the wall.
- The metallic enclosure will have an earthing terminal.
- The ON & OFF shall be clearly marked on it .
- The fixed contact and other metal parts shall be nickel plates or tin where it is desirable.

DISTRIBUTION BOARD



Main Switch, Main Fuse Board and Submain Distribution Boards Showing The Method of Distribution of Electrical Energy To Various Floor Levels For Sectionalizing of Wiring

- Distribution board is an assembly of parts, including one or more fuse or circuit breaker, arranged for the distribution of electrical energy to various circuit or other distribution board known as sub-main distribution board.
- The boards are usually metal cased, in sheet steel where earthing terminals and locking arrangements are provided.
- The number of ways depends upon the circuit or sub-circuit to be fed.
- Separate distribution fuse boxes should be provided for light and power circuit.

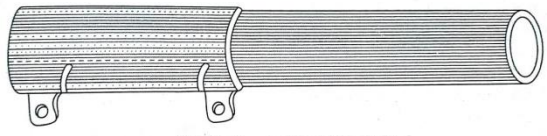
❖ **CONDUITS**

General conduits can be classified as :-

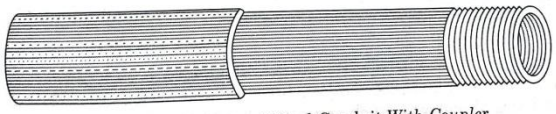
1. Light gauge steel-plain conduit
2. Heavy gauge steel-screw conduit
3. Flexible conduit
4. PVC conduit

1.Light gauge steel-plain conduit

- The external diameter of 12 mm, 16mm, 19mm, 25mm, 31mm, 38mm & 50 mm are available.
- This type of conduit is used on the surface usually in connection with special grip fitting.
- It is a cheapest and quickest of the conduit installation.
- It should be used where the location is dry and there is little livelihood of mechanical damage.



(Light Gauge Steel Conduit)



(Heavy Gauge Screwed Steel Conduit With Coupler
Fig. 3.11

2.heavy gauge steel-screw conduit

- It is expensive, this type of conduit provides a permanents installation with a maximum protection for the cable.
- The joints into fittings are by means of screw threaded which provide mechanical strength and good electrical continuity.
- They are available in approximate 3 m. length and are threaded at the two ends.

3.Flexible steel conduit

- This usually consists of light gauge galvanized steel, spirally wound and to some extent, inter-lock so as to form a tube
- The size from 19mm to 50 mm are present .
- Since conduits are flexible and has easily bend no elbow is required.
- It is costlier than the rigid conduit.
- One of the most common uses of flexible metal conduit is for protecting the final connection to motor.

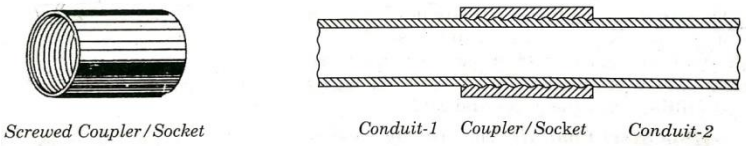
4.PVC conduits

- It is used for internal wiring because it is light in weight, shock-proof, self fixing and fire resistance, acid , alkali and corrosion resistance having high insulation value and dielectric strength.
- Such conduits can be used for both surface and concealed type wiring. Here a separate earth wire must be run inside the tube.

❖ **CONDUITS ACCESSORIES& FITTINGS**

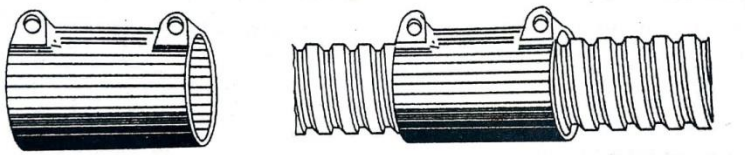
1. CONDUIT COUPLER

- It is used to joint two length of conduit. The length of screw conduits are always threaded at both end on outer side.



Rigid Conduit Coupling (Screwed)

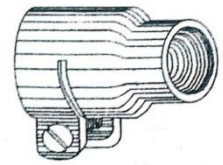
2. GRIP COUPLER



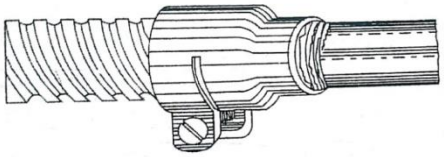
Grip Coupler *Grip Coupling For Joining Two Lengths of Light Gauge Conduit*

- In grip coupler, no extra labour is required for making threads. The ends of conduits are placed in the grip coupler and screw it tightly.

3. FLEXIBLE CONDUIT COUPLER



Flexible Conduit Coupler

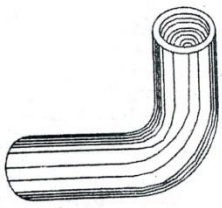


Flexible Conduit Connected To Rigid Conduit Through Coupler

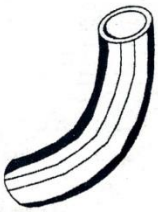
- For coupling a flexible conduit to the rigid conduit a combine coupling is used.

4. BENDS ,ELBOW, & TEES

BEND:- Bends are usually used for change in direction of conduit.



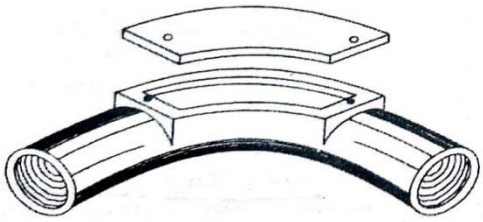
(a) Sharp Bend (Not Permissible)



(b) Normal Bend

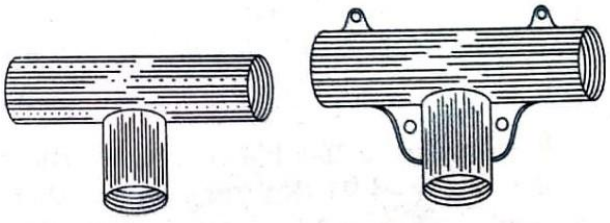
ELBOW:

Elbows are of shorter radius, are only used where sudden right turn is required.



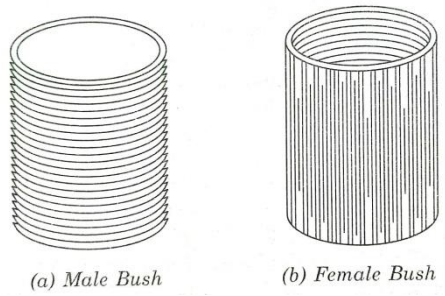
Inspection Elbow

TEES

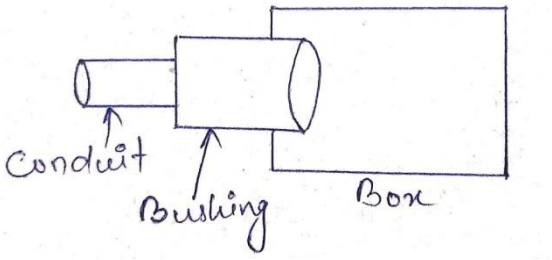


Solid Tee *Split Tee*

CONDUIT BUSHINGS



(a) Male Bush (b) Female Bush



- This are used when the rigid conduit enter the conduit box or a hole which is not threaded.
- This are used to prevent cable from being cut by the edges.

It is up two types.

a) Male -outer threads
b) Female-inner threads

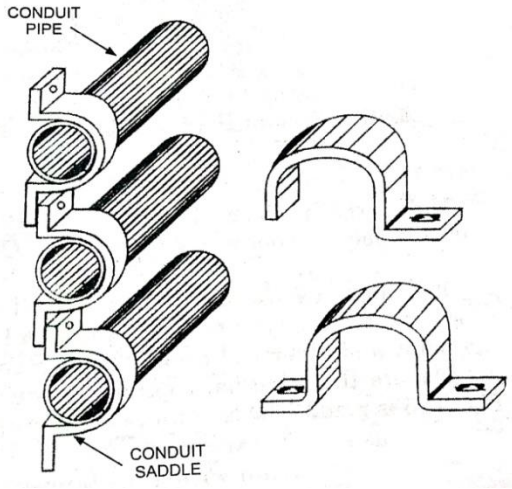
CONDUIT REDUCER

- Conduit reducers are used when the size of conduit change.
- Conduit reducer have both male & female threads.

CLIP:- Clip are used for fixing the conduit on rough brick walls and in concealed wiring.

Clip

SADDLE:



- Saddle are used for fixing the conduit where clips cannot provide a firm enough hold or a single screw cannot be dependent upon for fixing.

LOCKNUTS/CHECK NUTS:

- This are used when rigid conduit enter a conduit box.

CONDUIT NIPPLES

- This serve the same purpose as conduit bushing.
- This are rarely used due to their higher cost.

CONDUIT BOXES

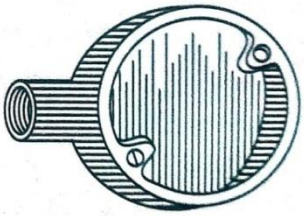
- The conduit boxes are used in surface conduit wiring as well as concealed conduit wiring.

It serve the following purpose:-

- It is used to provide connection to light,fan and other point.
- For pulling of cables into the conduits. The Boxes serving this purpose are known as inspection box. These are provided after every 30 metres length of straight run.
- For housing junction of cables. The conduit boxes serving this purpose are known as junction boxes.

3-Way Tangent Entry Box

Four-Way Conduit Box



(a) Side Entry Terminal Box

❖ **LIGHTING ACCESSORIES AND FITTINGS**

1. SWITCH
2. CEILING ROSE
3. SOCKET OUTLET
4. LAMP HOLDER
5. PLUGS

1. SWITCHES

- A switch is used in an electric circuit as a device for making or breaking the electric circuit in a convenient way i.e by the simple motion of a knob or handle to connect together or disconnect two terminals to which wires or cables are connected.

TYPES OF SWITCH:-

a) ACCORDING TO THE TYPE OF BASE MATERIAL:-

- Porcelain switch(high rating)
- Bakelite switch(low rating)

b) ACCORDING TO THE COLOUR:-

- black
- white
- Brown

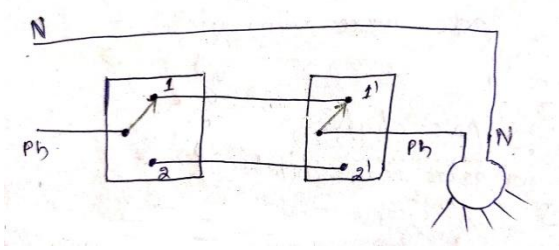
c) ACCORDING TO OPERATION:-

- One way switch
- 2 way switch
- 2 way centre off switch
- Double pole main switch
- Single pole single throw
- Single pole double throw
- Double pole double throw
- Push Button Switches
- Table Lamp Switches
- Bed switches
- Flush Switches

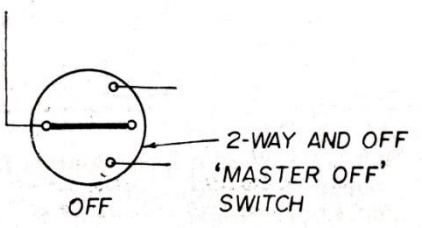
1. **ONE WAY SWITCH**
   - 6 amp,250 volt --------light load (fan, tube light)
   - 16 amp,250 volt -------heavy load(washing machine, heater, AC etc)

2. **TWO WAY SWITCH**
   - The switch of this type consist of 3 or 4 terminals
   - The switch of this type is usually used for staircase wiring or circuit where one point is to be controlled from two different places.
   - 6 amp, 250volt -------(light load)

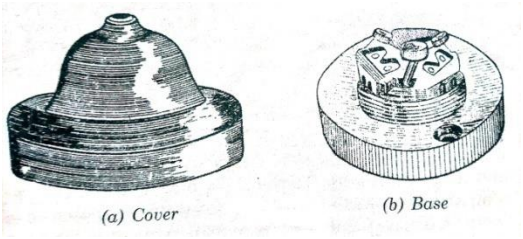
Connection diagram of 2 way switch



3. **2 WAY CENTRE OFF SWITCH**
   - 6 amp ,250 volt



2.CEILING ROSE



- The ceiling rose is used to connect the pendent lamp, fan and fluorescent tube to install through flexible wire.
- It consists of 2 parts
  1. Base 2.cover
- It is made up of Bakelite or porcelain

TYPES OF CEILING ROSES

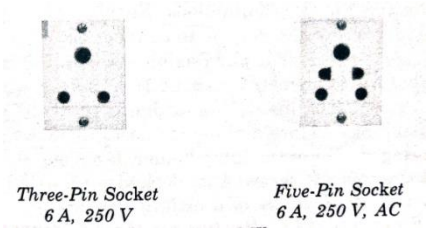
1. 2-way ceiling rose:-
   It is fitted with two terminal plate.
2. 3-way ceiling rose:-
   It is fitted with 3 terminal plates. Rating 6A, 250 volt

3.SOCKET OUTLET:-

- The socket outlets are used to supply electrical connection whenever required for electrical appliances such as TV, iron, table fan.

TYPES OF SOCKETS

- 2 PIN SOCKETS
- 3 PINSOCKETS
- 5 PIN SOCKETS

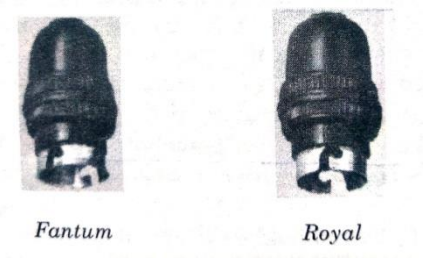


4.LAMP HOLDER:-

- It is used to support the lamp and also to connect it electrically.
- These are designed for quick removal and replacement of the lamp.
- It is made of either brass or Bakelite type with porcelain interior.

TYPES OF LAMP HOLDER:-

1. Pendant holder
2. Angle holder
3. Slanting holder



Fantum *Royal*

5.PLUG:-

- Plugs are used to collect the supply from the socket outlet for electrical appliances such as TV, Iron , table fan etc.

Types:- 2pin plug ,3pin plug

❖ FUSES:-

- It is a simplest and cheapest device used for interrupting an electrical circuit under short circuit or over load condition.
- The action of a fuse is based upon the heating effect of the electric current.

ADVANTAGES

- It is the cheapest form of protection available.
- It needs no maintenance.
- Its operation is completely automatic.
- It interrupts huge short circuit current without noise, gas or smoke.

