LECTURE NOTES

ON

ELECTRICAL INSTALLATION & ESTIMATING

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CAPTER-1

INDIAN ELECTRICITY RULES

1.1 Definitions, Ampere, Apparatus, Accessible, Bare, cable, circuit, circuit breaker, conductor voltage (low, medium, high, EH), live, dead, cut-out, conduit, system, danger, Installation, earthing system, span, volt, switch gear, etc.

1.2 General safety precautions, rule 29, 30, 31, 32, 33, 34, 35, 36, 40, 41, 43, 44, 45, 46.

1.3 General conditions relating to supply and use of energy : rule 47, 48, 49, 50, 51, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 70.

1.4 OH lines : Rule 74, 75, 76, 77, 78, 79, 80, 86, 87, 88, 89, 90, 91

1.1 DEFINITIONS

AMPERE

Ampere is the unit of electric current in IS unit.

An ampere is a unit of measure of rate of electron flow in an electrical conductor. One ampere of current represents one coulomb of electric charge charge($6.24x10^{18}$) moving a specific point in one second.

APPARATUS

It is a technical equipment or machinery needed for a particular activity or purpose. OR

It is a set of materials or equipment designed for a particular use. OR

Apparatus" means electrical apparatus and includes all machines, fittings, accessories and appliances in which conductors are used.

ACCESSIBLE

Accessible means easy to approach, reach, enter, speak with or use.

BARE

Bare means the conductor which is not covered with insulating materials.

CABLE

"Cable" means a length of insulated single conductor. The conductor may be solid or stranded , two no of more than two no and each provided with its own insulation. Such insulated conductor or conductors may or may not be provided with an overall mechanical protective covering.

CIRCUIT

"Circuit" means an arrangement of conductor or conductors for the purpose of conveying energy and forming a system or a branch of a system.
OR
Circuit is an interconnection of electrical components and conductors which form a complete path for the current to flow through it.

CIRCUIT BREAKER

"Circuit breaker" means a device which is capable of making and breaking the circuit under all conditions.
OR
A circuit breaker is an electrical protective device which protect the circuit from damaged caused by overcurrent, overload or short circuit by breaking the circuit.

CONDUCTOR VOLTAGE

It is the voltage/potential difference between any two conductor or voltage/potential difference between any conductor and neutral.
Low voltage-voltage level below 250volt.
Medium voltage- voltage level between 250volt to 650volt.
High voltage-voltage level less than or equal to 33000volt.
Extra high voltage- Voltage level greater than 33000volt.

LIVE - Live term in electrical means electrically charged.

DEAD

"Dead" means at or about earth potential and disconnected from any live System. The term "dead" is used only with reference to current carrying parts when these parts are not live.

CUT-OUT

"Cut-out" means any appliance for automatically interrupting the transmission of energy through any conductor when the current rises above a predetermined amount.

CONDUIT

"Conduit" means rigid or flexible metallic tubing or mechanically strong and fire resisting non-metallic tubing into which a cable or cables may be drawn for the purpose of affording it or for mechanical protection.

SYSTEM

System means an electrical system in which all the conductors and

apparatus are electrically connected to a common source of electric supply.

VOLT

"Volt" means a unit of electromotive force and is the electric pressure, which, when steadily applied to a conductor, the resistance of which is one ohm, will produce a current of one amphere.

SWITCHGEAR

"Switchgear" shall denote switches, circuit breakers, cut-outs and other apparatus used for the operation, regulation and control of circuits
"Span" means the horizontal distance between two adjacent supporting points of an overhead conductor.

INSTALLATION

"Installation" means any composite electrical unit used for the purpose of generating, transforming, transmitting, converting, distributing or utilizing energy;

EARTHING SYSTEM

"Earthing system" means an electrical system in which all the conductors are earthed
"Earthed" or "connected with earth" means connected with the general mass of earth in such manner as to ensure at all times an immediate discharge of energy without danger

DANGER

"Danger" means danger to health or danger to life or any part of body from shock, burn or other injury to persons, or property, or from fire or explosion, attendant upon the generation, transmission, transformation, conversion, distribution or use of energy

LIGHTING ARRESTOR

"Lighting arrestor" means a device which has the property of diverting to earth any electrical surge of excessively high amplitude applied to its terminals and is capable of interrupting follow current if present and restoring itself thereafter to its original operating conditions.

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 of sufficient mechanical strength. They shall be constructed, installed, protected, worked and maintained in such a manner as to ensure safety of human beings, animals and property.

The material and apparatus used shall conformed to have relevant specifications as per Bureau of Indian Standards.

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.

(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

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.

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.

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

(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 there to, to enable such conductor to be distinguished from any live conductor.
(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 .

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.
(2) The consumer shall take all reasonable precautions to prevent mechanical damage to the earthed terminal and its lead belonging to the supplier.
1[(3) The supplier may recover from the consumer the cost of installation of earthing.
RULE-34. Accessibility of bare conductors- 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; and
(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
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.
Every person who is working on an electric supply line or apparatus or both shall be provided with tools and devices such as gloves, rubber shoes, safety belts, ladders, earthing devices, helmets, line testers, hand lines and the like for protecting him from mechanical and electrical injury. Such tools and devices shall always be maintained in sound and efficient working conditions:
(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) Every telecommunication line on supports carrying a high or extra-high voltage line shall, for the purpose of working there on, be deemed to be a high

voltage line.

RULE-37. Supply to vehicles, cranes, etc.

Every person owning a vehicle, travelling crane or the like to which energy is supplied from an external source shall ensure that it is efficiently controlled by a suitable switch enabling all voltage to be cut off in one operation and, where such vehicle, travelling crane or the like runs on metal rails, the owner shall ensure that the rails are electrically continuous and earthed.

RULE-38. Cables for portable or transportable apparatus-

(1) Flexible cables shall not be used for portable or transportable motors, generators, transformer rectifiers, electric drills, electric sprayers, welding sets or any other portable or transportable apparatus unless they are heavily insulated and adequately protected from mechanical injury.

(2) Where the protection is by means of metallic covering, the covering shall be in metallic connection with the frame of any such apparatus and earth.

(3) The cables shall be three core type and four-core type for portable and transportable apparatus working on single phase and three phases supply respectively and the wire meant to be used for ground connection shall be easily identifiable.

RULE-39. Cables protected by bituminous materials-

(a) Where the supplier or the owner has brought into use an electric supply line (other than an overhead line) which is not completely enclosed in a continuous metallic covering connected with earth and is insulated or protected in situ by composition or material of a bituminous character-

(i) Any pipe, conduit or the like into which such electric supply line may have been drawn or placed shall, unless other arrangements are approved by the Inspector in any particular case, be effectively sealed at its point of entry into any street box so as to prevent any flow of gas to or from the street box; and

(ii) Such electric supply line shall be periodically inspected and tested where accessible, and the result of each such inspection and test shall be duly recorded by the supplier or the owner.

(2) It shall not be permissible for the supplier or the owner after the coming into force of these rules, to bring into use any further electric supply line as aforesaid which is insulated or protected in situ by any composition or material known to be liable to produce noxious or explosive gases on excessive heating.

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.
(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-
The owner of every generating station, substation, 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-42. Accidental charge-
The owners of all circuits and apparatus shall soarrange them that there shall be no danger of any part thereof becoming accidentally charged to any voltage beyond the limits of voltage for which they are intended.
Where A.C. and D.C. circuits are installed on the same support they shall be so arranged and protected that they shall not come into contact with each other when live.

RULE-43. Provisions applicable to protective equipment-
(1) Fire buckets filled with clean dry sand ,fire extingguishers must be kept in all generating ststion,enclosed sub-stations etc to extinguish fire.
(2The 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.
(3) Gas masks shall be provided conspicuously and installed and maintained at accessible places in every generating station with capacity of 5 MW and above and enclosed sub-station with transformation capacity of 5 MVA and above for use in the event of fire or smoke.

RULE-44. Instructions for restoration of persons suffering from electric shock-

(1) Instructions for restoration of persons suffering from electric shock in English ,Hindi or local language shall be affixed by the owner.

(2) In every high voltage or extra high voltage generating station ,substation etc, an artificial respirator shall be provided and kept on good working condition.

(3) The owner of every generating station, enclosed sub-station, enclosed switch-station and every factory should that all the persons employed by him are acquainted with these instructions and must apply.

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 low voltage domestic appliances shall be carried out by the user. Other installation works like addition of extra circuit, alterations, adjustments to the existing installation shall be carried out by an electrical contractor who is licensed by state government.

RULE-46. Periodical inspection and testing of consumer's installation. -

(1) Installations shall be periodically inspected and tested in every 5 years.

(2) Fees for such inspection and test be determined by the central or the state Government.

General conditions relating to supply and use of energy

Rule-47 Testing d consumer's installation

---If a consumer needs a new or additional supply of energy, he has a to submit application to the suppler. Then the supplier shall inspect and test the consumer's installation.

→After getting approval from Inspector new Supply of energy or reconnection of the Supply after a period of six months is provided to the consumer.

→ After inspection if the inspector & feels that the installation is not safe and can be dangerous to consumer, then the inspector will give notice fo modifications

→ No Consumer shall commission his generating plant of a capacity exceeding 10KW without written approval of the Inspector.

Rule-48 Precautions against leakage before Connection

→ The supplier shall not provide energy Supply to the installation ore apparatus unless he is Satisfied that there is no leakage from the installation or any apparatus.

→ For example insulation resistance of medium and low voltage installation shall be at least 1 Mega ohm.

Rule 49 Leakage on Consumer's Premises
If the supplier/inspector found that insulation resistance is low and which is likely to cause danger , he shall discontinue the supply of energy to the installation and gave 48 hours, disconnection of supply and shall not reconnect until the cause of leakage has been removed.

Rule 50→ Supply and use of energy
→ Energy shall not be supplied, trans formed, converted or wed untill the following arrangements are not done

Arrangement must be done to completely isolate the supply to the installation. A leaked Switch with fure(s) are a Circuit breaker must be used for low and medium voltage Consumer. and High voltage consumer also. Similarly a circuit breaker is used for HV(11 KV to 3kV) and EHV consumer. Every consumer shall ensure that no person other than the supplier shall interfere with the service lines and apparatus placed by the supplier.

Rule 50A Additional provision for supply use of energy in multi-storied building

1) Before 30 days the consumer must gave application for commencement of supply (new or old) to the inspector with all particulars. The supply of energy shall not be commenced or recommenced within this period.
2) The supplier shall provide cut out or breaker at a position not more than 2.75 meters
3) The owner of a multistoried building shall ensure the safety of installation
4) No other service popes shall be taken along with the power cable.

Rule 51.→ All conductors other than overhead lines Shall be completely enclosed in mechanically strong metal casting or metallic covering
→All metal works, enclosing shall be connected with an earthing system
→ A clearance of 1 meter shall be provided in front of switchboard
→ If the installation is done where gases/chemicals are produced, the installations, Equipments and apparatus must be provided flame proof, dust tight, totally enclosed protection.

Rule-52 Appeal to Inspector in regard to defects:-
If any applicant dissatisfied with the action of supplier in declining for a to commence he may appeal to the inspector to test the installation.

Rule-53 Cost of inspection and rest of consumer's Installation→ The cast of first inspection and test of consumer's installation Carried out shall be paid by the consumer

Rule-54 Voltage Regulation.

→ In case of low ore medium voltage the supply Voltage shall not more than 6 percent .

→ In case of high voltage, voltage shall not more than 6% on higher side and 9% on lower side.

→Fore extra high voltage→

1) higher side → 10%

2) Lower side → 12.5/

Rule-55 Declared frequency of supply to Consumer

The supply frequency should shall be allowed to vary between +3%. to -3%..

Rule-56 Sealing of meters and cut outs.

→ A Supplies may affix one or more seals to Cut-out and to any meter, maximum demand indicator on the consumer's premises.

→The consumer shall ensure that no such seal broken other than supplier.

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

Error of any meter/maximum demand indicators / other apparatus placed on consumer's premises should not exceed 3 percent above or below the accurate value.

→ No meter shall register at no load.

→ Every supplier shall examine, test and regulate all meters, maximum demand indicators etc. before their first installation

→Every supplier shall maintain a register of meters showing the date of last test, last error, limit of accuracy after adjustment.

Rule 58 -The point of commencement of supply

The point of commencement of supply of energy to a consumer shall be considered to be the point at which incoming terminal of the wet-outs installed by the consumer.