DISADVANTAGE

- Considerable time is lost in rewiring or replacing a fuse after operation.

FUNCTION OF WIRE:-

- To carry the normal working current safely without heating.
- To break the circuit when the current exceeds the limiting current.

FUSE ELEMENT MATERIALS:-

- The materials used for fuse elements must be of low melting point ,high conductivity , low cost and free from deterioration.
- The materials commonly used for fuse elements are tin, lead ,copper, zinc, aluminium and alloy of lead and tin.
- Fuse element is a low melting point material such as tin, lead and zinc.
- An alloy of lead and tin is used for small current rating fuses. (up to 15 amp)
- Beyond 15 A rating circuits copper wire fuses are used.
- Either copper or lead tin alloy is mostly used as an ordinary fuse wire.

Metals	Melting point in ^{o}C
Silver	980
Tin	240
Zinc	419
Lead	328
Copper	1090
Aluminium	665

TYPES OF FUSE:-

(a) Supply Main Fuse:-

This fuse is provided by the supplier and is fixed just before the service meter .The rating of supply main fuse will be as per load current of the consumers.

(b) Consumers Main Fuse:-

This is another fuse of rating slightly less than that of supply main fuse and placed after the consumer's main switch.

(c) SUB-Circuit Fuse:-

The total wiring system is divided into a number of sub-circuit or branch circuit. A separate fuse is provided for each branch circuit and is known as sub-Circuit or branch circuit fuse.

(d) **POINT FUSE :-**

In good quality indoor wiring of buildings, every light and plug point is provided with its individual fuse known as point fuse.

❖ IMPORTANT DEFINATION:-

FUSE:-

- Fuse is a current interrupting device which break or opens the circuit by fusing the elements when the current in the circuit exceeds a certain value.

FUSE ELEMENTS OR FUSE WIRE:-

- It is that part of the fuse which actually melts when an excessive current flows in the circuit and thus isolates the faulty device from the supply.

CURRENT RATING:-

- It is defined as the RMS value of the current which the fuse wire can carry continuously without deterioration and with temperature rise within specified limits.

FUSING CURRENT:-

- It is define as the minimum value of current at which the fuse elements or fuse wire melts. Its value will be more than the current rating of the fuse element.
- For a round wire the appropriate value of fusing is given by

$$I=Kd^{\frac{3}{2}}$$

Where k= fuse constant, depend upon the metal of the fuse elements
d =diameter of the wire

The fusing current depends upon various factors such as:-

1. Types of metal used.
2. The cross sectional area i.e whether round or rectangular section.
3. Diameter of the wire.
4. Types of enclosure employed.
5. Type of surface (No of stranded)

FUSING FACTORS:-

- It is the ratio between minimum fusing current to the current rating of fuse elements is known as fusing factor and it is always greater than unity.

$$\text{Fusing factor}=\frac{minimum\ fusing\ current}{current\ rating\ of\ fusing\ element}$$

❖ DETERMINATION OF SIZE OF FUSE-WIRE:-

The Factors responsible for determining the size of the fuse wire in an installation are:-

- Maximum current rating of the circuit.
- Current rating of the smallest cable in the circuit protect by the fuse.

❖ EARTHING CONDUCTOR:-

- Earthing conductor is of high conductivity copper and is of either stranded, flat strips, or circular or rectangular bar.
- It should be protect against mechanical injuries and corrosion.

❖ EARTHING:-

Connection of non-current carrying parts of electrical apparatus such as metallic framework, metallic covering of cables, earth terminals of sockets outlet, stay wires etc., to the general mass of earth in such a manner that at all times an immediate discharge of electrical energy takes place without danger.

EARTHING IS PROVIDED

- To avoid electric shock to the human beings.
- To avoid risk of fire due to earth leakage current through unwanted path.

❖ IS SPECIFICATION REGARDING EARTHHING OF ELETRICAL INSTALLATIONS:-

1. Distance of Earth from Building:-
   - An earthing electrode shall not be situated within a distance of 1.5m from the building whose installation system is being earthed.
2. Size of Earth continuity conductor:-
   - The conductor which is used to connect the metal body of an equipments or appliances to the earth is known as earth continuity conductors (ECC).
   - It should not be either less than 2.9 mm^2 (14 SWG) or half of installation conductor size.
3. Resistance of Earth:-
   - The earth resistance should be low enough to cause flow of current.
   - The value of earth resistance does not remain constant but change with the weather, as it depends upon the moisture contents of the soil and is maximum during dry season.
     Large power station =0.5 Ω
     Major power station=1.0 Ω
     Small sub-station=2.0 Ω
     In all other cases=5Ω Maximum
4. The earth wire and earth electrode will be of same material.
5. The earth wire shall be taken through G.I pipe of 13 mm diameter for at least 30 cm length below ground surface to the earth electrode to protect it against mechanical damage.
6. The earth electrode shall always be placed in vertical position inside the earth or pit so that it may be in contact with all the different earth layer.
7. All the earth wires run along the various sub-circuits shall be terminated and looped firmly at the main board and from main board, the main earth wire shall be taken to the earth electrode.

❖ POINT TO BE EARTH:-

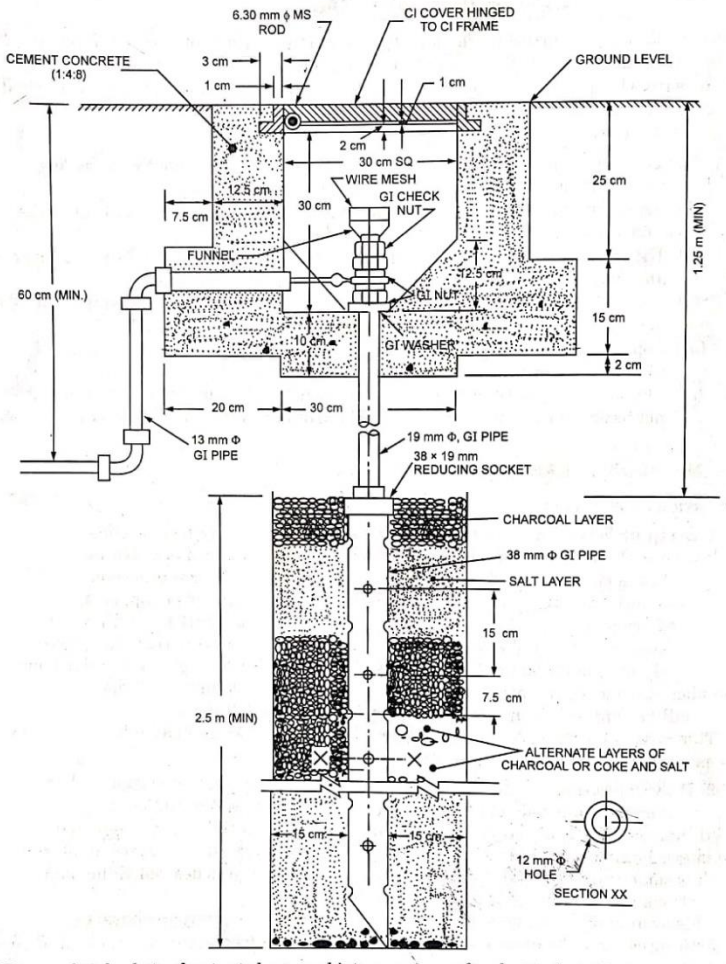
- Earth pin of 3- pin & 5- pin socket should be permanently and efficiently earthed.
- All metallic covering containing or protecting any electric supply line or apparatus, such as iron clad switches ,iron clad distribution fuse board, G.I pipes and conduit enclosing VIR or PVC cable ,the down rods of electric fans , etc. should be connected to earth.
- The frame of every generator, stationary motor, portable motor and the metallic part of all transformers and any other apparatus used for regulating and controlling energy and all medium voltage energy consuming apparatus should be earthed by two separate distinct connection with earth.
- Fabricated steel transmission line towers, tubular steel or rail poles carrying overhead conductor should be earthed.
- Stay wires provided for overhead lines should be connected to earth by connecting at least one strand of the earth wire .
- The neutral conductor of a 3phase, 4 wire system and the middle conductor of a 2-phase ,3-wire system should be earthed by not less than two separate and different connection with earth at the generating station and at the substation.

❖ DETRMINATION OF SIZE OF EARTH WIRE AND EARTH PLATE FOR DOMESTIC OF MOTOR INSTALLATIONS

Capacity of Apparatus	*Size of Earth Wire in SWG*		*Size of Earth Electrode*	
	Copper	*G I*	*Copper*	*G I*
Up to 10 hp	No 8	No 8	60 cm × 60 cm × 3 mm	60 cm × 60 cm × 6 mm
Above 10 hp & up to 15 hp	No 8	No 6	–do–	–do–
Above 15 hp & up to 30 hp	No 6	No 2	–do–	90 cm × 90 cm × 6 mm
Above 30 hp & up to 50 hp	No 4	–	90 cm × 90 cm × 6 mm	–
Above 50 hp & up to 100 hp	No 2 or strip 13 mm × 2.5 mm	–	–do–	–
Above 100 hp	Strip 25 mm × 2.5 mm	–	–do–	–

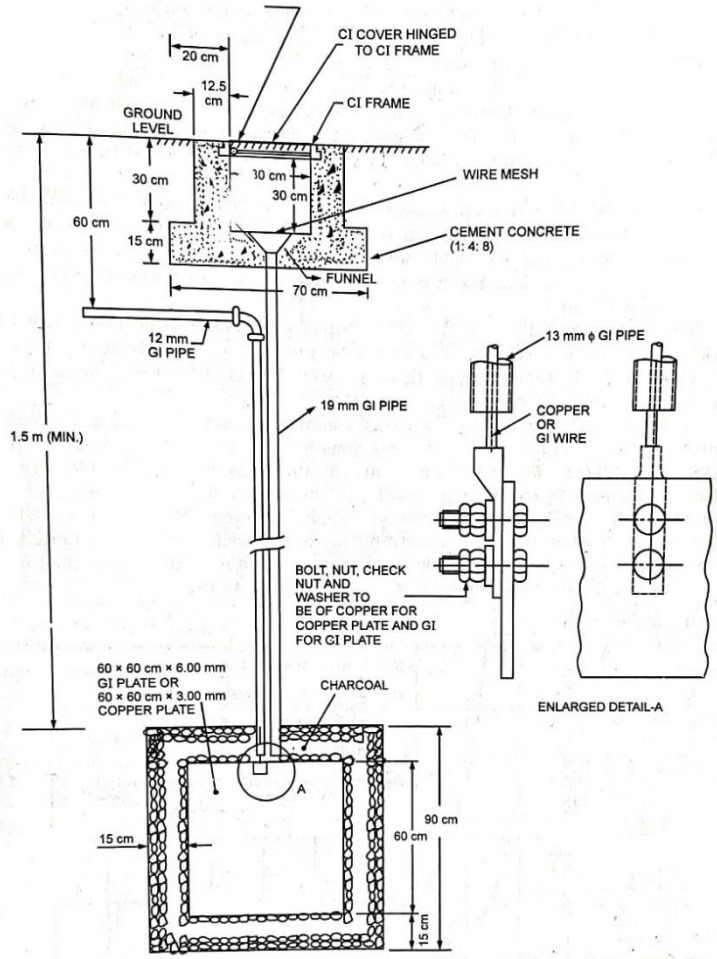
❖ THE LIST OF MATERIALS WITH COMPLETE SPECIFICATION FOR G.I PIPE EARTHING

S. No.	Description of Material With Complete Specifications	Quantity Required	
		Quantity	Unit
1.	38 mm diameter GI Pipe	2.5	metres
2.	19 mm diameter GI pipe for watering	1.5	–do–
3.	13 mm diameter GI pipe	4.0	–do–
4.	GI Wire 6 SWG	12.0 (1.2)	m (kg)
5.	GI lugs	2	nos
6.	10 mm diameter 32 mm long GI bolts and nuts	2	–do–
7.	16 mm diameter 40 mm long GI bolts and washers	2	–do–
8.	13 mm diameter GI bends	1	no
9.	30 cm square cast iron frame	1	–do–
10.	30 cm square cast iron cover	1	–do–
11.	Funnel with wire mesh	1	–do–
12.	Charcoal	10	kg
13.	Common salt	10	–do–
14.	Cement concrete 1 : 4 : 8	0.15	m^3



Note-Three or four buckets of water to be poured into sump every few days to keep the soil surrounding the earth pipe permanently moist.

A Typical Illustration of Pipe Earth Electrode



Note-Three or four buckets of water to be poured into sump every few days to keep the soil surrounding the earth pipe permanently moist.

A Typical Illustration of Plate Earth Electrode

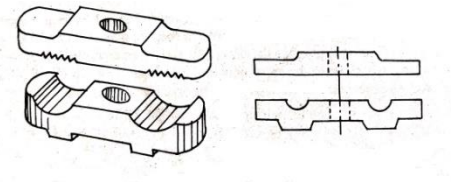
CHAPTER-3 INTERNAL WIRING

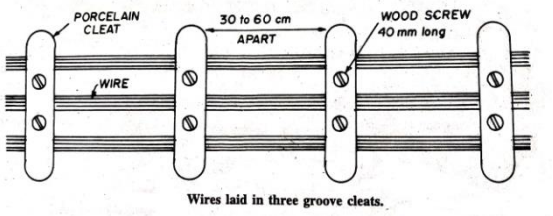
❖ 3.1 TYPES OF INTERNAL WIRING

Following are the types of internal wiring usually employed in industries and house wiring;-

1. Cleat wiring
2. Wooden casing & capping wiring
3. C.T.S/T.R.S or Batten wiring
4. Lead sheathed or Metal sheathed wiring
5. Conduit wiring
   - (a) Surface conduit wiring
   - (b) Concealed conduit wiring

1. CLEAT WIRIG





Wires laid in three groove cleats.

- In this type of internal wiring the cables used are either VIR or PVC type.
- The cables are held by porcelain cleat above wall or ceiling.
- The cleats are made in two halves, one is base and other is cap.
- The base is grooved to accommodate the cables and the cap is put over it and whole of it is then screwed on wooden plug (guttis) over the wall or ceiling.
- The cleats are of three types
  - One groove-one cable
  - Two groove-two cable
  - Three groove-three cable
- The cleat should be usually used at intervals of 30 cm and in no case at more than 60 cm.

ADVANTAGES

- It is cheapest system of internal wiring.
- It's installation and dismantlement is easy and quick.
- Inspection, alternation and addition can be easily made.
- Skill required is little.

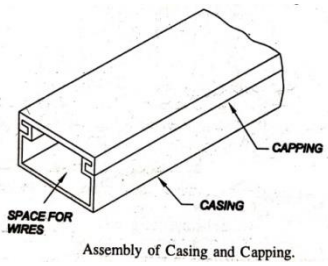
DISADVANTAGES

- It is not good looking.
- It is quite temporary & destroy quickly.
- The insulation catches dampness from the atmosphere and hence this system of wiring cannot be used in damp place.
- Oil & smoke are injurious to VIR insulation.

FIELD APPLICATION

- The wiring of this type is very suitable for temporary installation in dry places.
- It can be used where appearance is not so important and cost is the main consideration.

2. WOODEN CASING & CAPPNG WIRING



Assembly of Casing and Capping.

- The cables used in this type of wirings are either VIR or PVC type.
- It has two halves, one is casing and another is capping.
- The casing consist of V – shaped grooves to hold the cable and is covered at the top by means of rectangular strip of wood known as capping.
- The varnished is used to protect wood from white ants.

ADVANTAGES

- Cheaper in cost as compared to lead sheathed and conduit wiring system.
- Easy to install and rewire.
- It provides good insulation to conductors .
- Easy to inspect by opening the capping.

DISADVANTAGES

- This type of wiring is always coated with paint (varnish) to protect the wood from damp. So it cannot be used in damp places.
- Since there is a risk of fire. It cannot be used where there is a possibility of fire hazard.
- This type of wiring can be used only on surface and cannot be concealed in plaster.
- Since it require better workmanship, the labour cost is higher.

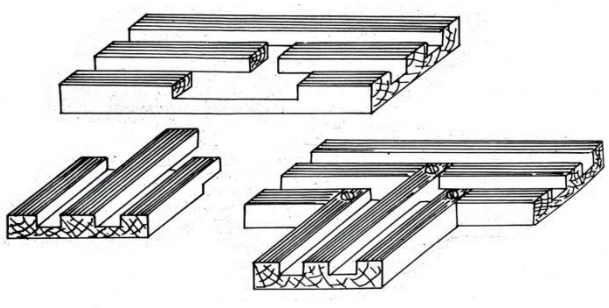
FIELD APPLICATION

- This type of wiring is suitable for low voltage domestic installation in dry places and where there is no risk of fire hazard.

PVC CASING & CAPING WIRING

- Due to increased cost of teak wood, the wooden casing & capping are becoming obsolete and PVC casing & capping are being used.
- This type of wiring is achieved by using hollow channel made of PVC plastic.

3. C.T.S/ T.R.S OR BATTEN WIRING



T.R.S-Tough rubber sheathed wiring
C.T.S-Cab Tyre sheathed wiring

- In this type of wiring the cables used may be single core, twin core or three core T.R.S cable with a circular shape.
- T.R.S cables are sufficiently chemical proof, water proof, steam proof but are slightly affected by lubricating oil.
- T.R.S cables are run on perfectly straight and well varnished teak wood batten.
- The width of batten depends upon number and size of cables to be carried by it.

ADVANTAGES

- Its installation is easy and quick.
- Its life is sufficiently long.
- Within certain limits it is fire proof.
- It can withstand the action of most chemical such as acids &alkalies.
- It is cheaper than other types of wiring except cleat wiring.
- If the job is carried out with a care it gives a nice appearance.

DISADVANTAGES

- Good workmanships is required for this type of wiring.
- This type of wiring cannot be recommended for use in situation open to sun & rain

FIELD APPLICATION

- The T.R.S wiring is suitable for low voltage installation in domestic & commercial building.
- It cannot be used in damp places.

4 .LEADSHEATHED / METAL SHEATHED WIRING

- In this type of wiring, the cables used are T.R.S or P.V.C with an outer covering of sheath of lead aluminium alloy containing about 95% of lead.
- This metal sheath gives protection to the cable from mechanical injuries, dampness and atmospheric corrosion.
- The whole lead covering is made electrically continuous and is connected to earth at the point of entry to protect against leakage current.

ADVANTAGES

- It provides protection against mechanical injuries better than that of T.R.S wiring.
- It is easy to fix and looks nice.
- Its life is long if proper earth continuity is maintained throughout.
- It can be used in damp situation provided protection against moisture.
- It can be used in situation exposed to rain & sun.

DISADVANTAGES

- It is costlier than T.R.S wiring.
- In case of damage of insulation, the metal sheath becomes alive and gives shock.
- Skilled labour & proper supervision is required.

5.CONDUIT WIRING

- In this system of wiring, all wires are enclosed in steel pipe known as conduit (PVC or VIR).
- There are 3 types of conduit wiring
    1. Concealed conduit wiring.
    2. Surface conduit wiring
    3. Flexible conduit wiring

(a) CONCEALED CONDUIT WIRING

- The conduit are embedded along wall or ceiling in plaster at the time of construction.
- The conduit should be electrically & mechanically continuous and connected to earth at suitable place through earth wire.
- The conduit used for this purposes is up two types.
    1. Light gauge conduit
    2. Heavy gauge conduit
- PVC conduit pipes are also available now and are increasing being employed in place of steel conduit.
- PVC Conduits are cheaper in cost. It required less time to install. Such conduits are resistant to acids, alkalis, oil & moisture.

2.SURFACED CONDUIT WIRING

- In surface conduit wiring, the conduit is placed on the surface of the wall and hold with the help of conduit saddle.
- This system of wiring is applied in the industrial wiring.

3.FLEXIBLE CONDUIT WIRING

- The flexible conduit pipe is a pipe which can bend or twist without the change in its diameter.
- The flexible conduits are not used for general electrical wiring system. It is used for connecting rigid conduit with machine terminal box in case of motor wiring, energy meter and main switch in case industrial & domestic wiring system.

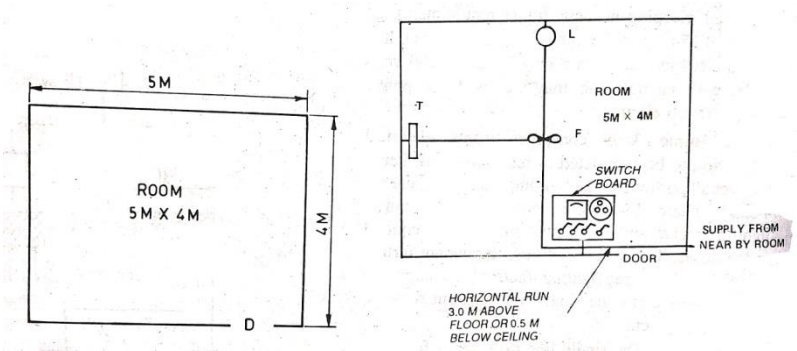
ADVANTAGES

- It provides protection against mechanical damage.
- The whole system is water proof.
- Replacement and alternation of defective wiring is easy.
- Its life is long if the work is properly executed.
- It is shock proof if earthing is properly done.

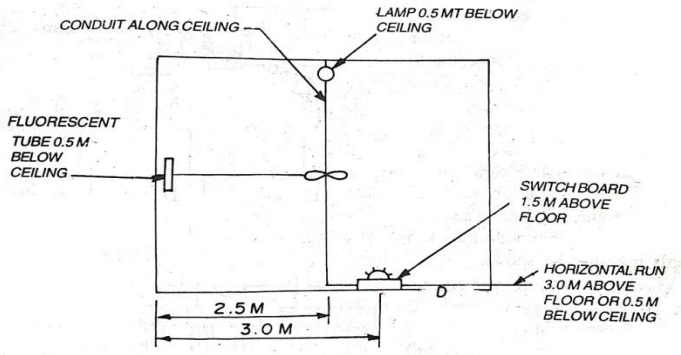
DISADVANTAGES

- It is a very costly system of wiring.
- Experienced & highly skilled labour is required for carrying out the job.

Q.1 The plan of a single room of size 5mtsX4mts is given below .The room is required to be provided with one lamp, one fan, fluorescent tube and one 5 Amp socket –outlet. Each of the points is controlled by its individual switch. Mark the location of the electrical points suitably and draw the installation plan. Also draw the wiring diagram. Calculate the total length of wire and other materials and prepare complete list of materials required for wiring the room in concealed steel conduit system of wiring .No main switch is to be provided as the entry of the sub-circuit is from adjoining room.



Solution



Installation plan

Assumptions:

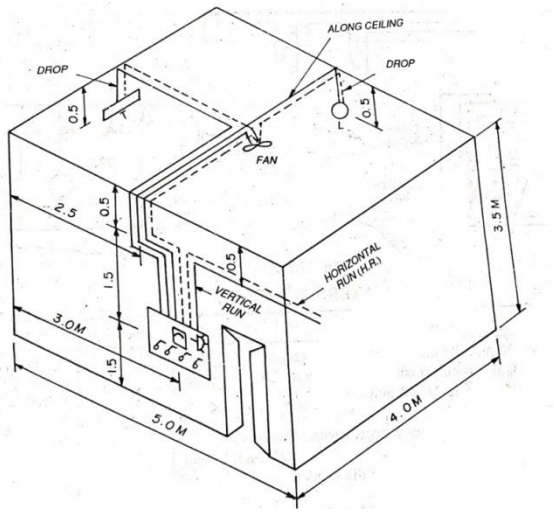
a) Total height of ceiling from floor =3.5 mts
b) Height of H.R(Horizontal run) from floor=3.0 mts
c) Height of switch board from floor=1.5mts
d) Light and tube points from ceiling=0.5 mts

Calculation for length of conduits pipe of 20 mm diameter

From SB to HR=1.5 mts
Fom HR to lamp point=0.5mt+ 0.5mt+ 4 mt +0.5 mt =5.5 mts
From fan to tube points=2.5mt+0.5mt=3 mts
From entry of circuit into room upto take off points(HR of SB)=2.0 mts

Total length of conduit pipe=(1.5+5.5+3+2)mts=12mts
Taking 10% for wastage=1.2 mts
Total length of conduit pipe required for wiring the room=13.2 mts
say 13.5 mts

Calculation for length of phase wire



From SB to fan =1.5(VR) + 0.5(HR) + 0.5(rise) + 2.0 (along ceiling upto fan)=4.5mts
From SB to lamp=(1.5+0.5+0.5+4+0.5)mts=7 mts
From SB to tube point=(1.5+0.5+0.5+2+2.5+0.5)mts=7.5 mts
From point of entry of circuit into room upto SB= 2(HR)+1.5(VR)=3.5 mts

Total length of phase wire=(3.5+4.5+7+7.5)mts=22.5mts
Taking 15% for wastage=3.375mts
Total length of phase wire required for wiring the room=22.5+3.375=25.875mts
say 26.0 mts

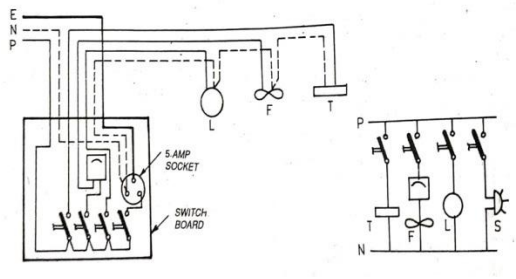
Calculation for length of neutral wire

From SB to fan =1.5(VR)+0.5(HR)+0.5(rise)+2(along the ceiling upto fan)=4.5mts
From fan to lamp points=2(along ceiling)+0.5(drop)=2.5mts
From fan to tube point=2.5(along ceiling)+0.5(drop)=3mts
From point of entry of circuit into room up to SB= 2(HR)+1.5(VR)=3.5 mts

Total length of neutral wire=(4.5+2.5+3+3.5)mts=13.5mts
Taking 15% for wastage=2.025
Total length of neutral wire required for wiring the room=13.5 +2.025=15.525mts
say 16.0 mts

Calculation for length of earth wire (14 SWG)

Length of earth wire=0.25 mt



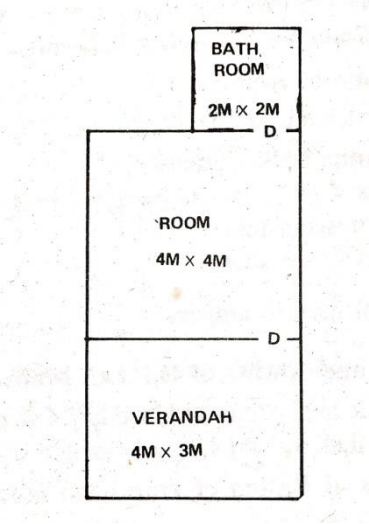
Material Table

Si no.	description of materials with specifications	Quantity
1	total length of conduit pipe (20 mm dia)	13.2 mts
2	total length of phase wire (1 mm^2)	25.075mts
3	total length of neutral wire(0.5 mm^2)	15.52mts
4	total length of earth wire(14 SWG ,G.I)	0.25 mt.
5	Conduit pipe accessories for 20 mm dia a. 1-way junction box b. 2-way junction box c. 3-way junction box d. Conduit bends	 2 nos 1no. 2nos. 3nos.
6	One way switch,5 amp ,rating	4nos.
7	Socket,5 amp rating, 3 pin	1nos.
8	Ceiling rose, 2-plate,bakelite	2nos.
9	Lamp brass bracket with holder	1nos.

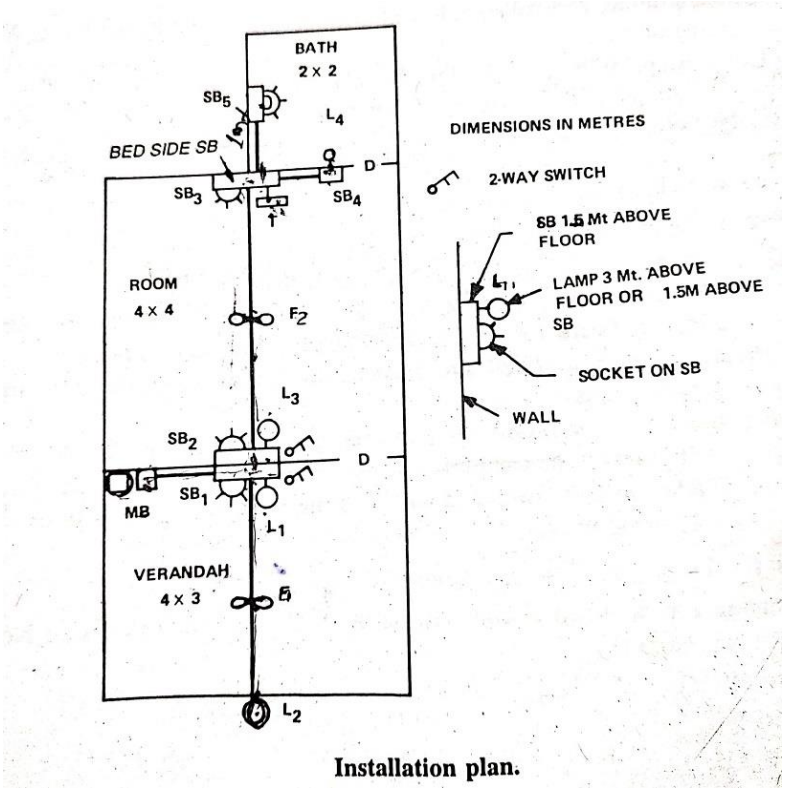
Q.2 A newly constructed Verandah, room and an attached bathroom are required to be provided with electrical wiring suitably. The bathroom must be provided with one 15 ampere socket apart from a lamp. The lamp outside the Verandah must be controlled from inside the room also. Decide the remaining electrical points suitably to provide maximum possible convenience to the consumer.