Rule 59-Precautions against failure of supply

The layout of election supply lines in an area shall be sectionalized and provided with cut-outs or circuit breakers . So the fault occurring in any part of a circuit can not transmits to other.

ELECTRIC SUPPLY LINES, SYSTEMS AND APPARATUR FOR LOW AND NEDIUM VOLTAGE

Rule-60-Test for resistance of insulation
If any closer supply line of low or medium voltage has been disconnected from a System or addition of new circuit or repair is done by disconnecting the supply , such electric Supply line shall not be reconnected to the system until the following test is done as per rule 48.
(leakage or insulation resistance)

Rule 61- Connection with Earth.
→ Neutral conductor of a 3-phase 4 wire system and middle conductor of a 2 phase 3- wire system shall be earthed.
→ If a system consist of concentric Cables, the external conductor must be earthed
→The frame of every generator, motor, mate metallic part of all transformer shall be earthed.
→All earthing syst Systems shall be test earth resistance on dry days testing fore

Rule-62 System 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 i under normal conditions, exceed low voltage

Rule-63. Approved by Inspector. →If an installation has been disconnected for one year , to recommence the supply the supplier and owner must ensure that the supply lines and apparatus are placed in position, properly tested and examined. Then application is given to the inspector for inspection.
→ The owner of any high or extra high voltage installation can not make additional installation or altercation to the system until he has the written approval from inspector.

R**ule- 64. Use of energy at high and extra high voltage →**
All conductors and apparatus situated on Consumer premises should be at inaccessible position, all operation related to the all items should be done by authorized sard person only.
→The consumer must place the apparatus and meter of the supplier in a separate building for all time assess of the supplier.
→ All pole type sub-stations are constructed and maintained in accordance with BIS.

Rule 65-Testing, operation & Maintenance.

→New HV OR EHV, apparatus, supply line, cables shall be commissioned after site test as pert BIS
→ If HV or EMV apparatus , supply line or cables has disconnected fore 6 months are more fore recommission of the items testing. must be done as per BIS

→ All apparatus, supply line ore cables shall be maintained en "healthy conditions and periodical tests should be carried out.
→ Records of all tests, maintenance work and repairs of apparatus, Supply line and Cables shall be duly kept.

Rule-66- Metal sheathed electric supply line, Precaution against excess leakage.

→ The metal sheathing of conductor must be electrically continuous and connected with earth.
→ the resistance of earth connected with metallic sheath shall be kept low.
→If electric-Supply line has concentric Cable the outer conductor may shall be Connected with earth.

Rule 67- Connection to earth
All non-current carrying metal parts, associated with HV/EHV installation shall be effectively earthed to a ground System or Mat.

Rule-68 General conditions for transformation and control of energy.
→ Sub-stations and switching stations shall be preferably elected above the ground. If it is required to build an underground substation , proper Ventilation system proper must be provided.

Rule-70- Condensers
Suitable provision shall be made for immediate and automatic discharge of every Static condenser on disconnection of supply.

OVERHEAD LINES

Rule-74. Material and strength
→All conductors of over head lines shall have breaking strength of not less than 150kg if voltage is low and the span is less than 15m.
→ If the span is more than 15m and voltage is low, medium or high than breaking strength of the overhead lines should not be less than 350kg.

Rule-75

→ Joints between conductors of overhead lines shall be mechanically and electrically secure under the conditions of operation.

→ Ultimate strength of the joint shall not be less than 95 percent of the original conductor and electrical conductivity shall not be less than that of original conductor

Rule-76.

Factor of Safety= Breaking strength/ Working strength or stress

* For metal supports = 1.5
* For mechanically processed concrete Supports = 2:0
* For hand-molded concrete supports = 2-5
* Wood supports = 3.0
*Stay wire, guard wire. = 2.5

Rule-77. Clearance above ground of the lowest conductor

If the supply line is across any street:-

*Low and Medium Voltage = 5.8m
*For high voltage line = 6.1m

If the supply line is along with any street:-

*Low and Medium Voltage = 5.5m
*For high voltage line = 5.8m

If the supply line is away from any street or population:-

*Low and Medium Voltage = 4.6m
*For high voltage line = 4m
For high voltage line above 11kv = 5.2m

Rule-78- Clearance between conductors and trolley wires

*Low and medium voltage lines →1.2m
*High voltage line upto 11 kv →1.8m
*High voltage live above 11KV→2.5m
* Extra-high voltage line→3.0m

Rule 79-clearcances from building of low and medium voltage lines and service lines.

Low and medium voltage→

a) Vertical clearance from a building. = 2.5m
b) Horizontal clearance from a building = 1.2m

Rule-80-Clearance between building and high cand extra high voltage line

a) Vertical clearance -

*Voltage upto 33KV →= 3.7m

*For E-H-V line→3.7m+0.3m (for additional 11KV)

b) Horizontal clearance.

*upto 11KV →1.2m

*11KV to 33KV → 2m

* EHV lives. →2m+ 0-3 (for additional 33 KV)

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 less than 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.

Where an overhead line crosses another overhead line, clearances shall be as

Rule 87. Lines crossing or approaching each other-

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

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.	11-66 KV	2.44	3.05	4.58	5.49	7.94
3.	110-132 KV	3.05	3.05	4.58	5.49	7.94
4.	220 KV	4.58	4.58	4.58	5.49	7.94
5.	400 KV	5.49	5.49	5.49	5.49	7.94
6.	800 KV	7.94	7.94	7.94	7.94	7.94

Rule 88. Guarding-

*Every guard-wire shall be connected with earth at each point at which its

electrical continuity is broken.
*Every guard-wire shall have an actual breaking strength of not less than 635 kg and if made of iron or steel, shall be galvanized.
*Where there is only one trolley-wire, two guard-wires shall be erected as in diagram A.

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 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 m 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).

ELECTRICAL INSTALLATIONS

2. 1 Electrical installations, domestics, industrial, Wiring System, Internal distribution of Electrical Energy. Methods of wiring, systems of wiring, wire and cable, conductor materials used in cables, insulating materials mechanical protection. Types of cables used in internal wiring, multi-stranded cables, voltage grinding of cables, general specifications of cables.

2. 2 ACCESSORIES: Main switch and distribution boards, conduits, conduit accessories and fittings, lighting accessories and fittings, fuses, important definitions, determination of size of fuse – wire, fuse units. Earthing conductor, earthing, IS specifications regarding earthing of electrical installations, points to be earthed. Determination of size of earth wire and earth plate for domestic and industrial installations. Material required for GI pipe earthing.

2. 3 LIGHTING SCHEME: Aspects of good lighting services. Types of lighting schemes, design of lighting schemes, factory lighting, public lighting installations, street lighting, general rules for wiring, determination of number of points (light, fan, socket, outlets), determination of total load, determination of Number of sub-circuits.

ELECTRICAL INSTALLATION

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)

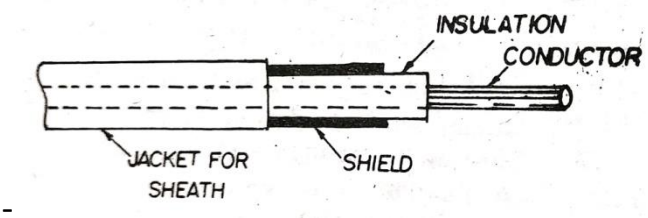
NECESSITY IN A CONDUCTOR/WIRE/CORE:

- 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 ccaluminium.

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

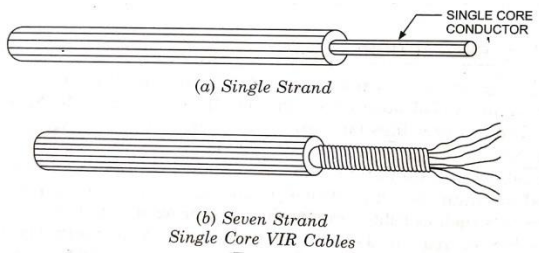
3. According to voltage grading, the cables are 2 types:-
a) 250/500 volt cable
b) 660/1100 volt cable

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.

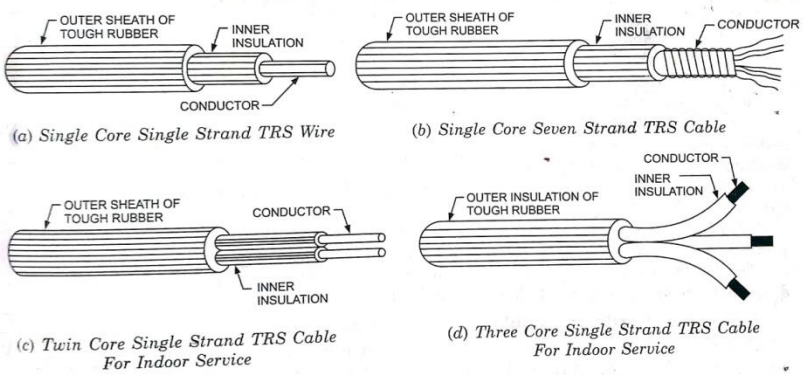


(a) Single Strand

(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*

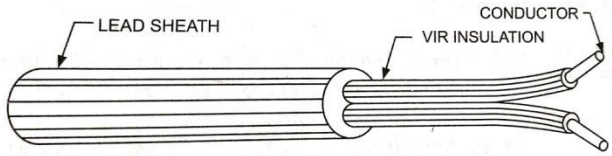
(b) *Single Core Seven Strand TRS Cable*

(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.

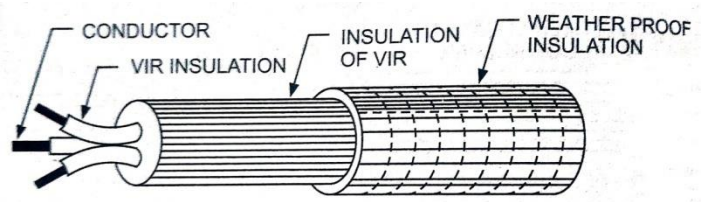
ADVANTAGES

- 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 CABLE

- 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 CABLE:
   19/24
   19-No. of strand in cable 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.)

LIGHTING ACCESSORIES AND FITTINGS

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

1. SWITCHES

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

2. 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
- Double pole main switch
- Single pole main switch

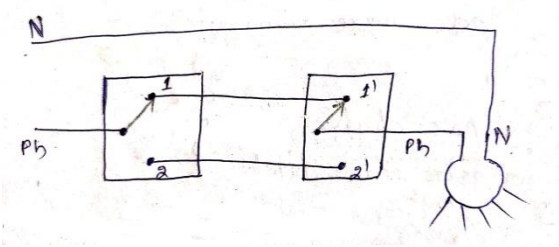
1. ONE WAY SWITCH

- 6 amp,250 volt --------light load (fan, tube light)
- 16 amp,250 volt -------heavy load(washing machine, heater, AC etc)

2. TWO WAY SWITCH

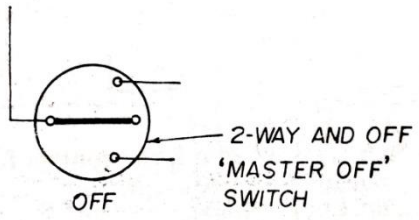
- The switch of this type consist of 3 or 4 terminals
- The switch of this type is usually used for staircase wiring or circuit where one point is to be controlled from two different places.
- 6 amp, 250volt -------(light load)

Connection diagram of 2 way switch



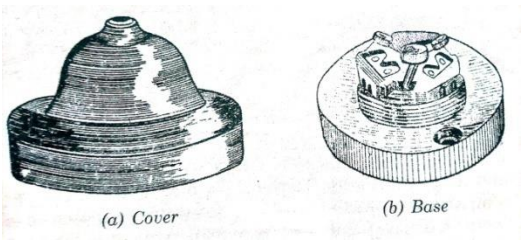
3. 2 WAY CENTRE OFF SWITCH

- 6 amp ,250 volt



4. **SINGLE POLE MAIN SWITCH**
5. DOUBLE POLE MAIN SWITCH
6. SINGLE POLE SINGLE THROW
7.SINGLE POLE DOUBLE THROW
8.**DOUBLE POLE DOUBLE THROW**

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 of bakelite, 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

SOCKET OUTLET:-

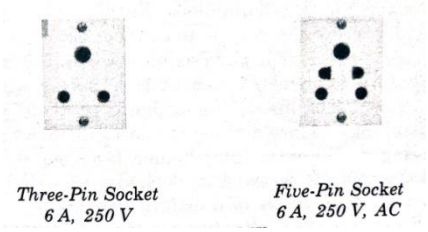
The socket outlet are used to supply outlet connection when ever required for electrical appliances such as TV, iron table fan.