Draw the following:

(a) **Prepare an installation plan showing path of wiring to each point.**
(b) **Draw the wiring diagram starting from energy meter.**
(c) **Calculate the length of wire required and a complete list of material showing quantity and cost with full specification of each item.**



Solution:



Installation plan.

1. Assumptions:

(a) Height of ceiling from floor =3.5 mts
(b) Height of HR from floor =3.0 mts
(c) Height of SB from floor=1.5 mts
(d) Height of bedside SB from floor =1.0 mts
(e) Height of 15 amp. socket SB from floor =2.0 mts
(f) Thickness of wall=0.25 mts

2. Calculation of load:

Total lamp point =4X60W=240W
5 ampere socket =3X100W=240W
fan =2X60W=120W
Fluorescent tube=1X40W=40W
15 amp socket=1000W

Total load in amperes= $\frac{\text{Watts}}{\text{Volts}}$ =$\frac{1700\ \text{Watts}}{230\ \text{Volts}}$ =7.4 Amp.

3. Selection and Rating of D.P.I.C Main Switch :

As the total connected load is 7.4 amperes, it is therefore suggested that a D.P.I.C main switch of 16 ampere ,250 volts grade should be used.

4. Selection and Rating of Iron Clad Distribution Board :

There are only 10 electrical points and one 15 amp socket. It is therefore suggested that a two way Distribution box with neutral link should be used. The following MCB units are suggested to be installed.

1 unit of 6 amp, 250 volt MCB is used for light,fan,5 amp socket point

1 unit of 16 amp, 250 volt MCB is used for 15 amp socket

5. Calculatios for the length of 25 mm diameter conduit pipe:

Conduit for Sub-circuit -1

From D.P.I.C to SB1=1.5+ 1.5+1.5= 4.5 mts
From HR of SB1 to L1=0.5 + 3 + 0.5 + 0.25 =4.25 mts
From SB1 to SB2=0.25 mts (Through the wall)
From SB2 to SB3=1.5 + 0.5 + 4 + 0.5 + 2 =8.5 mts
From HR of SB3 to SB4=1+ 1.5=2.5 mts
From HR of SB4 to L4=0.25 mts
Total length of conduit=4.5 +4.25+0.25+8.5+2.5+0.25=20.25 mts

Conduit for Sub-circuit -2 (for 15 ampere socket point)

From DB to SB5=1.5 + 1.5 + 0.25 + 0.5+4+0.5 + 0.25 + 1 + 1=10.5 mts

Total length of conduit pipe=Sub-circuit 1 + Sub- circuit 2 = 20.5 mts +10.5 mts = 30.75 mts

Taking 10% for wastage=10 % of 30.75=3.075 mts

Total length of conduit pipe required for wiring the building=(30.75+3.075) mts=33.825

say 34.0 mts

6. Calculation for the length of PVC insulated wires for both sub-circuit 1 and sub-circuit 2

Sub-circuit-1 (Calculation for Phase wire of size 1.5 mm^2)

From DB to SB1 =1.5 + 1.5 + 1.5 = 4.5mts

From SB1 to L 1 =1.5 mts

From SB1 to F1 = 1.5 + 0.5 + 1.5=3.5mts

From SB1 to L2= 1.5 +0.5+3+ 0.5 + 0.25=5.75 mts

From SB1 to SB2= 0.25 mts

From SB2 to L3= 1.5 mts

From SB2 to F2= 1.5 + 0.5 + 2= 4 mts

From SB2 to SB3= 1.5 + 0.5 + 4 + 0.5 + 2= 8.5 mts

From SB3 to tube=2 mts

From SB3 to SB4= 2 + 1.0 + 1.5= 4.5 mts

From SB4 to L4= 1.5+ 0.25(wall)=1.75 mts

from SB1 to SB2 for two way switches= 0.25 X 2 = 0.5 mts

Total length of phase wire=4.5+1.5+3.5+5.75+0.25+1.5+4+8.5+2+4.5+1.75+0.5=38.25 mts

Sub-circuit-1 (Calculation for Neutral wire of size 1.5 mm^2)

From DB to SB1 through L1=1.5 + 1.5 + 1.5 = 4.5mts

From L1 to F1 through F1=0.5 + 3+0.5 + 0.25 = 4.25mts

From SB1 to SB2= 0.25 mts.

From SB2 to SB3 through L3, F2, and tube light=1.5 + 0.5 + 4 + 0.5 + 2= 8.5 mts

From tube light to L4= 1+ 0.25(wall)=1.25 mts

Total length of Neutral wire=4.5+4.25+0.25+ 8.5+1.25 =18.75

Total Phase and Neutral wire of size 1.5 mm^2=phase + Neutral =38.25+18.75=57

Taking 15% for wastage=8.55mts

Total length of phase and Neutral wire required for wiring the room=57.0+8.55=65.55mts

say 66.0 mts

Sub-circuit-2 (Calculation for Phase wire of size 4 mm^2)

From DB to SB4=1.5 + 1.5 + 0.25 + 0.5+4+0.5 +1+1.5=10.75 mts

Sub-circuit-2 (Calculation for Phase wire of size 4 mm^2)

From DB to SB5=1.5 + 1.5 + 0.25 + 0.5+4+0.5 + 0.25 + 1 + 1=10.5 mts

Total Phase and Neutral wire of size 4 mm^2=phase + Neutral =10.75 +10.5 =21.25mts

Taking 15% for wastage=3.1875mts

Total length of phase and Neutral wire required for wiring the room=21.25+3.1875=24.4375mts

say 24.5 mts

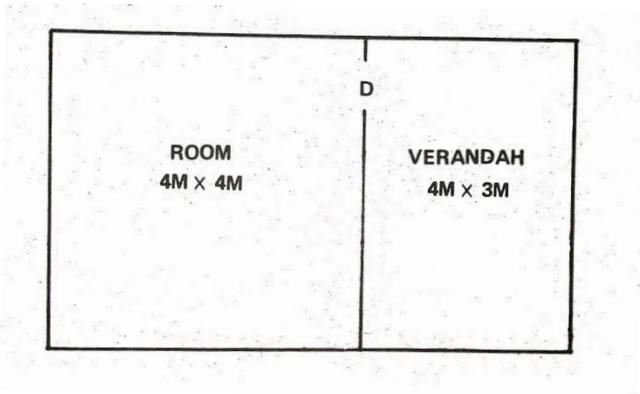
7. Calculation for length of earth wire (14 SWG)

Length of earth wire=4 x 0.25 mt = 1 mts

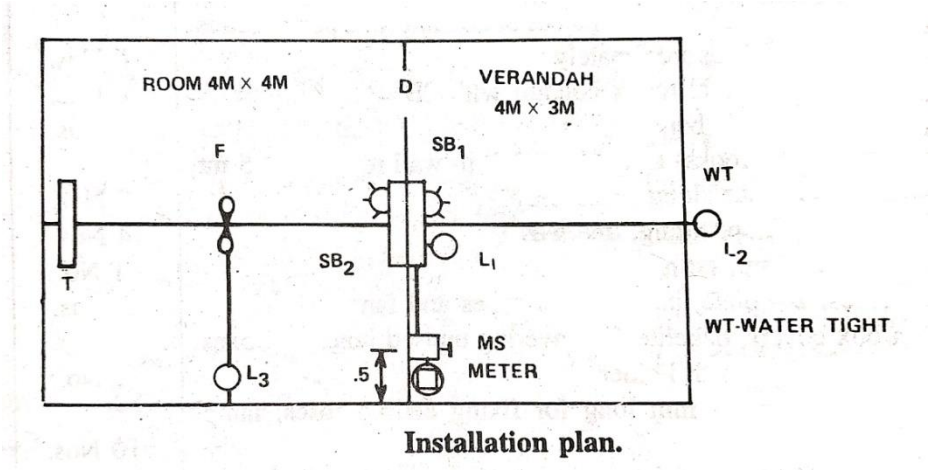
8. Material Table

Si no.	description of materials with specifications	Quantity
1	D.P.I.C Main switch,16 amp, 250 volt	1 no.
2	Iron clad DB (2way,250 volt grade -6 Amp,)	1 no.
3	Total length of conduit pipe (25 mm dia)	34.0 mts
4	Total length of phase and neutral wire (1.5 mm^2)	66.0 mts
5	Total length of phase and neutral wire (4 mm^2)	24.5 mts
6	Total length of earth wire(14 SWG ,G.I)	1.0 mt.
7	Concealed type ,Switch board with Bakelite sheets a. 20 cm x 25 cm for SB1 & SB2 b. 20 cm x 10 cm for SB3 & SB5 c. 10 cm x 10 cm for SB4	 2 nos. 2nos. 1no.
8	Conduit pipe accessories for 25 mm dia a. 1-way junction box b. 2-way junction box c. 3-way junction box d. Conduit bends	 1 no 8 nos. 2 nos. 10 nos.
9	One way switch,5 amp ,rating Two way switch,5 amp ,rating One way switch,15 amp ,rating	9 nos. 2 nos. 1 no.
10	Socket,5 amp rating, 5 pin Socket,15 amp rating, 5 pin	3 nos. 1 no.
11	Ceiling rose, 2-plate,bakelite	1 no.
12	Lamp brass bracket with holder	4nos.
13	Regulators	2nos.
14	Lamp brass bracket with holder	1nos.
15	Machine screws 25 mmlong	250 grm.
16	Earthing set complete with pipe,earth wire,charcoal,salt,thimbles,nuts & bolts etc	1 set.

Q.3 A room and a verandah ,the plan of which is given below is required to be provided with electrical wiring. Mark the location of energy meter, main switch and switch board and electrical points suitably and draw the installation plan showing supply path to each points and wiring diagram .Calculate the total length of wire required for wiring the room and verandah in batten system of wiring. Prepare a list of materials with complete specification of each item with approximate cost.



Solution:



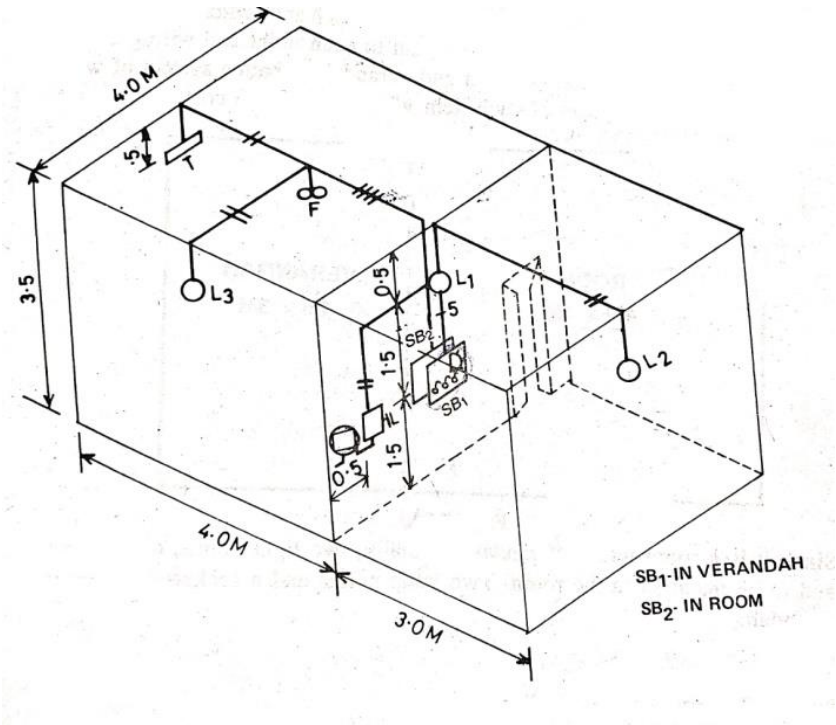
Installation plan.

1. Assumption

a) Height of ceiling from floor =3.5 mts
b) Height of H.R from floor=3.0 mts
c) Height of switch board from floor=1.5mts
d) Height of Light and tube points from floor=1.5 mts
e) Location of energy meter and main switch board=0.5 mt. inside verandah on room wall

2. Calculation of load

Lamps= 3X60 W=180W
Fan=1X60W=60W
Socket outlet 5 amp.=2X100W=200W
Fluorescent tube=1X40W=40W
Total connected load=480W
Load in ampere=480W/230V=2.1 amp



3. Selection and rating of main switch

A D.P.I.C Main switch of 6 ampere ,250 volt grade is selected.

4. Selection and rating of Distribution board

There are only seven light/fan/5 amp. socket points, hence no distribution board will be used.

5. Calculation for length of batten

From Main Board to HR=1.5 mts =(13mm X13mm) (2 wires)
From HR of Main Board to L_1=1.5mts=(13mm X13mm) (2 wire)
From SB_1 to L_1=1.5mts=(31mm X13mm) (5wire)
From L_1 to L_2=0.5+3+0.5=4mt=(13mm X13mm) (2 wire)
From SB_2 to Fan=1.5+0.5+2=4mts =(25mm X13mm) (4wire)
From fan to L_3=2+0.5=2.5mt=(13mm X13mm) (2 wire)
From fan to tube point=2+0.5=2.5mt=(13mm X13mm) (2 wire)

Total length of batten of size

13mm X13mm=1.5+1.5+4+2.5+2.5=12mt
Taking 10% for wastage=1.2mt
Total length of batten of size 13mm x 13 mm =13.2 mts say 13.5 mts

25mm X13mm=1.5+2.5=4mt
Taking 10% for wastage=0.4mt
Total length of batten of size 25 mm x 13mm =4.4 mts say 4.5 mts

31mm X13mm=1.5mt
Taking 10% for wastage=0.15mt
Total length of batten of size 31mm x13mm =1.65 mts say 2.0 mts

6. Calculation for length of PVC insulated wire of size 1.5 mm^2 (Both Phase and neutral)

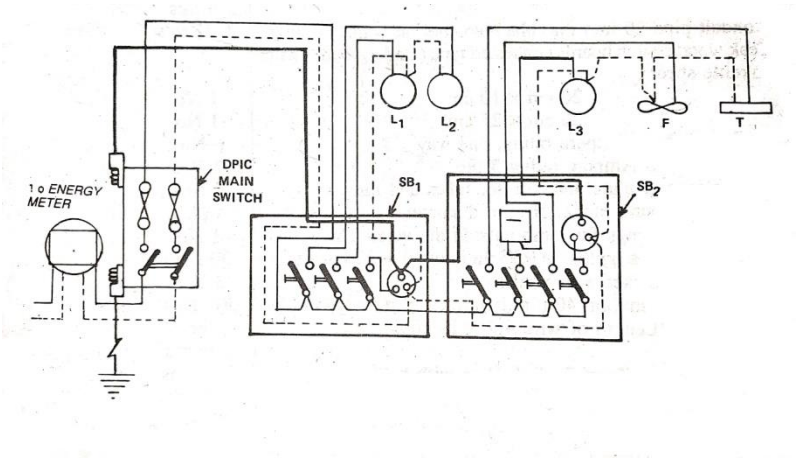
13mm X13mm=12mtX 2 wire=24 mts
25mm X13mm=4mt X 4 wire=16 mts
31mm X13mm=1.5mt X 5 wire=7.5 mts

Wire in conduits at crossing of wall=0.25 x 4=1 mts

Total length of wire on batten=48.5mts
Taking 15% for wastage=7.275mts
Total length of Phase and Neutral wire required for wiring the room=48.5+7.275=55.775 mts say 56mts

7. Calculation for length of earth wire (14 SWG)

From MS to SB_2 through SB_1=1.5+1.5+1.5+0.25(thickness of wall)=4.75mts
Taking 10% for wastage=0.475 mts
Total length of earth wire required for wiring the room=4.75+0.475=5.225 mts say 5.5 mts



8. Material Table

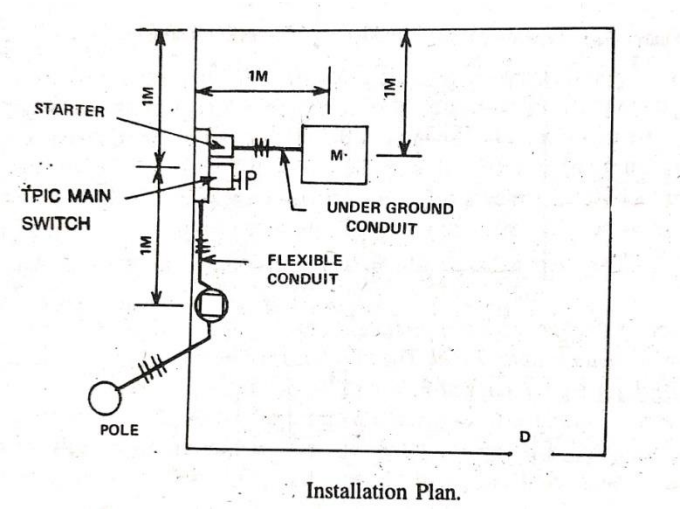
Si no.	description of materials with specifications	Quantity
1	DPIC main switch 6 amp rating,250 volt grade with fuse and NL	1no.
2	Total length of Different size of Batten 13mm X13mm 25mm X13mm 31mm X13mm	 13.5mt 4.5 mts 2 mts
2	Total length of phase & neutral wire (1.5 mm^2)	56 mts
4	Total length of earth wire(14 SWG ,G.I)	5.5 mts
5	Concealed type ,Switch board with Bakelite sheets a. 20 cm x 25 cm b. 10 cm x 10 cm	 1no. 1no.
6	One way switch,5 amp ,rating	6nos.
7	Socket,5 amp rating, 5 pin	2nos.
8	Ceiling rose, 2-plate,bakelite	2nos.
9	Lamp brass bracket with holder	2nos.

10	Link clip,aluminium 40 mm long (10 cm apart)	300 nos
11	Black enamel nails to fix clips with batten	100 gms
12	Teak wood plugs (guttis) at 0.75 mt interval	30nos.
13	Earthing thimbles 5 amp rating for fixing earth wire to main switch	2nos.
14	Earthing set complete with pipe,earth wire,charcoal,salt,thimbles,nuts & bolts etc	1 set.

Q.4 It is proposed to install a power connection of 3 phase 5 HP induction motor for an agriculture tube-well in the room of size 3MX3MX3M high. The motor is one metre away from two nearest walls. Prepare the estimate in the following order.

a) **Draw installation plan showing location of MB and motor etc. Also mark path of wiring by a thick line.**
b) **Single line diagram. Showing earth wires also.**
c) **Wiring diagram.**
d) **Decide the rating and specification of important materials and calculate of wire , conduits, earth wire etc. and prepare a complete list of materials required for wiring the room with complete specification of each item. Also calculate the approximate cost for the power wiring.**

Solution



Installation Plan.

1.Assumption

a) Height of MB (Main Board) from floor =1.5 mts
b) Two earth wires enclosed in their respective 15 mm dia. G.I pipe installed side by side for earthing the motor.
c) The Motor with pumping set is installed 0.25 mt above floor on a suitable foundation

2.Calculation of load

Running current =$\frac{5\times735.5}{\sqrt{3}\times400\times0.85\times0.8}$ =7.8 amp say 8 amp

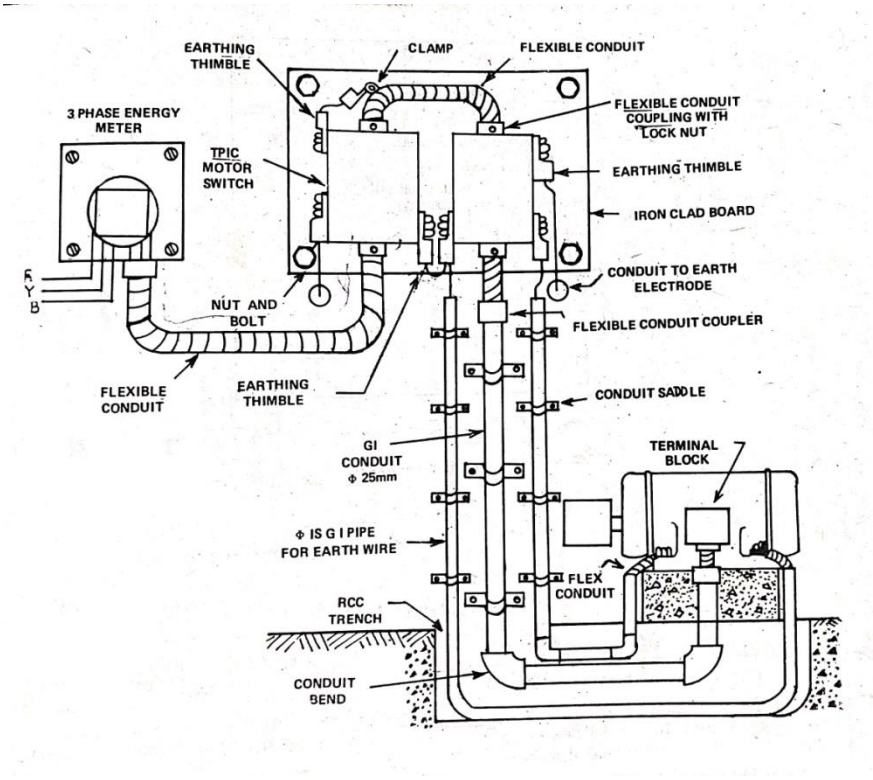
Starting current=1.5× $8 = 12$ amp

3.Selection and rating of MS

The total current drawn by the motor is only 12 amp. Therefore it is suggested that a TPIC, Main switch, 32 amp rating ,500 volt grade should be selected.

4.Selection and rating of wire

It is suggested that a PVC Insulated aluminium conductor, single core ,660 volts grade of size 6 mm^2 or 1/2.80 mm diameter, should be used for power wiring.



5.Calculation for length of heavy gauge conduits of size 25 mm diameter

From MB to motor foundation=1.5+0.25+1+0.25+0.25=3.25 mts
Taking 10% wastage=0.325mt
Total length of conduit required for wiring the motor =3.25+0.325=3.575 mts say 4 mts

6.Calculation for length of heavy gauge conduits of size 15 mm diameter for earth wire

From MB to motor foundation= (1.5+0.25+1+0.25+0.25)X2=3.25 mts X 2=6.5 mts
Taking 10% wastage=0.65mt
Total length of conduit required for wiring the motor =6.5+0.65=7.15 mts say 7.5 mts

7.Calculation for length of flexible conduits of Size 25 mm diameter

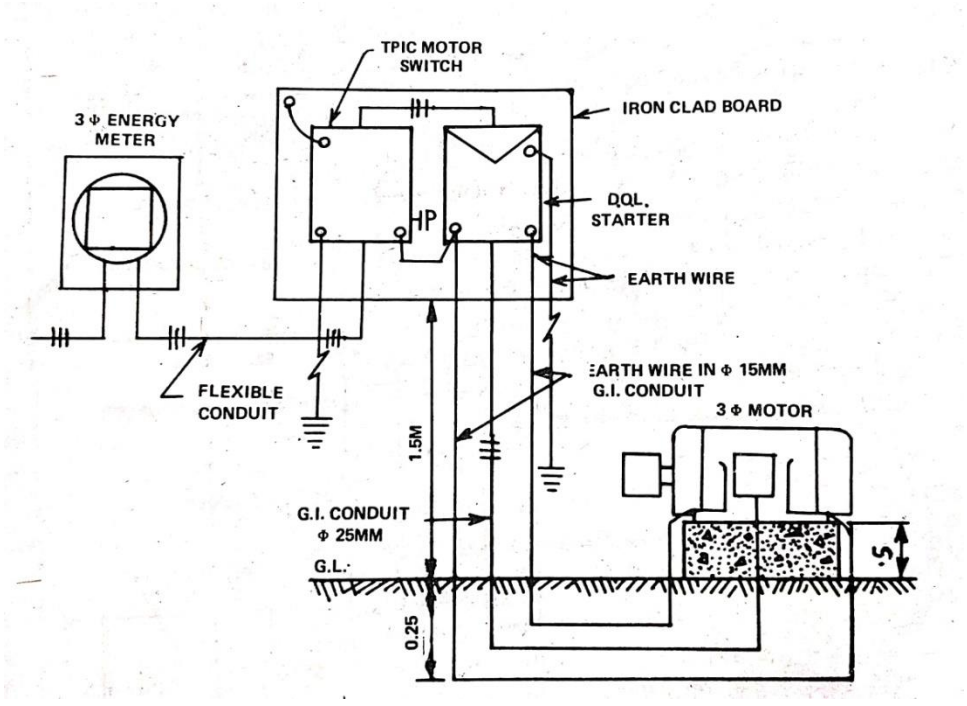
From energy meter to main board=1.0 mt
From main switch to starter=0.5 mt
From starter to conduit mouth=0.25mt
From motor foundation to motor terminal block=0.25mt
Total length of conduit= (1.0+0.5+0.25+0.25)mt=2mt
Taking 10% wastage=0.2mt
Total length of flexible conduit required for wiring the motor =2+0.2=2.2mts say 2.5 mts

8.Calculation for length of phase wire of 6 mm^2 or 1/2/80 mm dia

From TPIC to motor terminal=length of conduit (rigid conduit +flexible conduit) X 3 wires
=(3.25+2)mts X 3
=15.75 mts
Taking 15% wastage=2.5mt
Total length of phase wire required for wiring the motor=(15.75+2.5)mts=18.25 mt=18.5 mts

9.Calculation for length of 8 SWG ,G.I , earth wire

From starter to motor foundation = length of conduit X 2 earth wires
=3.25 X 2 Wires
=6.5 mts
Taking 10% wastage=0.65mt
So total earth wire required for wiring the motor=6.5 +0.65=7.15mt say 7.5 mts



10.Material Table

Si no.	description of materials with specifications	Quantity
1	TPIC main switch, 32 amp rating,500 volt grade	1no.
2	Total length of Heavy gauge rigid conduit (25mm dia)	4 mts
3	Total length of heavy gauge flexible conduit (25 mm dia)	2.5 mts
4	Total length of rigid conduit (15mm dia)	7.5 mts
5	Total length of phase wire(6 mm^2)	18.5 mts
6	Earth wire (8 SWG)	7.5 mts
7	Saddle	1 pkt
8	Nuts & bolts	1 pkt
9	Wooden screw 20 mm long	30 nos.
10	PVC tape	1 pkt.
11	Bend	30 gms
12	Earthing thimbles 5 amp rating for fixing earth wire to main switch	2nos.
13	Earthing set complete with pipe,earth wire,charcoal,salt,thimbles,nuts & bolts etc	1 set.

CHAPTER-4 OVERHEAD INSTALLATION

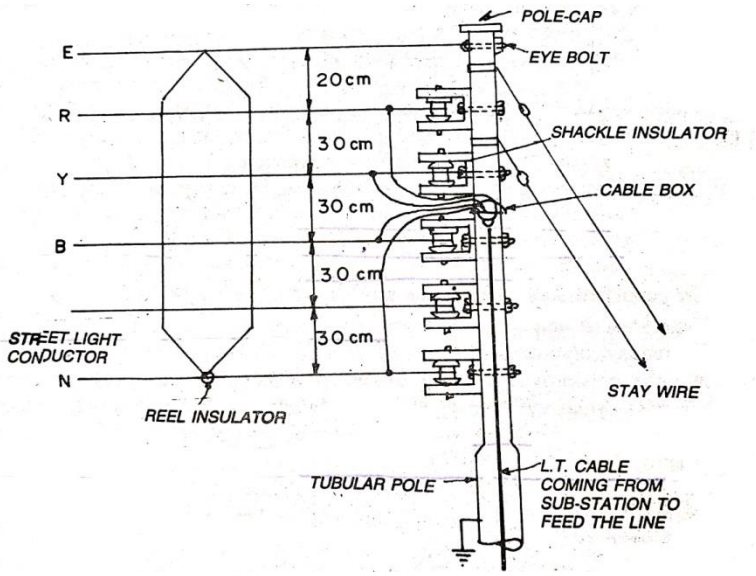
Q.1 In a city locality, an overhead distribution line of 400 volts, 3 phase ,50 cycle/sec. is to be erected along a straight route on steel tubular poles. The length of the line is 500 metres and the line terminates at the ends. The span between adjacent poles is 50 mts. The street light conductors are also supported on the same poles.Make a neat sketch of the last 2-3 poles and estimate the quantity of material required for installing the distribution line with full specification of each items. Other details of the line are suggested as under.