TYPES OF SOCKETS

1 PIN SOCKETS

3 PINSOCKETS

5 PIN SOCKETS



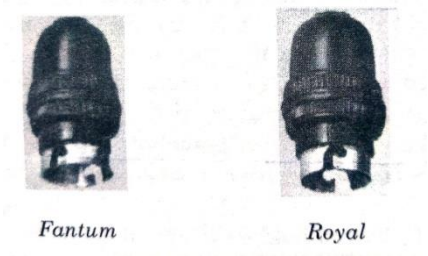
Three-Pin Socket 6 A, 250 V *Five-Pin Socket 6 A, 250 V, AC*

LAMP HOLDER:-

- It is used to support the lamp and also to connect of electricity.
- These are design for quick removal, replacement. Of the lamp.
- It is made of Bakelite with porcelain interiar.

TYPES OF LAMP HOLDER:-

1. Pandent holder
2. Angle holder
3. Slanting holder



Fantum *Royal*

PLUG:- Plugs are use to connect the supply from the socket outlet for electrical appliances such as TV,

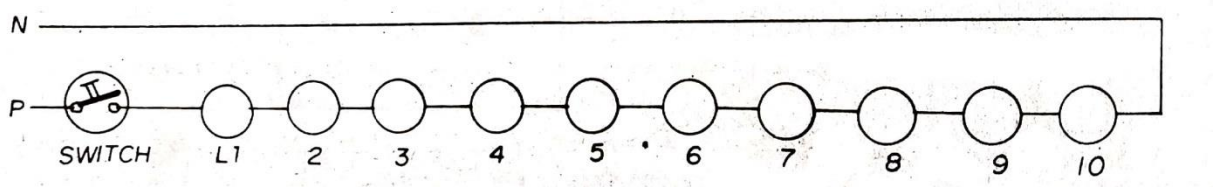
Iron

2pin plug 3pin plug

PARALLEL OPERATION ADVANTAGES

- The supply voltage is uniform in each load.
- In case the light or same other equivalent goes out of order, it will not affect the supply of current to other light etc as each one of them is individually connected to line.
- The voltage in the ckt will be uniform and every will glow with full brightness.

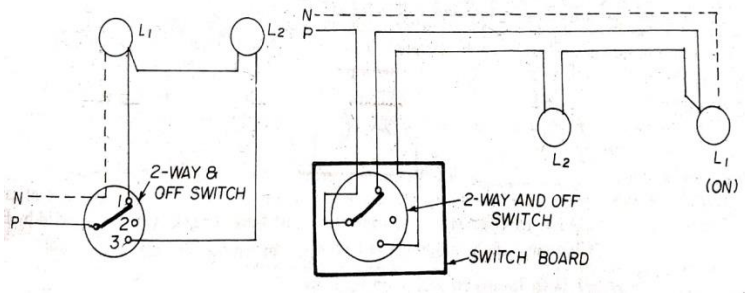
SERIES CONNECTION



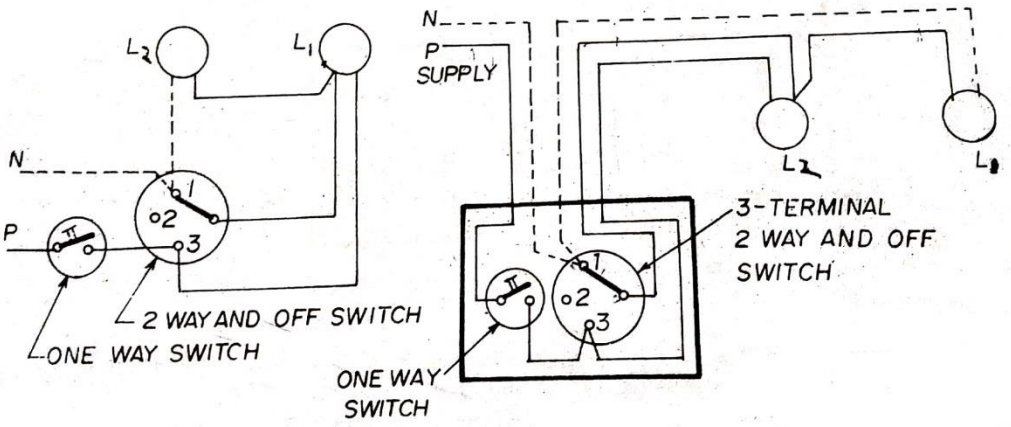
- The ckt useful for decorative lighting for marriage and other places where groups of lamps are to be control by switch instead of placing separate switch for each light.
- The major disadvantages are of one light goes out of order , light and other equipments in that ckt will go off . As the flow of current from one point to other is stop.

SERIES PARALLEL CONNECTION

(a) With 2-way centre off switch



(b) With 2-way and off switch and one way switch



Circuit for either L_1 or L_2 to be full bright or two in series giving dim light.

Series parallel circuit are used either to provide dim light or full bright light through the same lamp by using special switch such as two way centre off switch .

To operate either both lamp in series or parallel by wiring two pole double throw switch

(c) <u>CIRCUIT FOR ONLY ONE PARTICULAR LAMP BRIGHT OR TWO LAMPS IN SERIES WITH TWO WAY AND SINGLE WAY SWITCHES</u>

(d) <u>TO OPERATE EITHER BOTH LAMPS IN SERIES OR BOTH IN PARALLEL BY USING 2 POLE DOUBLE THROW SWITCH</u>

For position 1-2=The lamp will provide dim lights
For position 3-4=The lamps are connected in parallel across 230 volt giving full bright light.

<u>FUSE</u>

It is a simple and cheapest device used for interrupting and 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 cheaper form of protection available.
- It needs no maintenance.
- Its operation is completely automatic.
- It interrupt huge short circuit current without noise, gas, smoke.

DISADVANTAGE

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

FUNCTION OF WIRE

- To carry the current working current flow without heating.
- To break the circuit when the current exceed the limiting current.

FUSE ELEMENT MATERIAL

- The material used fuse elements must be of low rating point ,high conductivity , low cost and from deterioration.
- The material commonly use for fuse elements are tin, lead ,copper, zinc, aluminium and alloy of lead and tin(60+40)
- Fuse element is a low melting point material such as tin, lead and zinc.
- The alloy of lead and tin is used for small current for fuse (up to 15 amp)
- Beyond 15 amp rating circuit copper wire fuse are used.
- Either copper or lead tin alloy is mostly used as an ordinary use wire.

Metals	Melting point
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 from bad 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 consumers main switch.

(c) SUB Circuit fuse:-

The total wiring system is divided in to no. of sub circuit or branch. A separate fuse is provided for each branch circuit and is known as sub. Circuit or branch circuit use

(d) **POINT FUSE :-**

In good quality indoor wiring in building light and plug point is provided with its individual fuse known as point fuse.

IMPORTANT DEFINATION (2 MARK)

FUSE:-

Fuse is a current interrupting device which break or open the circuit by fusing the elements when the current in the ckt exceed a certain voltage.

FUSE ELEMENTS OR FUSE WIRE:-

It is that point of the fuse which actually melt when an excessive current flow in the circuit and thus isolate the faulty device from the supply.

CURRENT RATING:-

It is define as the RMS value of current which the fuse wire can carry continuously without deterioration and with temperature rise with in specific limit.

FUSING CURRENT:-

It is define as the minimum value of current at which the fused elements or fuse wire melt. Its value will be more than 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 factor such as

1. Types of metal used.
2. The cross sectional area i.e whether round or regular section
3. Diameter of the wire
4. Types enclose employed
5. Type of surface (stranded)

The fusing current for stranded fuse will be less than the product of the fusing current one strand and the no. of strand.

NO. OF WIRE	1	2	3	4	7
FUSING CURRENT	1	1.667	1.25	2.75	4

FUSING FACTORS:-

It is the ratio between minimum fusing current to the current rating of fusing 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

1. Factors responsible for deteriorating 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 v high conductivity material specially we i. E copper & G.I wire.
- I should be protect against mechanical injuries in corrosion.

WHAT IS EARTHING:-

Connection of non-current carrying part of electrical apparatus such as metallic frame, metallic covering of cables, earth terminals of sockets outlet, stay wire etc to the general mass of earth in such a manner that at all time an immediate discharge of electric energy taken 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 ELETRIC INSTALLATION:-

1. Distance of earth from Building

   An earth electrode shall not be situated within a distance of1.5m from the building whose installation is being earthed.
2. Size of earthed 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 less than 2.9mm^2 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 =0.5Ω

      Major power station=1Ω

      Small sub-station=2Ω

      In other all cases=5Ωmaximum
4. The earth wire and earth electrode shall be of same material.
5. The earth wire shall be taken through G.I pipe of 13 mm diameter for atleast30 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 wire run along the various sub circuit shall be terminated and looped firmly at the main board and from main board, the main earth shall be taken to the electrode.

POINT TO BE EARTH

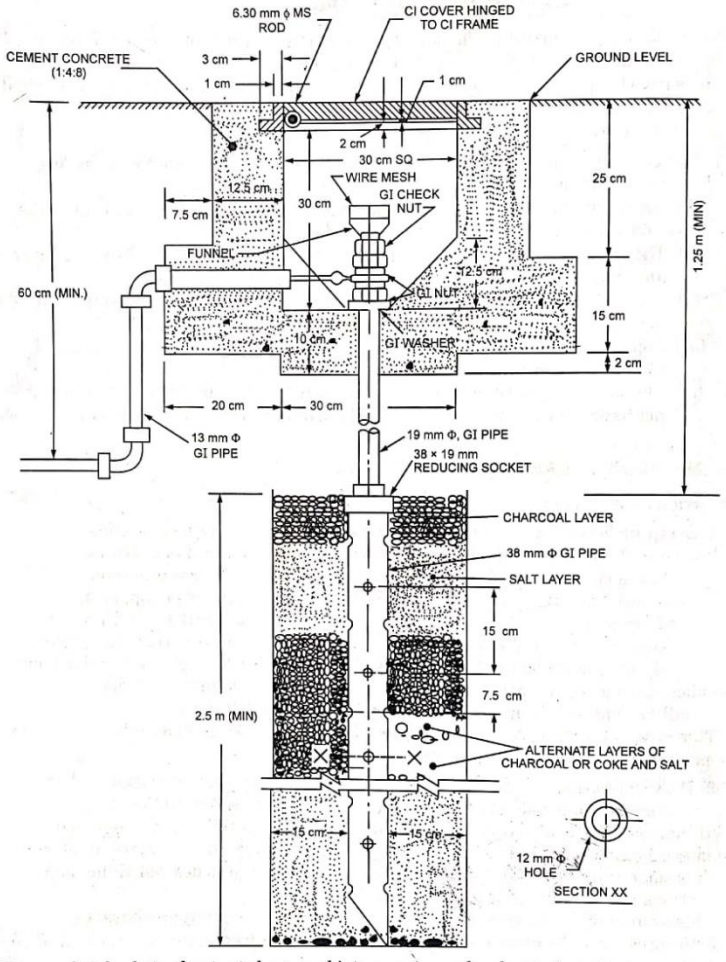
- Earth pin of 3- pin& 5- pin socket should be permanently and efficiently earth.
- All metallic covering containing or protecting any electric supply line or apparatus such as iron clad switches ,iron clad distribution fuse board, G.I pipes and conduit enclosing VIR or PVC cable etc should be connected to earth.
- The frame of energy generator, stationary motor ,portable motor and the metallic part of all transformer and any other apparatus used for regulating and controlling energy and all medium voltage energy consuming apparatus should be a earth by two separate different connection with earth.
- Fabricating steel, transformer line tower, tubular steel or rail poles carrying overhead conductor should be earthed.
- Stay wire provide for overhead lines should be connected to earth buy connecting at least one strand of the earth wire .
- The neutral conductor of a 3phase, 4 wire system and the middle conductor of a 2pjase ,3 wire system should be earthed by two separate and different connection in earth at the generating station and at the substation

DETRMINATION OF SIZE OF EARTH WIRE AND EARTH PLATE FOR DOMESTIC OF MOTOR INSTALLATION

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–	–

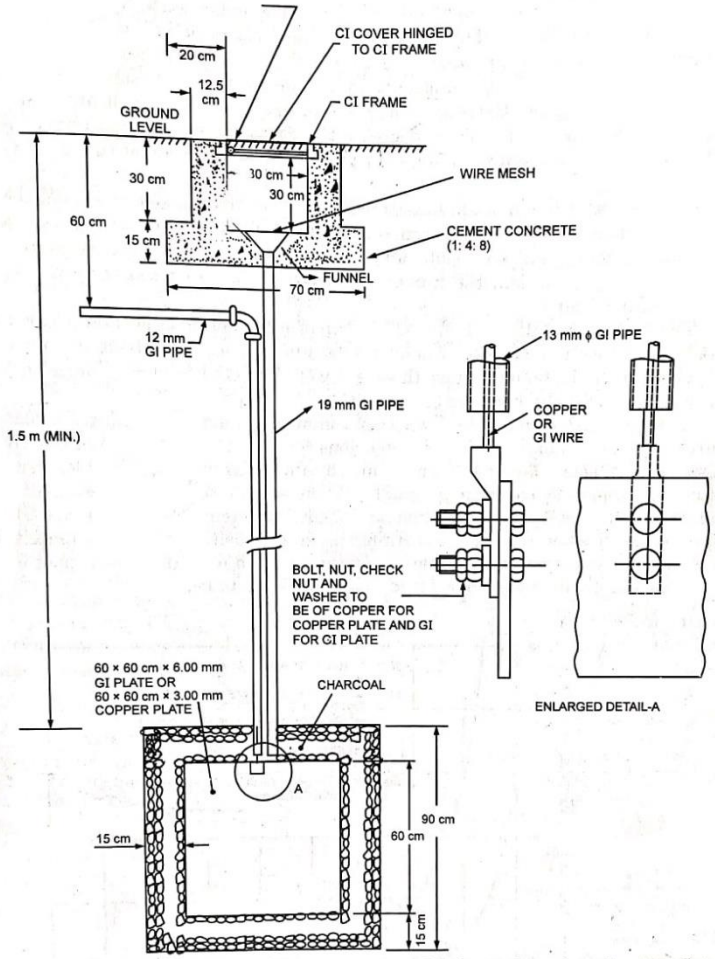
THE LIST OF MATERIALS WITH COMPLETE SPECIFICATION FOR G.I PIPE EARTHING IS GIVEN BELOW

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

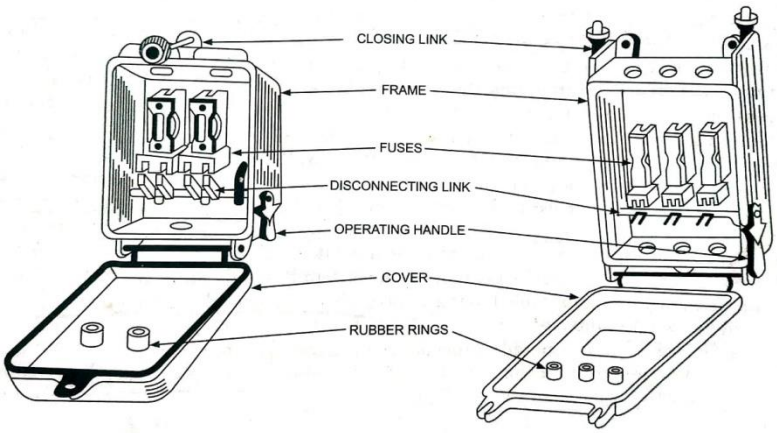
MAIN SWITCH AND DISTRIBUTION BOARD

- 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.

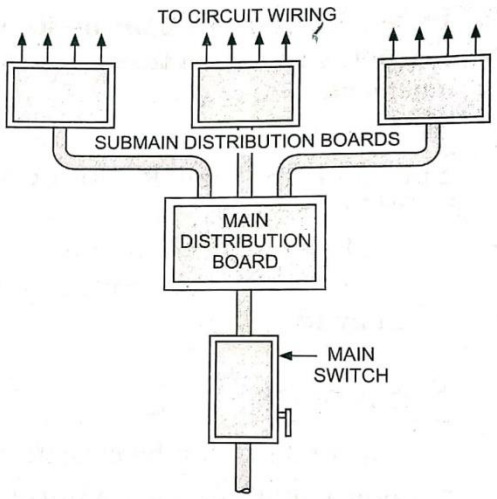


(a) DPIC Switch (b) TPIC Switch

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.

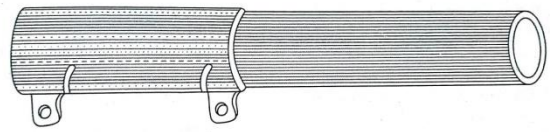
CONDUITS

General conduits can be classified as :-

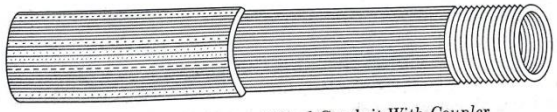
1. Light gauge steel-plain conduit
2. Heavy gauge steel-screw conduit
3. Flexible conduit
4. PVC conduit

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.

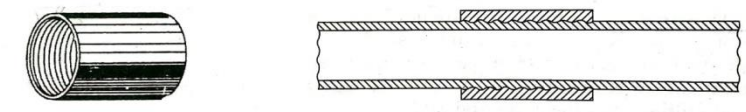
4.PVC conduits

- 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

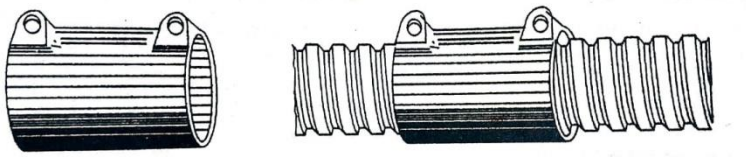
1. **CONDUIT COUPLER**

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



Rigid Conduit Coupling (Screwed)

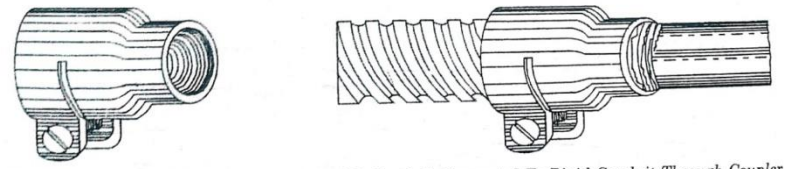
2. **GRIP COUPLER**



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.
It is covered above two conductor and the screw is used to make it tight.

3. FLEXIBLE CONDUIT COUPLER

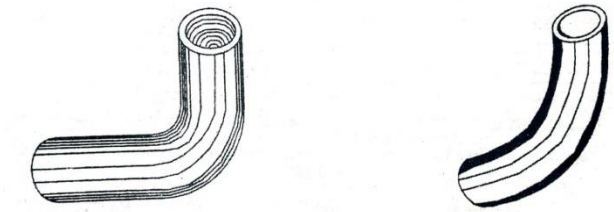


Flexible Conduit Coupler *Flexible Conduit Connected To Rigid Conduit Through Coupler*

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

4. BENDS ,ELBOW, & TEES

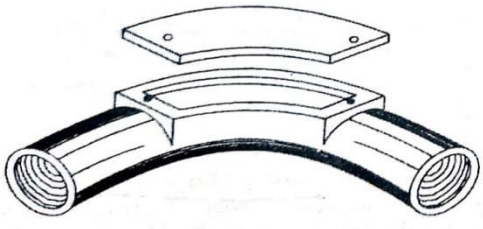
BEND:- Bends are usually used for change in direction of conduit.



(a) Sharp Bend (Not Permissible) *(b) Normal Bend*

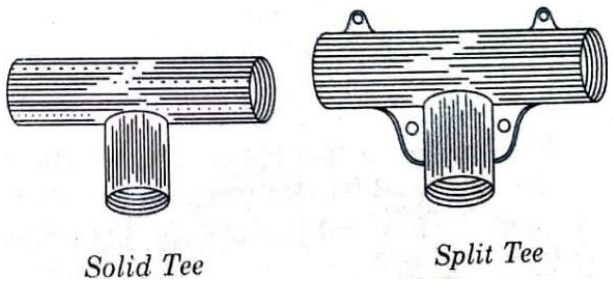
ELBOW:

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



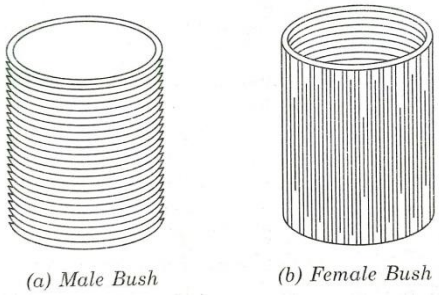
Inspection Elbow

TEES

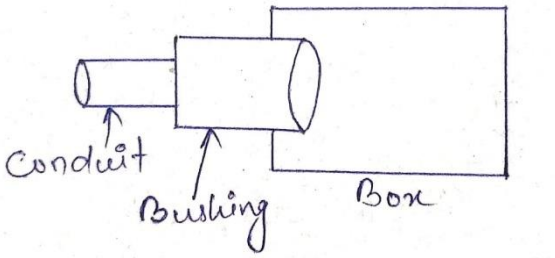


Solid Tee *Split Tee*

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

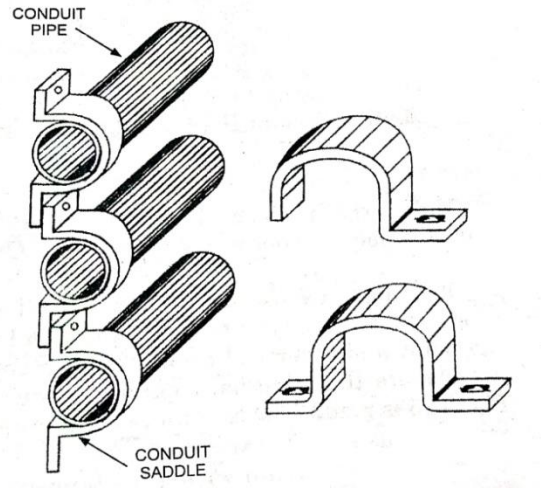
CONDUIT REDUCER

Conduit reducers are used when the size of conduit change.
Conduit reducer have both male & female threads.
FIXING OF CONDUIT
It is used to fix the conduit over the wall.

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.

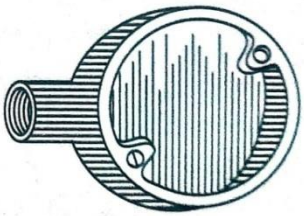
CONDUIT BOXES

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 rigid fan and other point.

for pulling of cable into the conduit. Boxes serving this purpose are known as inspection box . this are provided after every 30 cm length straight run.
For housing junction of cables, the conduit boxes serving this purpose are known as junction box.