ACSR conductors are phase lines, neutral and street light conductor of size 6/1$\times$ 2.11 (squirrel conductor). Earth wire 8 SWG , Galvanised iron

Solution

Assuming that the connection is taken for the line from an existing sub-station of 11/0.4 KV.
Length of line =500 metres
Average span=50 mts.
No. of tubular poles required=$\frac{500}{50}$+1=11 nos.
Length of squirrel ACSR conductor of size(6/1$\times$ 2.11 mm)=(500 mts$\times$ 5)+2% for sag
=2500+50
=2550 mts

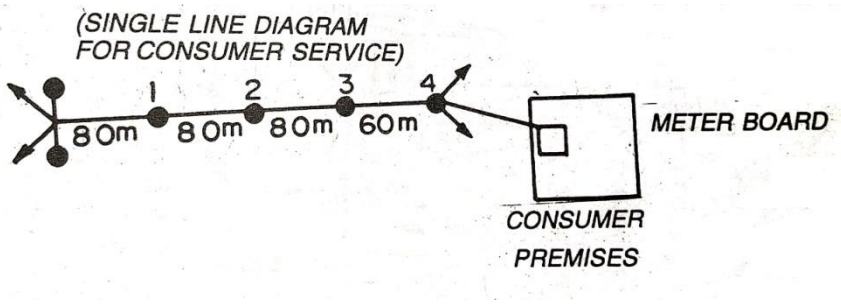
In weight=85 kg/km=216.75 kg say 217kg
Length of 8 SWG, galvanized iron= 500+2% for sag
=510 mts
In weight =10 mts/kg=51 kg



Material Table

Si no.	description of materials with specifications	Quantity
1	Steel tubular poles (9 mts long)	11 nos
2	ACSR squirrel conductors of size(6/1× 2.11 mm)	2550 mts(218 kg)
3	E arth conductors 8 SWG GI	510 mts (51kg)
4	shackle Insulators with 'D' straps i.e 5 on each pole	55 nos.
5	Nuts and Bolts 15 mm dia ,200 mm long with washers for fixing 'D' straps with pole,one for each straps	55 nos.
6	Nuts and Bolts 15 mm dia ,125 mm long with washers for fixing insulators with 'D' straps	55 nos.
7	Earth wire pole clamp one on each end pole	2nos.
8	Eye bolts,15 mm dia ,200 mm long for holding earth wire on intermediate pole	9 nos.
9	Guard wire of size 7/16 SWG ,for guarding at approximate 15 places	45 mts
10	Reel insulator	15 nos.
11	Pole caps for steel tubular poles	11 nos.
12	Stay wire set complete i.e 2 sets on each terminals poles	2+2=4 nos
13	Earthing sets complete for earting(one at each terminal pole and one central pole)	3 sets
14	Street light fitting complete with tube and clamps	11nos.
15	Number plates with clamps	11nos.
16	Pole foundation for each pole	11nos.
17	To complete the job miscellaneous items such as cement ,sand, concrete etc	-
18	14 SWG ,galvanized steel wire as binding wire	5kg

Q.2 A tube well owner wants 3 phase,4 wire power connection to his 10 BHP motor from an over head double pole structure having of 25 KVA ,11/0.4 KV . The double pole structure is 300 metres away from tube well. Estimate the quantity of materials required for erecting a line and for giving a service connection to the tube well motor. Also draw neat sketch of the same.



Solution

Total connected load =10BHP

Running current=$\frac{10\times746}{\sqrt{3}\times400\times0.85\times0.9}$ = 14.07 amp

Starting current=1.5$\times$ $14.07 = 21.10$ amp

To meet the present load requirement and Provision for future requirement in the event expansion of building and any other electrical points in the existing building =(50% $\times$ 21.10)+21.10=31.65 amp

It is therefore suggested that

- L.T 4 core ,aluminium conductor weather proof cable of size =6 mm^2 (from distribution transformer to pole and from last pole to the meter box)
- A.A.C of minimum size =3/3.00 mm mantis stranded conductor (from first pole to last pole)

Average span=50 mts.

No. of Concrete pole required(9 mt. long) =$\frac{300}{50}$=6 nos.

Length of mantis AAC conductor of size(3/3.00 mm)=(300 mts$\times$ 4)+2% for sag

=1200+24

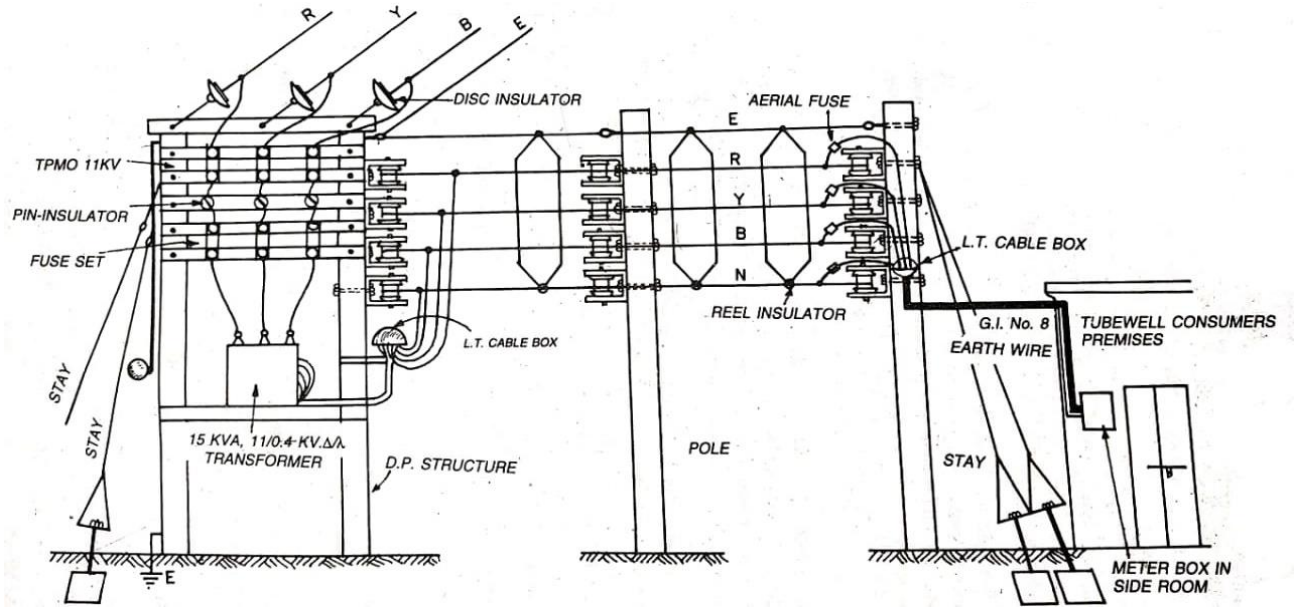
=1224 mts

In weight=58 kg/km=70.998kg say 71 kg

Length of 8 SWG, galvanized iron= 300+2% for sag

=306mts

In weight =10 mts/kg=30.6kg

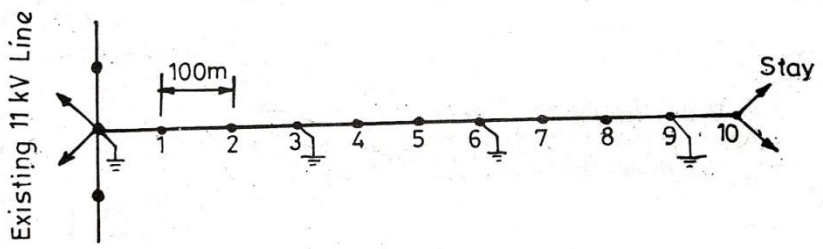


Material Table

Si no.	description of materials with specifications	Quantity
1	RCC poles (9 mts long)	6 nos
2	AAC, mantis conductors of size(3/3.00mm)	1224 mts(70kg)
3	E arth conductors 8 SWG GI	306 mts (30.6kg)
4	Shackle Insulators with 'D' straps i.e 4 on each pole	24+4=28 nos
5	Nuts and Bolts 15 mm dia ,200 mm long with washers for fixing 'D' straps with pole,one for each straps	28nos.
6	Nuts and Bolts 15 mm dia ,125 mm long with washers for fixing insulators with 'D' straps	28 nos.
7	Eye bolts,15 mm dia ,200 mm long for holding earth wire on intermediate pole	4 nos.
	Earth wire pole clamp one on each end pole	2 nos.
9	Guard wire of size 7/16 SWG ,for guarding at approximate 15 places	30 mts
10	Aerial fuse,32 amp rating on last pole	3 nos.
11	L.T outdoor cable box, complete with clamps	2 nos.
12	Reel insulator	10 nos.
14	Stay wire set complete i.e 2 sets on each terminals poles	2+2=4 nos
15	Earthing sets complete for earting	1 sets
16	Number plates with clamps	6 nos.
17	Pole foundation for each pole	6 nos.
18	To complete the job miscellaneous items such as cement ,sand, concrete etc	-
19	14 SWG ,galvanized steel wire as binding wire	2kg

Q.3 Estimate the quantity of material required for the construction of 1 kilometre overhead line. The line is tapped from the existing 11 KV line to feed a particular locality. The particulars of the important materials to be used for the line to be erected are as follows.

a) Size of conductor : ACSR 6/1× 2.59 mm
b) Tubular pole or supports of 11 metres length
c) Size of earth wire : G.S (galvanized steel) 8 SWG
d) Average span length=100 mts.
e) No. of earthing sets to be installed:3 nos.



Single line diagram of the line

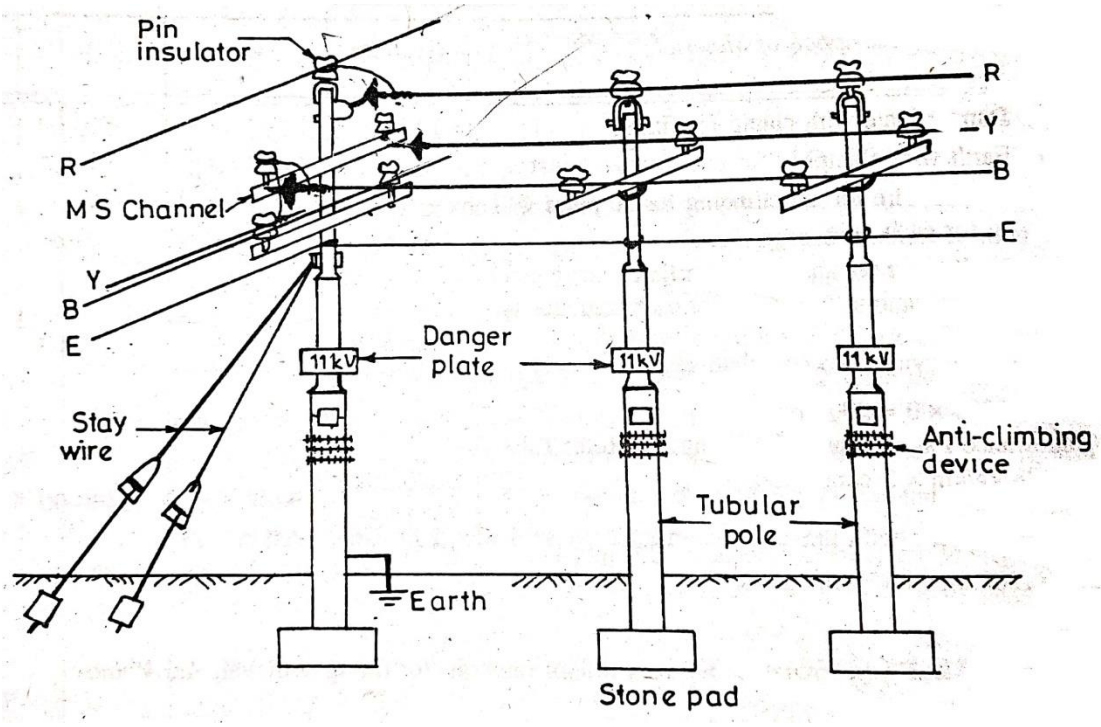
Solution

Total Length of conductors (ACSR weasel conductor 6/1 X 2.59 mm)= (1000X3)+2% for sag

=3000+60=3060 mts

Total length of G.I. earth wire of size 8 SWG =1000+2% for sag

=1000+20=1020 mts



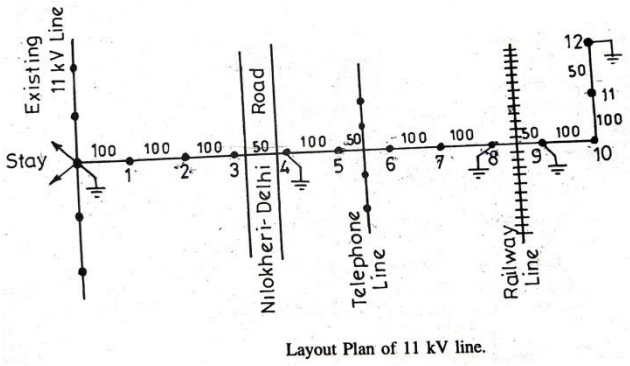
Material Table

Si no.	description of materials with specifications	Quantity
1	Tubular line supports (11 mts long)	10 nos
2	Material required for connection with existing line of 11 KV line 1. M.S channel for cross arm (10 cmX5 cmX1.5mts) 2. H.T ,11 KV Disc insulator with complete fittings 3. H.T ,11 KV ,pin type insulators with nuts and bolts 4. Stay complete sets (clamps ,stay wire, egg insulators ,stay rod stay bow, stay plates) 5. Earth wire clamp 6. Binding wires 7. Clamps for M.S channel 8. Concreting for stay rod	 1no. 3nos. 2 nos. 2nos. 1no. 1 kg 1 no. 2nos.
3	Fitting for new line supports 1. Stone pads for poles 2. Angle iron cross arms, 1 for each pole 3. clamps for fixing cross arm with poles 4. 11 KV ,pin type insulators with nuts and bolts 5. No. plates with clamps for fixing 6. Danger plates with clamps for fixing 7. Earth wire clamp 8. Barbed wire for anti climbing for 10 poles @ 1 kg for each pole 9. Binding wires (for fixing conductors over insulators) 10. Stay complete sets (clamps ,stay wire, egg insulators ,stay rod stay bow, stay plates)	 10 nos. 10 nos. 10 nos. 30 nos. 10 nos. 10 nos. 10 nos. 10kg 6kg 2nos
4	ACSR weasel conductors of size 6/1 X 2.59 mm	3060 mts
5	G.I earth wire of size 8 SWG	1020 mts.
6	Earthing complete sets (G.I pipe, charcoal ,salt etc)	3 nos.
7	Painting for poles	10 nos.