3-Way Tangent Entry Box

Four-Way Conduit Box

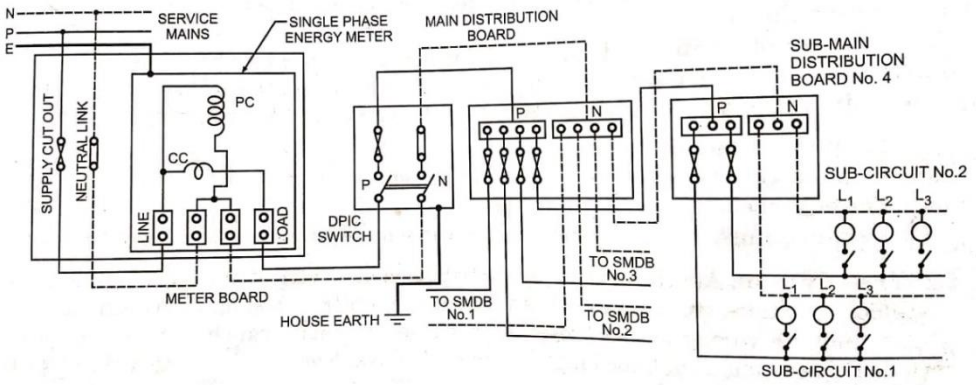


(a) Side Entry Terminal Box

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

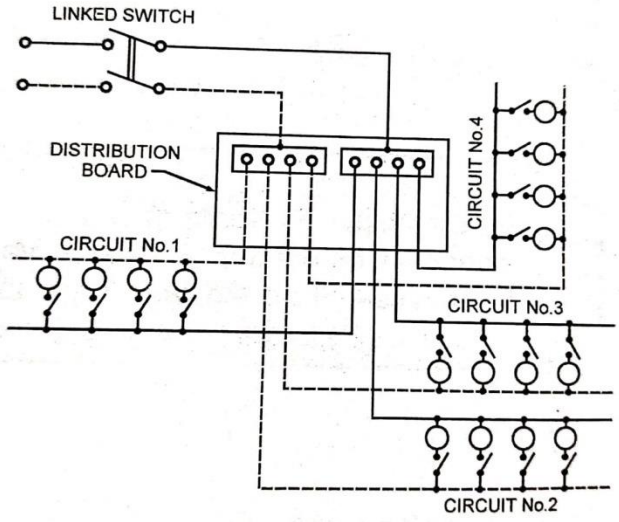
SYSTEM OF DISTRIBUTION OF ELCTRICAL ENERGY

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

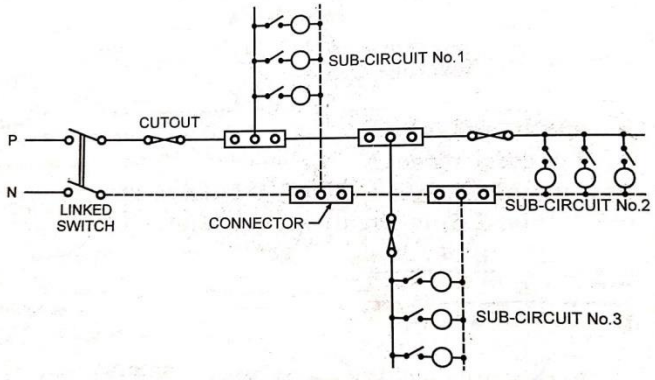
a) Distribution board system
b) Tee system

a) DISTRIBUTION BOARD SYSTEM



Distribution Board System

TREE SYSTEM

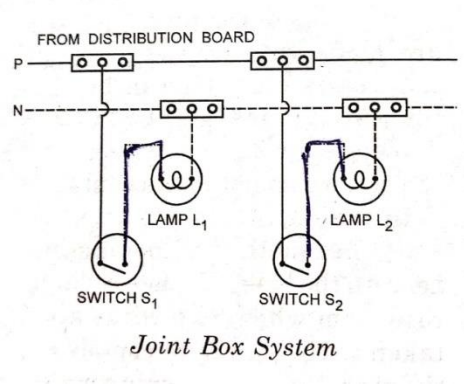


Tree System

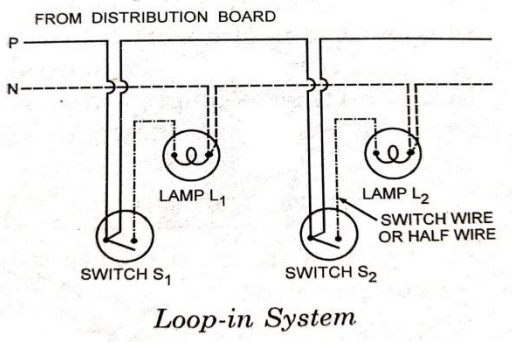
METHODS OF WIRING

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



Loop-in System

INTERNAL WIRING

3 . 1 Type of internal wiring, cleat wiring, CTS wiring, wooden casing capping, metal sheathed wiring, conduit wiring, their advantage and disadvantages comparison and applications.

3 . 2 Prepare one estimate of materials required for CTS wiring for small domestic installation of one room and one verandah within 25 m2 with given light, fan & plug points.

3 . 3 Prepare one estimate of materials required for conduit wiring for small domestic installation of one room and one verandha within 25 m2 with given light, fan & plug points.

3 . 4 Prepare one estimate of materials required for concealed wiring for domestic installation of two rooms and one latrine, bath, kitchen & verandah within 80m2 with given light, fan & plug points.

3 . 5 Prepare one estimate of materials required for erection of conduct wiring to a small workshop installation about 30m2 and load within 10 KW.

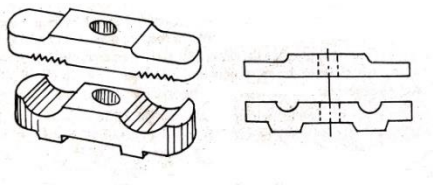
CHAPTER-3 INTERNAL WIRING

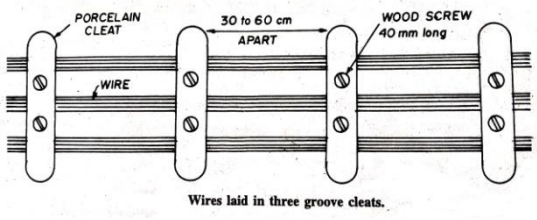
TYPES OFINTERBNAL WIRING

Following are the type 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

1. CLEAT WIRIG





Wires laid in three groove cleats.

- In this type of internal wiring the cable used are either VIR or PVC.
- 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 groove to accommodate the cable and the cap is put over it and a whole of it then screwed on wooden plug (guttis) over the wall or ceiling.
- The cleat are up three types
  - One groove-one cable

- Two groove-two cable
- Three groove-three cable

- The cleat should be usually used at interval 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.

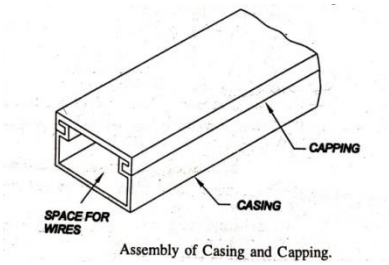
DISADVANTAGES

- It is not good looking.
- It is quite temporary & destroy quickly.
- The insulation dampness from the atmosphere hence this system of wiring can 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, where appearance is not so important and cost is the main consideration.

2. WOODEN CASING & CAPING WIRING



Assembly of Casing and Capping.

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

ADVANTAGES

- Cheaper in cost as compare to lead sheath wiring.
- Easy to install and rewire.
- It provides good insulation as conductors are at a good distance apart.
- Easy to inspect by opening the capping.

DISADVANTAGES

- This type of wiring is also coated with pain to varnish to protect from dampness. So it can be used in damp place.

- 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 can be concealed in plaster.
- Since it require better work skills, the labour cost is higher.

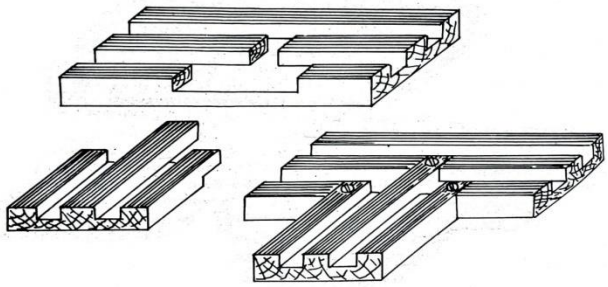
FIELD APPLICATION

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

PVC CASING & CAPING WIRING

- Due to increased cost of teak wood, the wooden casing & capping are becoming absolute 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.
- The wood battens are screw to wood by plugs at an interval not exceeding 75 cm.
- The cables are held on the wood batten by means of tin-brass links clips at an interval of 10 cm or 15cm.

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 &alkalis.
- It is cheaper than other types of wiring excepts cleat wiring.
- If the job is carried out with a care it gives a nice appearance.

DISADVANTAGES

- Good workmanships is required forth is 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 protection to the cables 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 look nice.
- Its life is long if proper earth continuity is maintain 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 al wires are enclosed in steel pipe known as conduit (PVC or VIR).
- There are3types of conduit wiring
    1. Concealed conduit wiring.
    2. Surface conduit wiring
    3. Flexible conduit wiring

1. 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 resist to acids, alkalis, oil & moisture.

2.SURFACED CONDUIT WIRING

- The conduit in surface conduit wiring is placed on the surface of the wall and hold with the 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.

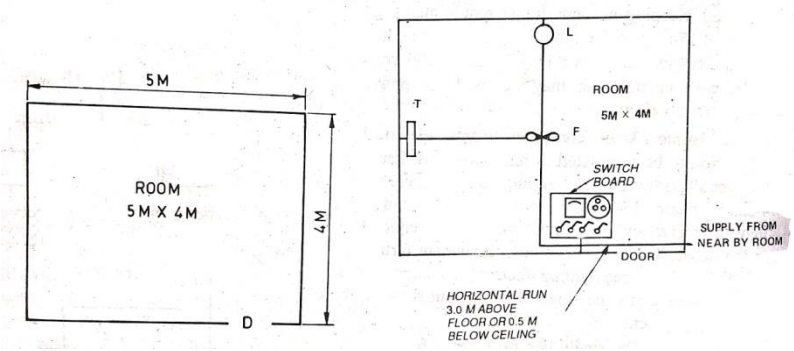
ADVANTAGES

- 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 &bonding is properly done.

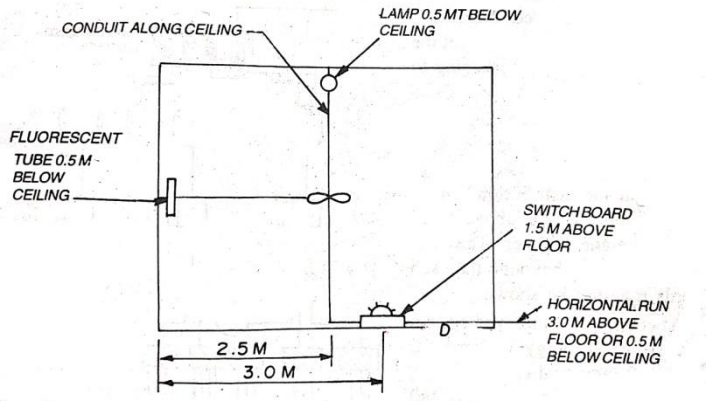
DISADVANTAGES

- It is a very costly system of wiring.
- Experience & highly skilled labour needed 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

Assume

a) Total height from floor to ceiling=3.5 mts
b) Height of H.R 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
from entry of circuit into room upto take off points=2.0+0.5=2.5mts
from HR to lamp point=0.5mt+4+0.5=5mts
from fan to tube points=2.5+0.5=3 mts
total length of conduit pipe=(1.5+2.5+5+3)mts=12mts
taking 10% for wastage=1.2 mts
total length of conduit pipe required for wiring the room=13.2 mts

Calculation for length of phase wire

from point of entry of circuit into room upto SB= 2(HR)+1.5(VR)=3.5 mts

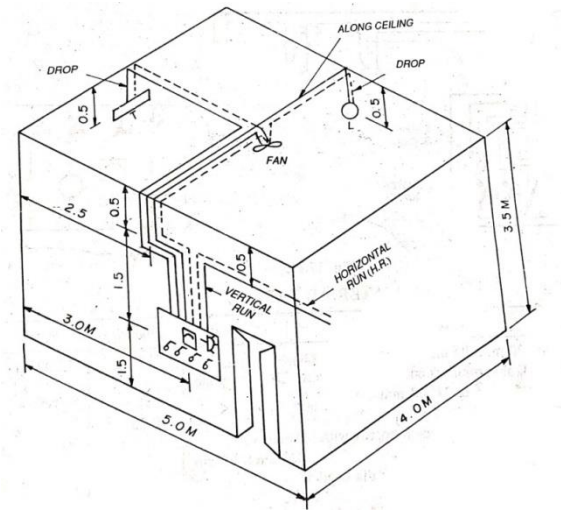
from SB to fan =1.5(VR)+0.5(HR)+0.5+2=4.5mts
from SB to lamp=4.5+2+0.5=7 mts
from SB to tube point=4.5+2.5+0.5=7.5 mts
total length of phase wire=(3.5+4.5+7+7.5)mts=22.5mts
taking 15% for wastage=3.37mts
total length of phase wire required for wiring the room=22.5+3.37=25.075mts

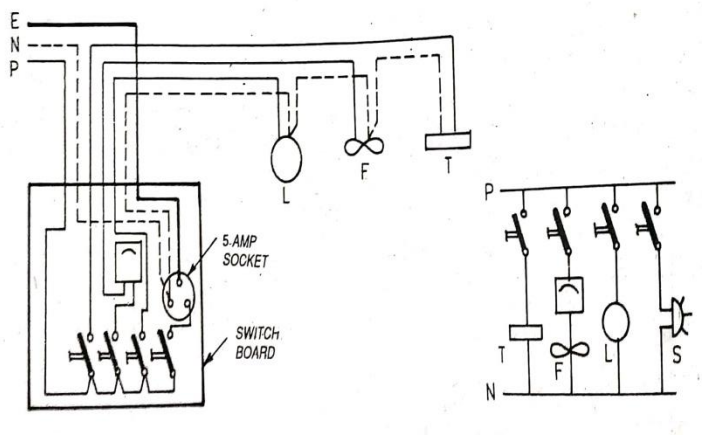
Calculation for length of neutral wire

from point of entry of circuit into room up to SB= 2(HR)+1.5(VR)=3.5 mts
from SB to fan =1.5(VR)+0.5(HR)+0.5+2=4.5mts
from fan to lamp points=2+0.5=2.5mts
from fan to tube point=2.5+0.5=3mts
total length of neutral wire=(3.5+4.5+2.5+3)mts=13.5mts
taking 15% for wastage=2.02
total length of neutral wire required for wiring the room=13.5 +2.02=15.52mts

calculation for length of earth wire (14 SWG)

length of earth wire=0.25 mt.