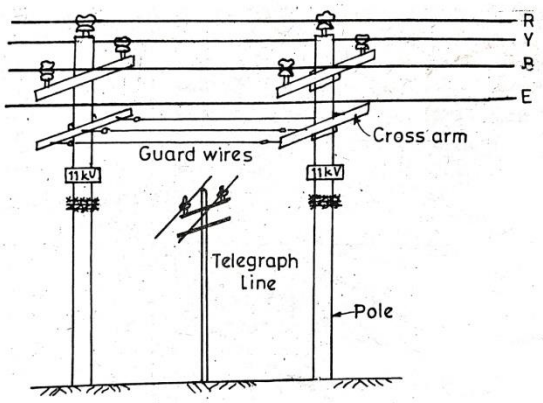
Q.4 Estimate the material and cost for the construction of 1 kilometre overhead line. The line is tapped from the existing 11 KV overhead line. Assuming that the line is passing over the main road, telegraph line and railway line. Given data:

a) Size of conductor : ACSR 6/1$\times$ 2.36 mm gopher
b) Type of pole : R.S (Rolled steel) joist 10 mts and 11.5 metres long.
c) Size of earth wire : G.S (galvanized steel) 8 SWG
d) Type of cross arm : mode of angle iron
e) No. of earthing : plate eathing

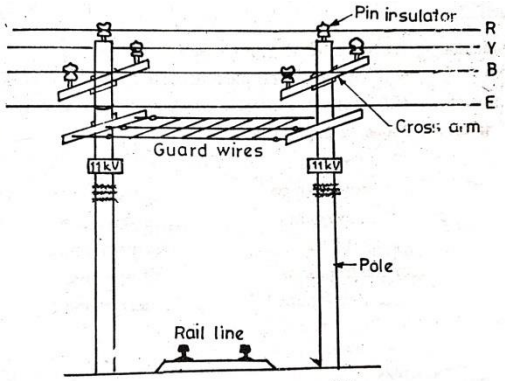
Solution



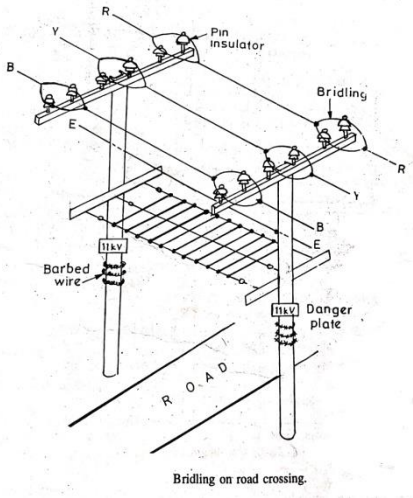
Layout Plan of 11 kV line.



Guarding for telegraph line.



Guarding for rail line



Bridling on road crossing.

Total Length of conductors (ACSR gopher conductor 6/1 X 2.36 mm)= (1000X3)+2% for sag

=3000+60=3060 mts

Total length of G.I. earth wire of size 8 SWG =1000+2% for sag

=1000+20=1020 mts

Material Table

Si no.	description of materials with specifications	Quantity
1	a) R.S joist poles 15cm diameter 10 mt long b) R.S joist poles 15cm diameter 11.5 mt long	6 nos. 6 nos.
2	Material required for connection with existing line of 11 KV a) M.S channel for cross arm (10 cmX5 cmX1.5mts) b) H.T ,11 KV Disc insulator with complete fittings c) H.T ,11 KV ,pin type insulators with nuts and bolts d) Stay complete sets (clamps ,stay wire, egg insulators ,stay rod stay bow, stay plates) e) Earth wire clamp f) Binding wires g) Clamps for M.S channel h) Concreting for stay rod	 1no. 3nos. 2 nos. 2nos. 1no. 1 kg 1no. 2nos.
3	Fittings for new line supports a) Stone pads for poles b) Angle iron cross arms, 1 for each pole c) clamps for fixing cross arm with poles d) 11 KV ,pin type insulators with nuts and bolts e) No. plates with clamps for fixing f) Danger plates with clamps for fixing g) Earth wire clamp h) Barbed wire for anti climbing for 10 poles @ 1 kg for each pole i)Binding wires (for fixing conductors over insulators)	 12 nos. 12 nos. 12nos. 42 nos. 12 nos. 12 nos. 12 nos. 12 kg 8 kg
4	Extra material for poles at road crossing a) Brindling cross arm b) Cross arm clamps c) Guard wire d) Eye bolts for holding guard wire	 2 nos. 2nos. 25 kg 6 nos
5	Extra material for telegraph line crossing a) Cross arm b) Clamps for cross arm c) Guard wire d) Eye bolts for holding guard wire	 2nos. 2 nos. 25 kg. 6 nos
6	Extra material for rail way line crossing a) Cross arm b) Clamps for cross arm c) Guard wire d) Eye bolts for holding guard wire	 2nos. 2 nos. 25 kg. 6 nos
7	ACSR gopher conductors of size 6/1 X 2.36 mm	3060 mts
8	G.I earth wire of size 8 SWG	1020 mts.
9	Earthing complete sets (G.I pipe, charcoal ,salt etc)	4 nos.
10	Painting for poles	12 nos.

CHAPTER -5 OVERHEAD SERVICE LINE

❖ PREPARE AND ESTIMATE FOR PROVIDING SINGLE PHASE SUPPLY LOAD OF 5KW (LIGHT,FAN,SOCKET) TO A SINGLE STORED RESIDENTIAL BUILDING

Q.1 A newly constructed single storeyed house is to be provided with single phase 230 volts,50 HZ having a load of 5 KW (light, fan, socket). The supply is to be given from overhead line 20 mts. away from the building. Prepare a list of the material, for giving service connection and also estimate the cost of the service connection. A G.I pipe is to be raised along the roof to receive bare conductor on its cross arm fitted with insulators. Also draw sketch of service connection.

Solution

1. Assumptions

2. Height of ground floor=3.5 mts.
3. Service connection received at the height of 6 mts. from ground.

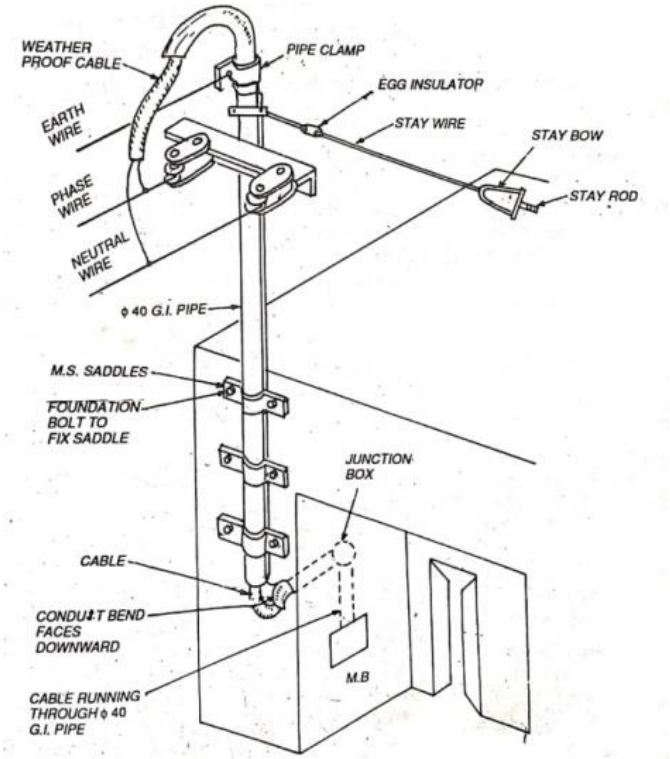
2. Selection and rating of weatherproof ,twin core, aluminium conductor cable and line conductor (Bare conductor)

Total connected load=5 KW
Total load in ampere=5000/230=21.7 amp
Diversity factor=60% X 21.7=13 amp

To meet the present load requirement and Provision for future requirement in the event expansion of building and any other electrical points in the existing building = (50% X13) + 13=19.5 amp

It is therefore suggested that

- Rating of weatherproof cable =6 mm^2 or 1/2.80 mm , twin core, PVC insulated cable to carry a load current of 27 amp.
- Rating of bare conductor for installation between distribution pole up to insulators=10 mm^2 ,AAC
- Rating of earth wire=8 SWG



3. Material Table

Si no.	Specification	Quantity
1	PVC weatherproof cable of size 6mm^2 or 1/2.80 mm twin core including wastage	10mts
2	AAC for phase and neutral connection (10 mm^2)	42 mts
3	8 SWG GI earth wire(from pole to meter board)	20+1+10=31 mts
4	G I pipe (50 mm diameter)	8mt.
5	Conduit bends	3 nos
6	GI pipe Saddles	10 nos.
7	Earthing Thimble (to fix earth wire and stay wire)	2 nos.
8	LT shackle insulators	4 nos.
9	Angle iron bracket insulator of size(50mmX50mmx6mmx60mm) long	2 nos.
10	Stay insulator	1no.
11	Stay wire	7mt.
12	Stay bow	1 nos
13	Stay rod	1 nos
14	Cement	1 bag
15	Sand	3 bag
16	Concrete	2 bag
17	2 Way junction box	2 nos.
18	Nuts & bolts	2 pkt

Q.2 A newly constructed single storey house is to be provided with single phase 230 volts,50 HZ having a load of 4 KW. The supply is to be given from overhead line 30 mts. away from the building. Prepare a list of the materials and estimate the cost for providing the service connection.

Solution

1. Assumptions

4. Height of ground floor=3.5 mts.
5. Service connection received at the height of 6 mts. from ground.

2. Selection and rating of weatherproof ,twin core, aluminium conductor cable

Total connected load=4 KW

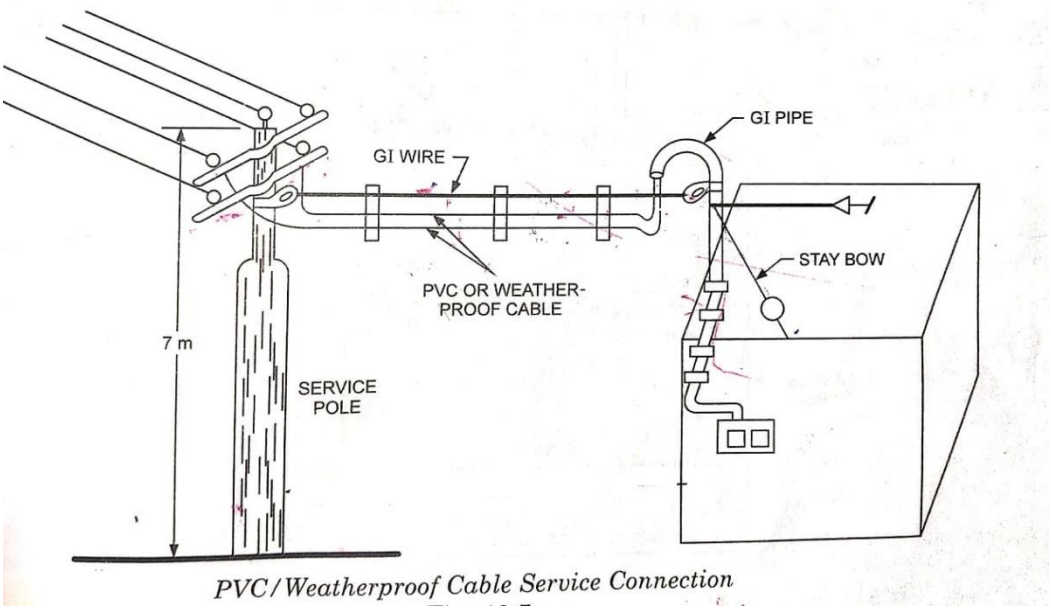
Total load in ampere=4000/230=17.29 amp

Diversity factor=60% X 17.29=10.43 amp

To meet the present load requirement and Provision for future requirement in the event expansion of building and any other electrical points in the existing building =(50% X10.43) + 10.43 =15.21 amp

It is therefore suggested that

- Rating of weatherproof cable = 4 mm^2 or 1/2.24 mm ,twin core, PVC insulated cable
- Rating of G.I wire=8 SWG



PVC/Weatherproof Cable Service Connection

3.Material Table

Si no.	specification	quantity
1	PVC weatherproof cable(from pole to EM with wastage)	30+2+15=47 mt
2	8 SWG GI wire	32 mt.
3	G I pipe (50 mm diameter)	8mt.
4	Conduit bends	3 nos
5	GI pipe Saddles	10 nos.
6	Earthing Thimble	2 nos.
7	Stay wire	7mt.
8	Stay insulator	1 nos
9	Stay bow	1 nos
10	Stay rod	1 nos
11	Cement	1 bag
12	Sand	3 bag
13	Concrete	2 bag
14	2 Way junction box	2 nos.
15	Nuts & bolts	2 pkt
16	Binding wire	2 mts

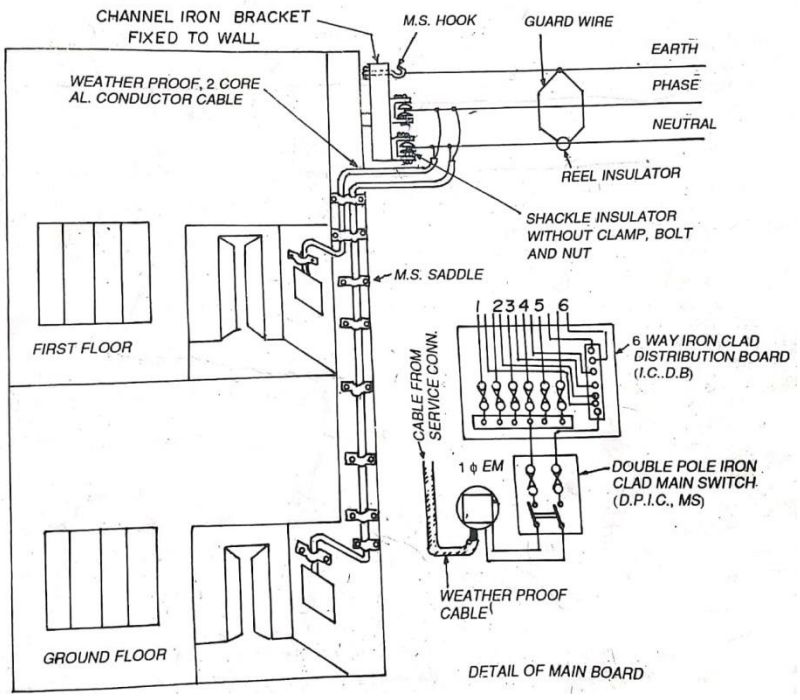
❖ 5.3 PREPARE AND ESTIMATE FOR PROVIDING SINGLE PHASE SUPPLY LOAD OF 3KW TO EACH FLOOR OF A DOUBLE STORED RESIDENTIAL BUILDING HAVING SEPARATE ENERGY METER

Q.3 Prepare a list of material and estimate the cost for giving service connection to a double storeyed building having two energy meters. The supply is to be given at 230 volt single phase having a load of 4 sub-circuit (light, fan) and two 15 amp socket points on each floor .The supply is to be given from overhead line 20 metres away from the building .Also draw diagram of service connection.