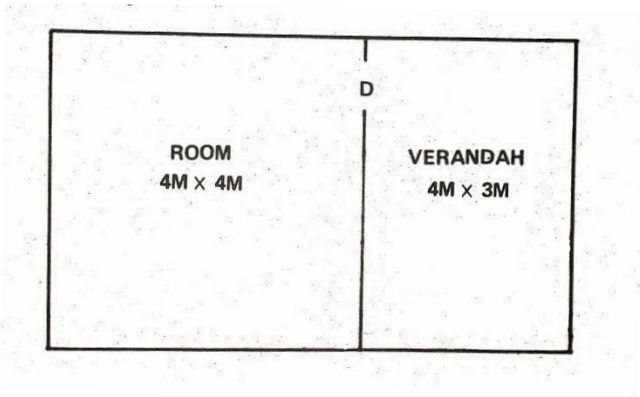


Material Table

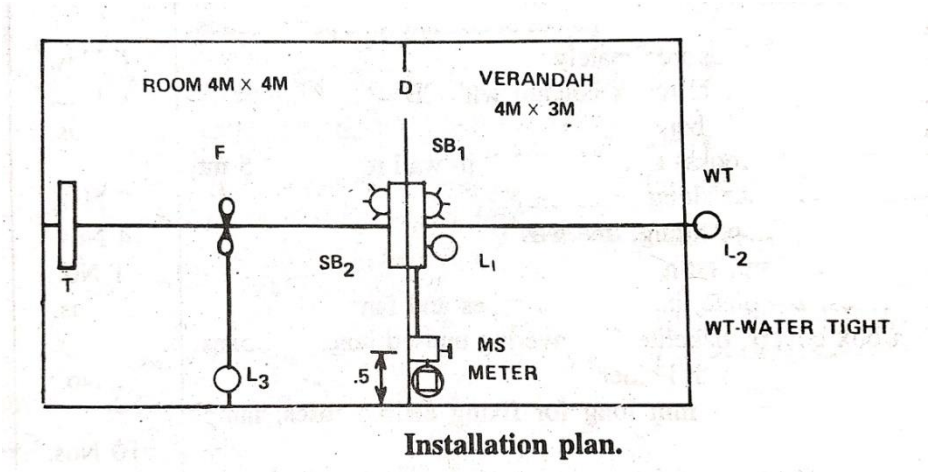
Si no.	description of materials with specifications	Quantity
1	total length of conduit pipe (20 mm dia)	13.2 mts
2	total length of phase wire (1 mm^2)	25.075mts
3	total length of neutral wire(0.5 mm^2)	15.52mts
4	total length of earth wire(14 SWG ,G.I)	0.25 mt.
5	Conduit pipe accessories for 20 mm dia 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 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.

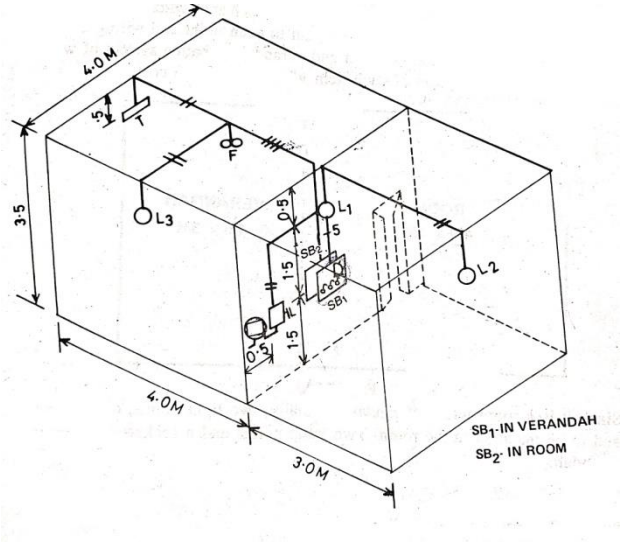
Assume

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

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



Selection and rating of main switch

Rating of DPIC , Main switch =5 ampere ,250 volt grade

Selection and rating of Distribution board

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

Calculation for length of batten

from main board to HR=1.5 mts =13mm X13mm (2 wire)
from SB_1 to HR =1.5mts=31mm X13mm (5wire)
from SB_2 to HR=1.5mts=25mm X13mm (4wire)
from HR above main board to L_1=1.5mts=13mm X13mm (2 wire)
from L_1 to L_2=0.5+3+0.5=4mt=13mm X13mm (2 wire)
from HR above SB_2 to fan =0.5+2=2.5 mts=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

25mm X13mm=1.5+2.5=4mt
31mm X13mm=1.5mt

taking 10% for wastage which is required for wiring the room
13mm X13mm=12mt +1.2=13.2 say 13mt
25mm X13mm=4mt+0.4=4.4mt say 4.5 mt
31mm X13mm=1.5mt+0.15=1.65 mt say 2mt

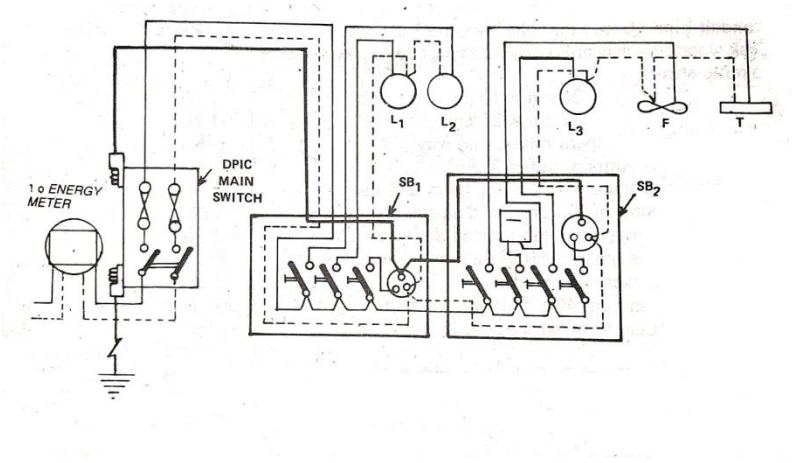
Calculation for length of aluminium conductor VIR wire of size 1.5 mm^2

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

total length of wire on batten=47.5mts
taking 15% for wastage=7.2mts
total length of phase wire required for wiring the room=47.5+7.2=55.7mts say 56mts

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 15% for wastage=0.47mt
taking 10% for wastage which is required for wiring the room=4.75+0.47=5.2 mts say 5.5 mts



Material Table

Si no.	description of materials with specifications	Quantity
	DPIC main switch 5 amp rating,250 volt grade with fuse and NL	1no.
1	total length of Different size of Batten	

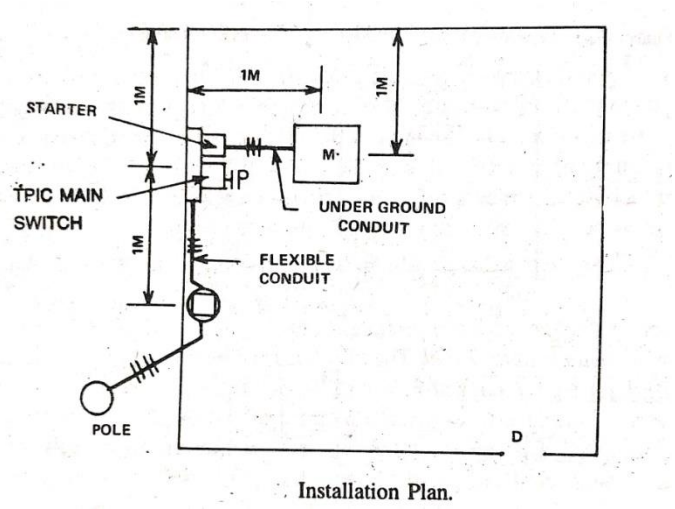
	13mm X13mm 25mm X13mm 31mm X13mm	13mt 4.5 mt 2mt
2	total length of phase & neutral wire (1.5 mm^2)	56mt
4	total length of earth wire(14 SWG ,G.I)	5.5 mts
5	Conduit pipe accessories for 20 mm dia a. 1-way junction box b. 2-way junction box c. 3-way junction box d. Conduit bends	 2 nos 1no. 2nos. 3nos.
6	One way switch,5 amp ,rating	6nos.
7	Socket,5 amp rating, 3 pin	2nos.
8	Ceiling rose, 2-plate,bakelite	2nos.
9	Lamp brass bracket with holder	2nos.
9	Link clip,aluminium 40 mm long (10 cm apart)	300 nos
9	Black enamel nails to fix clips with batten	100 gms
9	Teak wood plugs (guttis) at 0.75 mt interval	30nos.
9	Earthing thimbles 5 amp rating for fixing earth wire to main switch	2nos.
9	Earthing set complete with pipe,earth wire,charcoal,salt,thimbles,nuts & bolts etc	1 set.

Q.3 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 complte specification of each item. Also calculate the approximate cost for the power wiring.

Solution



Installation Plan.

Assumption

a) Total height of 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

Calculation of load

Running current $=\frac{5\times746}{\sqrt{3}\times400\times0.85\times0.8}$ = 9.1 amp say 8 amp

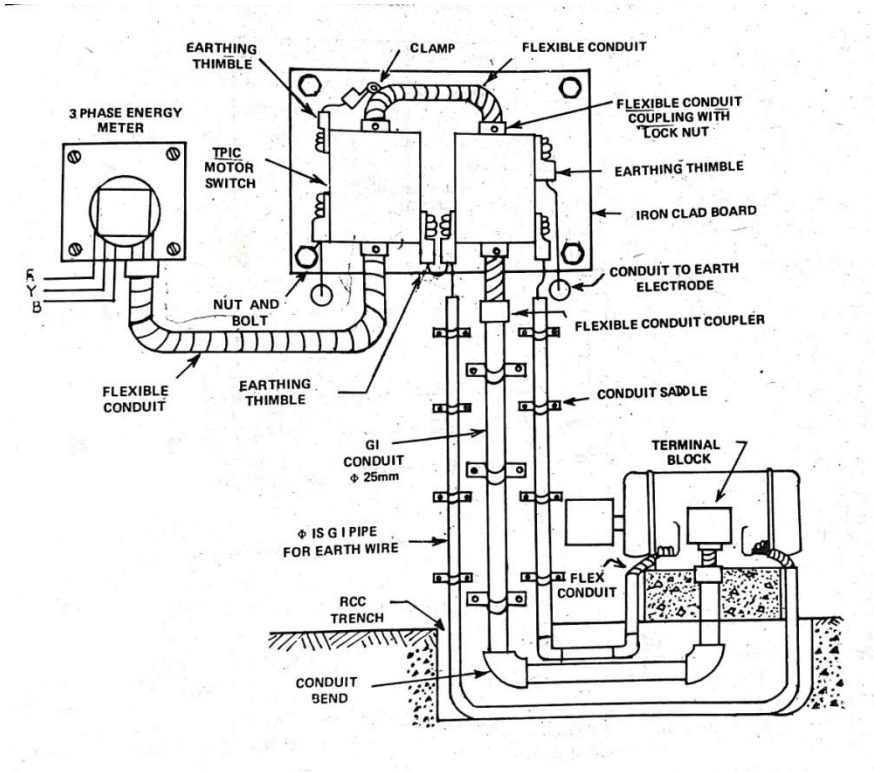
Starting current=$1.5\times 8 = 12$ amp

Selection and rating of MS

It is suggested that a TPIC, Main switch=32 amp,500 volt grade

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



Calculation for length of heavy gauge conduits of 25 mm diameter

From TPIC to motor foundation=1.5+0.25+1+o.25+0.25=3.25 mts
Taking 10% wastage=0.325mt
Total length of conduit required for wiring the motor =3.25+0.325=3.57 mts say 4 mts

Calculation for length of heavy gauge conduits of 15 mm diameter

From starter to motor foundation=(1.5+0.25+1+o.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=7.1 mts say 7.5 mts

Calculation for length of flexible conduits of 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 3.25 mts

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

From TPIC to motor foundation=(rigid conduit +flexible conduit)X3

=(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

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

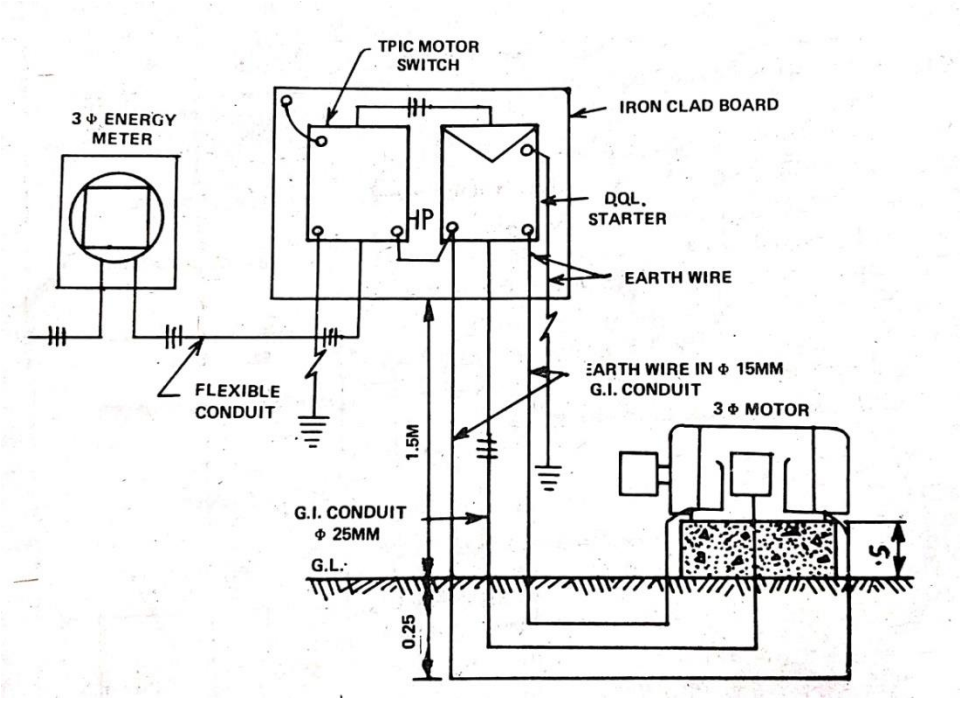
From starter to motor foundation = length of conduit X 2 earth wires

=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



Material Table

Si no.	description of materials with specifications	Quantity
1	TPIC main switch 32 amp rating,500 volt	1no.
2	Total length of rigid conduit (25mm dia)	4 mt
3	Total length of flexible conduit (25 mm dia)	2.5 mt
4	Total length of rigid conduit (15mm dia)	7.5
5	Total length of phase wire(6 mm^2)	19 mt.
6	Earth wire (14 SWG)	8 mt
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.

OVER HEAD INSTALLATION

4.1. Main components of overhead lines, line supports, factors Governing Height of pole, conductor materials, determination of size of conductor for overhead transmission line, cross arms, pole brackets and clamps, guys and stays, conductors configurations, spacing and clearances, span lengths, overhead line insulators, types of insulators, lighting arresters, danger plates, anti-climbing devices, bird guards, beads of jumpers, jumpers, tee-offs, guarding of overhead lines.

4.2. Prepare an estimate of materials required for LT distribution line within load of 100 KW maximum and standard spans involving calculation of the size of conductor (from conductor chart), current carrying capacity and voltage regulation consideration using ACSR.

4.3. Prepare an estimate of materials required for LT distribution line within load of 100 KW maximum and standard spans involving calculation of the size of conductor (from conductor chart), current carrying capacity and voltage regulation consideration using ACSR.

4.4. Prepare an estimate of materials required for HT distribution line (11 KV) within 2 km and load of 2000 KVA maximum and standard spans involving calculation of the size of conductor (from conductor chart), current carrying capacity and voltage regulation of the size of conductor (from conductor chart), current carrying capacity and voltage regulation consider action using ACSR.

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

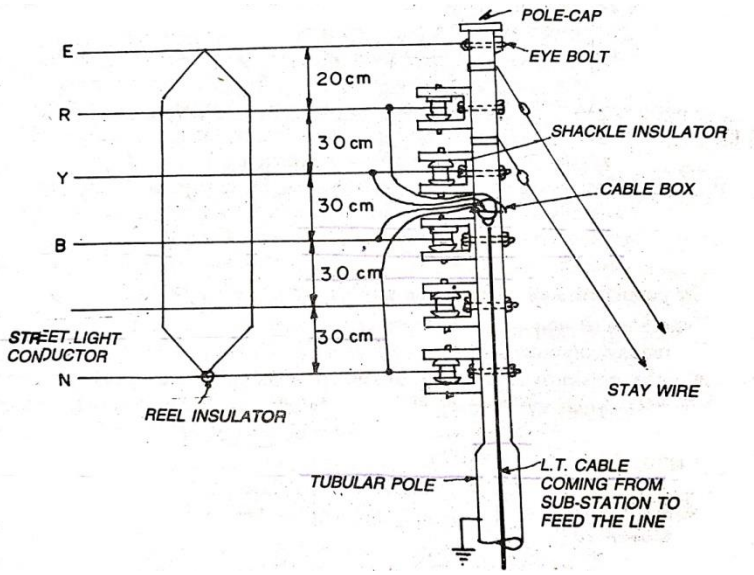
Average span=50 mts.

No. of tubular poles required=$\frac{500}{50}$+1=11 nos.

Length of squirrel ACSR conductor of size(6/1× 2.11 mm)=(500 mts× 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

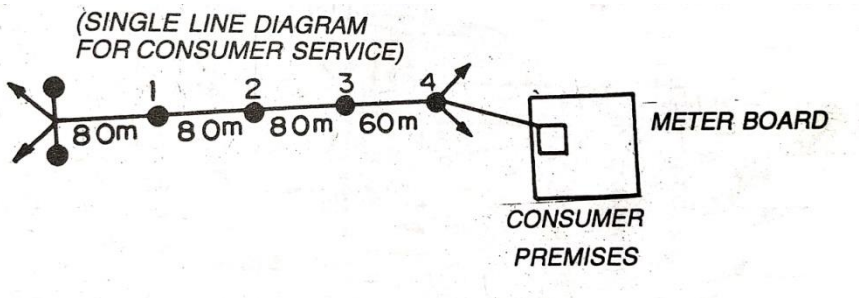


Material Table

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

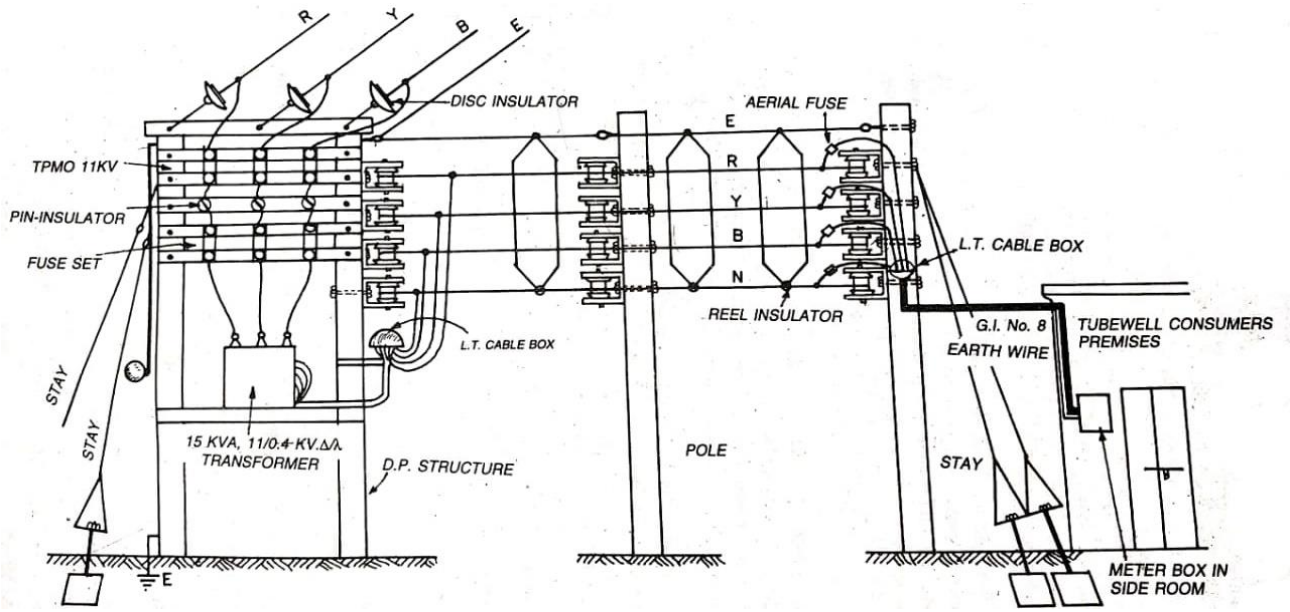
To meet the present load requirement and Provision for future requirement in the event expansion of building and any other electrical points in the existing building =(50% $\times$ 21.10)+21.10=31.65 amp

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



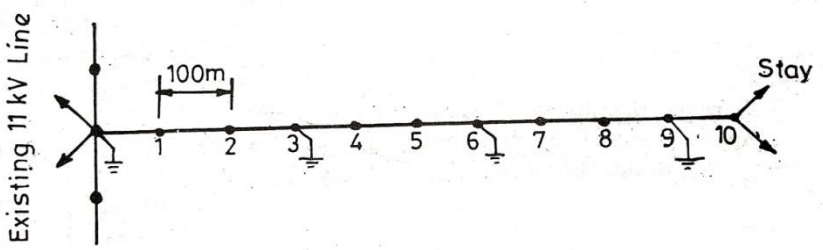
Material Table

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

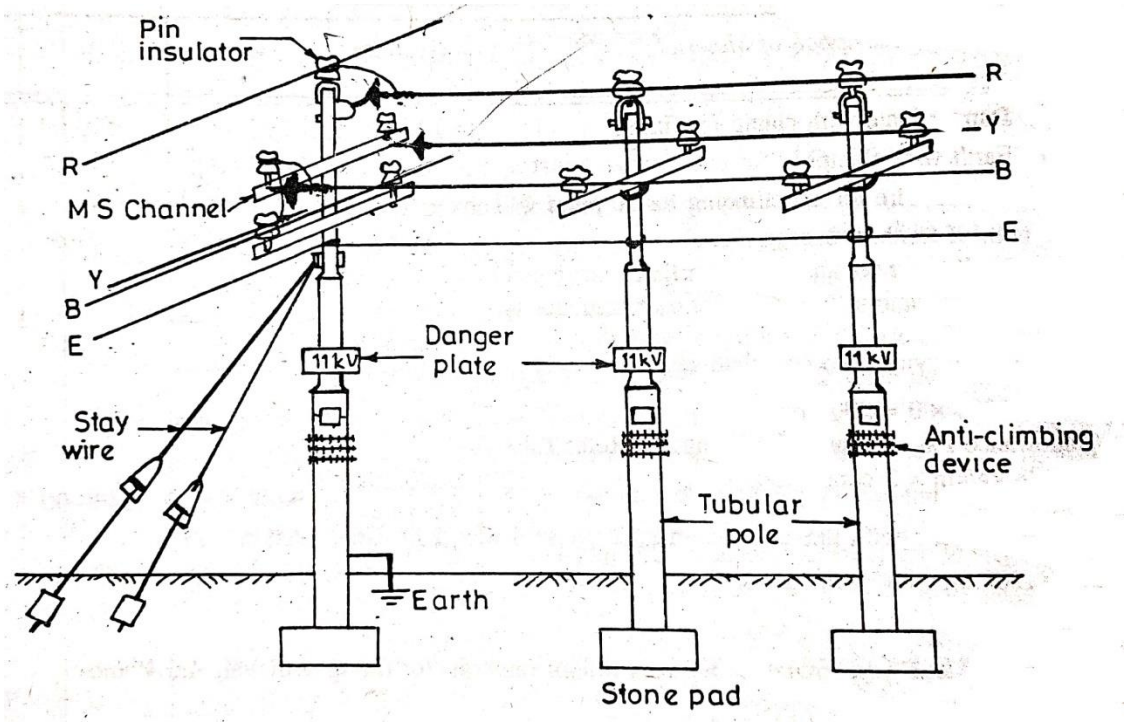
Solution

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

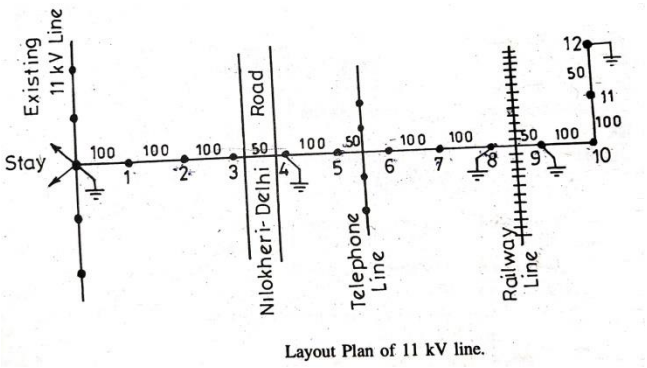
Si no.	description of materials with specifications	Quantity
1	Tubular line supports (11 mts long)	10 nos
2	Material required for connection with existing line of 11 KV line 1. M.S channel for cross arm (10 cmX5 cmX1.5mts) 2. H.T ,11 KV Disc insulator with complete fittings 3. H.T ,11 KV ,pin type insulators 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.