Solution

1.Assumptions

1. Height of ground floor=3.5 mts.
2. Total height of first floor from ground=7mts.
3. Service connection received at the height of 6 mt. from ground.
4. Height of ground floor meter board from floor=1.5mts.



3.Selection and rating of weatherproof ,twin core, aluminium conductor cable and Line conductor (Bare conductor)

Total connected load for 4 sub-circuit=4X800=3200 watts
2-15 amp sockets=2X1000=2000watts
So total load of a single building storeyed=3200+2000=5200 watt
Total load in ampere=5200/230=22.6amp (for single storeyed)
Total connected load for both floor=22.6+22.6=45.2 amp
Diversity factor=60%X45.2=27.12amp

To meet the present load requirement and Provision for future requirement in the event expansion of building and any other electrical points in the existing building .It is therefore a better suggestion that a weather proof cable of higher rating may be used=(50% X27.12) + 27.12 = 40.68amp

It is therefore suggested that

- Rating of weatherproof cable =16 mm^2 or 7/1.70 mm ,twin core, PVC insulated cable
- Rating of bare conductor for installation between distribution pole upto insulators=16 mm^2 ACSR Conductor
- Rating of G.I wire=8 SWG

4. Material Table

Si no.	Specification	Quantity
1	Shackle insulators with U clamps, nuts & bolts	2+2=4 nos.
2	Mild steel channel or hook	2 nos.
3	ACSR conductor for phase and neutral connection ($16mm^2$) including wastage	20+20+2=42mts
4	8 SWG GI earth wire(from pole to meter boa)	20+1+15=36mts
5	MS angle iron bracket of size (50mmX50mmx6mmx1mt) long	2 nos.
6	PVC Weather proof cable	15 mt
7	MS Saddles	15 nos.
8	Earthing Thimble (to fix earth wire)	2 nos.
9	Reel insulator	1no.
10	Guard wire	7mt.
11	Cement	1 bag
12	Sand	3 bag
13	2 Way junction box	2 nos.
14	Nuts & bolts	2 pkt

❖ 5.4 PREPARE ONE ESTIMATE OF MATERIAL REQUIRED FOR SERVICE CONNECTION TO A FACTORY BUILDING WITH LOAD WITHIN 15KW USING INSULATED WIRE

Q.4 A workshop required to connect a 3-phase 15 KW ,415 V ,50 HZ motor to a 3-phase ,4-wire,415/240 volt ,50 HZ overhead line .The distance of the service line from the workshop structure having motor is 15 mt. The motor has an efficiency of 85% and a power factor of 0.8 . Estimate the quantity and cost of material required.

Solution

1.Assumptions

1. Height of ground floor=6 mts.
2. Service connection received at the height of 7 mts. from ground.

2.Selection and rating of weatherproof four core cable

Total connected load =15KW

Running current=$\frac{15\times1000}{\sqrt{3}\times415\times0.85\times0.8}$ =30 amp

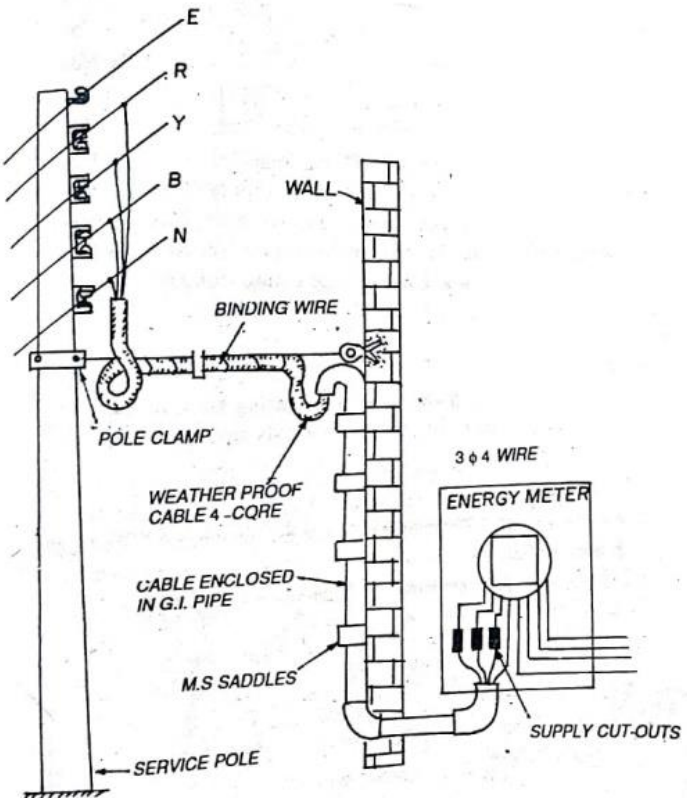
Starting current=$1.5\times 30 = 45$ amp

Diversity factor =$60\%\times 45 = 27$

To meet the present load requirement and Provision for future requirement in the event expansion of building and any other electrical points in the existing building =$(50\% \times 27)+27=40.5$ amp

It is therefore suggested that

- Rating of weatherproof cable =20mm^2 or 19/1.12 mm ,4 core, PVC insulated copper conductor
- Rating of G.I wire=8 SWG



3.Material Table

Si no.	specification	quantity
1	PVC weatherproof cable(from pole to EM with wastage)	15+2+5+10=32 mt
2	8 SWG GI wire	17 mt.
3	G I pipe (50 mm diameter)	7mt.
4	Conduit bends	3 nos
5	GI pipe Saddles	15 nos.
6	Pole clamp	1 nos
7	Cement	1 bag
8	Sand	3 bag
9	Concrete	2 bag
10	2 Way junction box	2 nos.
11	Nuts & bolts	2 pkt
12	Binding wire	2 mts
13	M S hook	1 no.

Q.5 A tube well owner wants 3-phase ,4 wire power connection to his 10 HP motor from the pole of 400v ,3 phase 50 HZ overhead line at a distance of 200mt. from the workshop. Make a sketch showing the arrangement of supply and estimate the quantity and cost of the material required.

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Solution

1.Assumptions

1. Height of ground floor=6 mts.
2. Service connection received at the height of 7 mts. from ground.

2.Selection and rating of weatherproof four core Cable and line conductor (Bare conductor)

Total connected load =10HP

Running current =$\frac{10\times746}{\sqrt{3}\times400\times0.85\times0.8}$ = 15.8 amp

Starting current=1.5$\times$ $15.8 = 23.7$amp

To meet the present load requirement and Provision for future requirement in the event expansion of building and any other electrical points in the existing building =(50% $\times$ 23.7)+23.7=35.55 amp

It is therefore suggested that

- Rating of weatherproof cable =16 mm^2 or 7/1.70 mm ,4 core, PVC insulated aluminium conductor
- Rating of bare conductor for installation between distribution pole up to insulators=10 mm^2 ACSR Conductor
- Rating of G.I wire=8 SWG

3. Material Table

Si no.	specification	quantity
1	PVC weatherproof cable	15 mts
2	Bare conductors	808 mts
3	Shackle insulator	8 nos.
4	8 SWG GI wire	202 mt.
5	G I pipe (50 mm diameter)	6 mt.
6	Conduit bends	3 nos
7	GI pipe Saddles	15 nos.
8	Earthing Thimble	2 nos.
9	Cement	1 bag
10	Stay insulator	1no.
11	Stay wire	7mt.
12	Stay rod	1 nos
13	Stay bow	1 nos
14	Reel insulator	2no.
15	Guard wire	8mt.

16	Sand	3 bag
17	Concrete	2 bag
18	2 Way junction box	2 nos.
19	Nuts & bolts	2 pkt
20	Binding wire	2 mts

CHAPTER -6 ESTIMATING FOR DISTRIBUTION SUBSTATION

Q.1 Estimate the cost of a pole mounted sub-station of capacity 50 KVA transformer of rating 11/0.4 KV. The H.T line is available about 50 metres from the proposed site.Also make a neat sketch of the pole mounted sub-station.

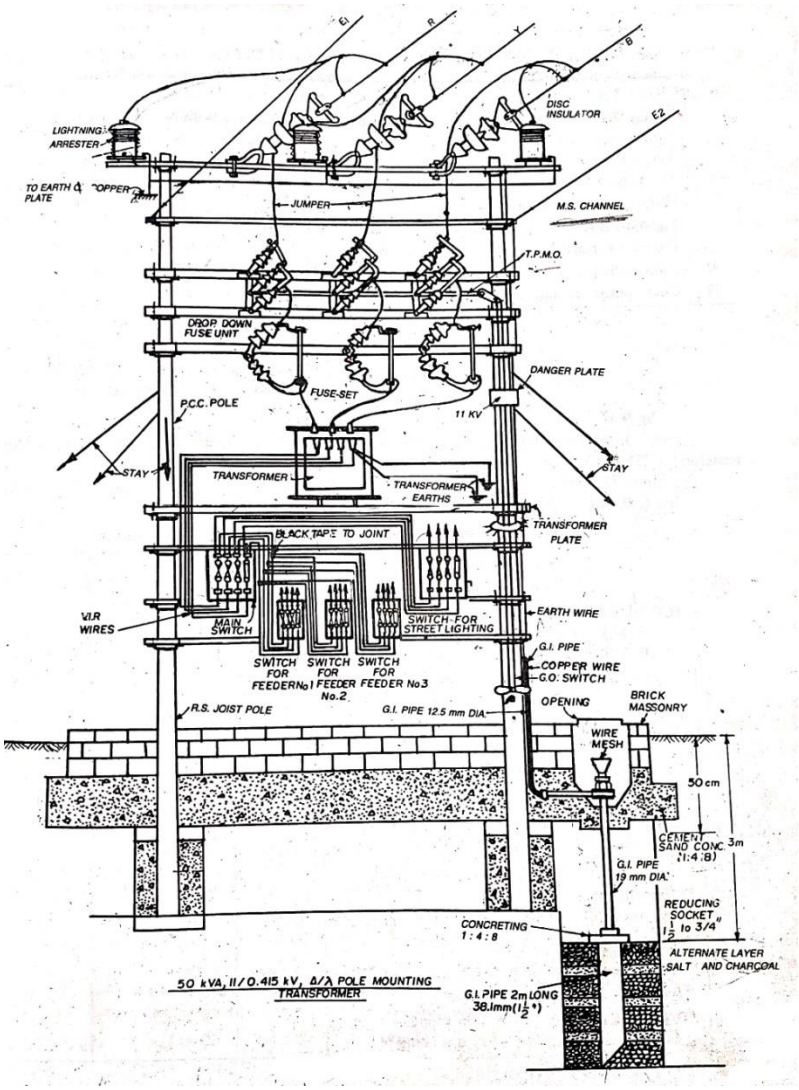
Solution

Total Length of conductors (ACSR gopher conductor 6/1 X 2.36 mm)= (50X3)+2% for sag

=150+3=153 mts

Total length of G.I. earth wire of size 8 SWG =50+2% for sag

=50+1=51 mts.



Material Table

Si no.	description of materials with specifications	Quantity
1	Material for H.T connection with main line 1. M.S channel cross arm 10 cm× 5cm ×1.5 mt long 2. H.T ,11 KV Disc insulator with complete fittings 3. Stay complete sets (clamps ,stay wire, egg insulators ,stay rod stay bow, stay plates) 4. Earth wire clamp 5. Binding wires 6. Clamps for M.S channel 7. Concreting for stay rod	 1no. 3nos. 2 nos. 2nos. 500 gms 1 no. 2nos.
2	Conductor ACSR gopher 6/1×2.36 mm diameter	153 mts.
3	Earth conductors 8 SWG GI	51 mts.
4	R .S joist 175 mm× 100mm ×10 mt long	2 nos.
5	Fittings on H.T double pole structure for pole mounted sub-station. 1. Stone pad 2. Sub-station plate 3. M.S channel cross arm 100 mm× 50mm × 8mm ×2.65mt long 4. Eye bolt 5. Dropper angle iron 75 mm× 75mm × 8mm ×2mt long 6. Stay complete sets 7. 11 KV ,Disc type insulators with nuts and bolts 8. Binding wires 11. No. plates with clamps for fixing 12. Danger plates with clamps for fixing 13. Earth wire clamp 14. Barbed wire 15. Earthing complete 16. Jumper wire for jumping 17. Nuts and bolts of size as required. 18. Concreting poles 19. T.P.M.O switch 20. Painting of pole and other attachments 21. Fuse sets	 2 nos. 1 no. 1no. 3 nos. 6no. 4 nos. 3nos. 500 gms 1no. 1no. 1no. 5kg. 1set 11mts 18nos. 2 nos 1no. 2 litres 1set
6	Transformer 50 KVA ,11/0.4 KV	1no.
7	TPICN(triple pole iron clad with neutral) main switch 100 ampere rating	1no.
8	Earthing for transformer	1no.
9	Lighting arresters one set of three	1set