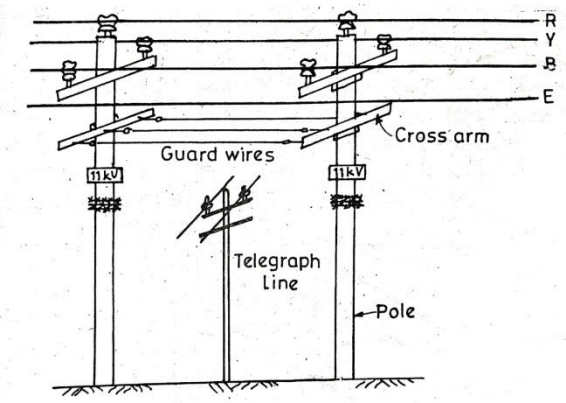
Q.4 Estimate the material and cost for the construction of 1 kilometre overhead line. The line is tapped from the existing 11 KV overhead line. Assuming that the line is passing over the main road, telegraph line and railway line. Given data:

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

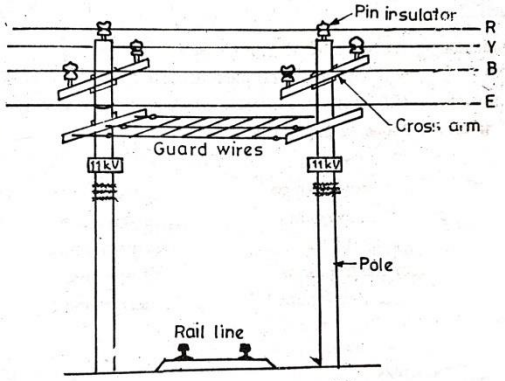
Solution



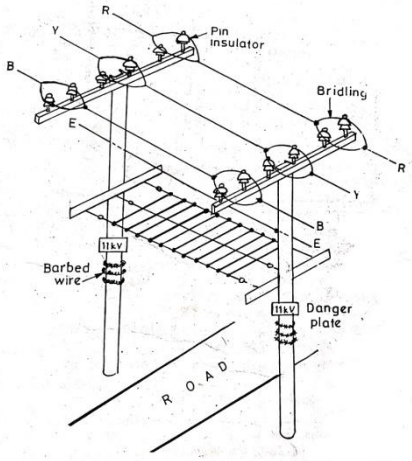
Layout Plan of 11 kV line.



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	 2 nos. 2nos.

	c) Guard wire d) Eye bolts for holding guard wire	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.

OVER HEAD SERVICE LINES

5. 1 Components of service lines, service line (cables and conductors), bearer wire, lacing rod. Ariel fuse, service support, energy box and meters etc.

5. 2 Prepare and estimate for providing single phase supply of load of 5 KW (light, fan, socket) to a single stored residential building.

5. 3 Prepare and estimate for providing single phase supply load of 3KW to each floor of a double stored building having separate energy meter.

5. 4 Prepare one estimate of materials required for service connection to a factory building with load within 15 KW using insulated wire.

5. 5 Prepare one estimate of materials required for service connection to a factory building with load within 15 KW using bare conductor and insulated wire combined.

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 mt. away from the building. Prepare a list of the material,for giving sevice 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

Assumptions

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

Selection and rating of weatherproof ,twin core, aluminium conductor cable and line conductor

Total connected load=5 KW

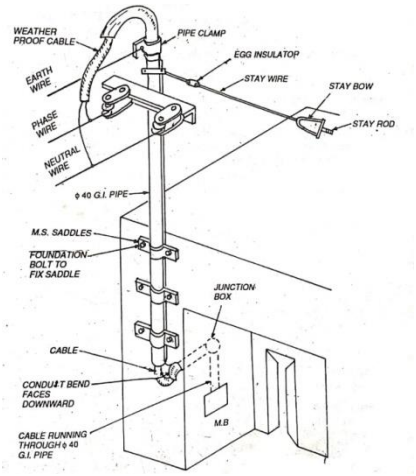
Total load in ampere=5000/230=21.7 amp

Diversity factor=60%X21.7=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 upto insulators=10 mm^2 ,AAC
- Rating of earth wire=8 SWG



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 storeyed 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 mt. away from the building. Prepare a list of the material,for giving sevice connection and also estimate the cost of the service connection.

Solution

Assumptions

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

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

Total connected load=4 KW

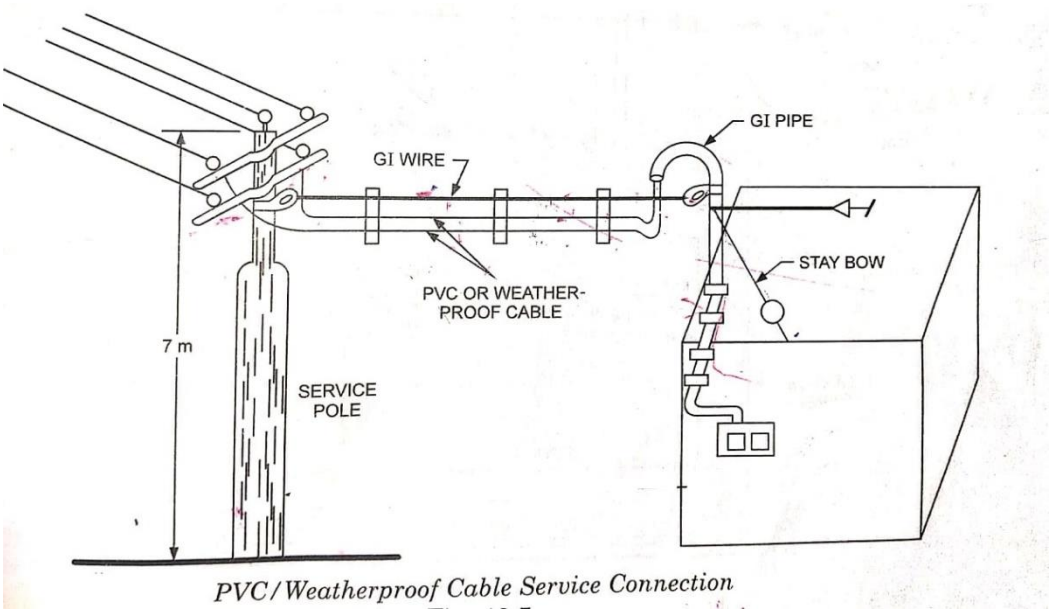
Total load in ampere=4000/230=17.29 amp

Diversity factor=60%X17.29=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

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

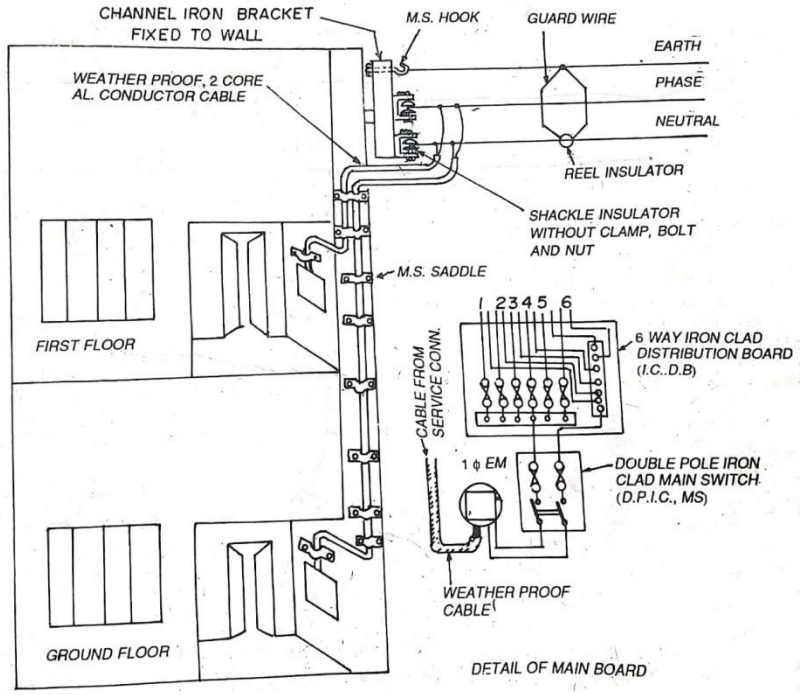
PREPARE AND ESTIMATE FOR PROVIDING SINGLE PHASE SUPPLY LOAD OF 3KW TO EACH FLOOR OF A TO DOUBLE STORED RESIDENTIAL BUILDING HAVING SEPARATE ENERGY METER

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-cicuit (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

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.



Selection and rating of weatherproof ,twin core, aluminium conductor cable and Line 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

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=42 mts
4	8 SWG GI earth wire(from pole to meter boa)	20+1+15=36 mts
5	MS angle iron bracket of sze(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

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

Q.1 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

Assumptions

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

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

Total connected load =15KW

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

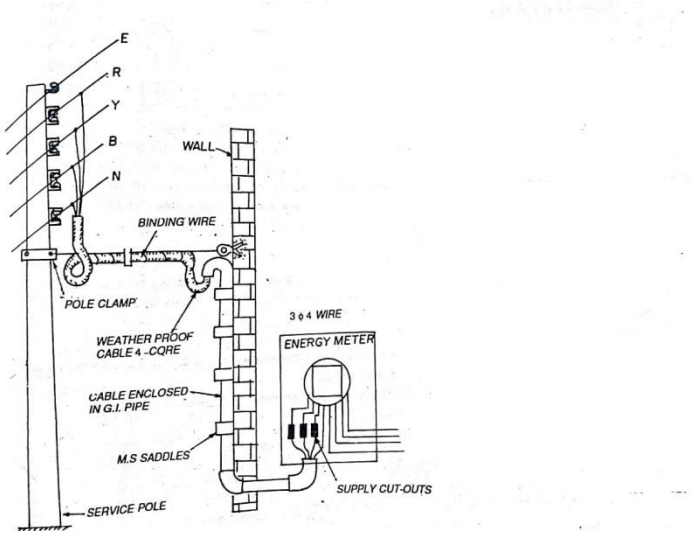
Starting current=1.5$\times$ $30 = 45$ amp

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 =10mm^2 or 1/3.55 mm ,4 core, PVC insulated aluminium conductor
- Rating of G.I wire=8 SWG



Material Table

Si no.	specification	quantity
1	PVC weatherproof cable(from pole to EM with wastage)	15+2+5+10 =32mt
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.2 A workshop 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

Assumptions

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

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

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 =6 mm^2 or 1/2.80 mm ,4 core, PVC insulated aluminium conductor
- Rating of bare conductor for installation between distribution pole upto insulators=10 mm^2 ACSR Conductor
- Rating of G.I wire=8 SWG

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

ESTIMATING FOR DISTRIBUTION SUBSTATIONS

6. 1 Prepare one materials estimate for following types of transformer substations.

6.1.1 Pole mounted substation.

6.1.2 Plinth Mounted substation.

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.

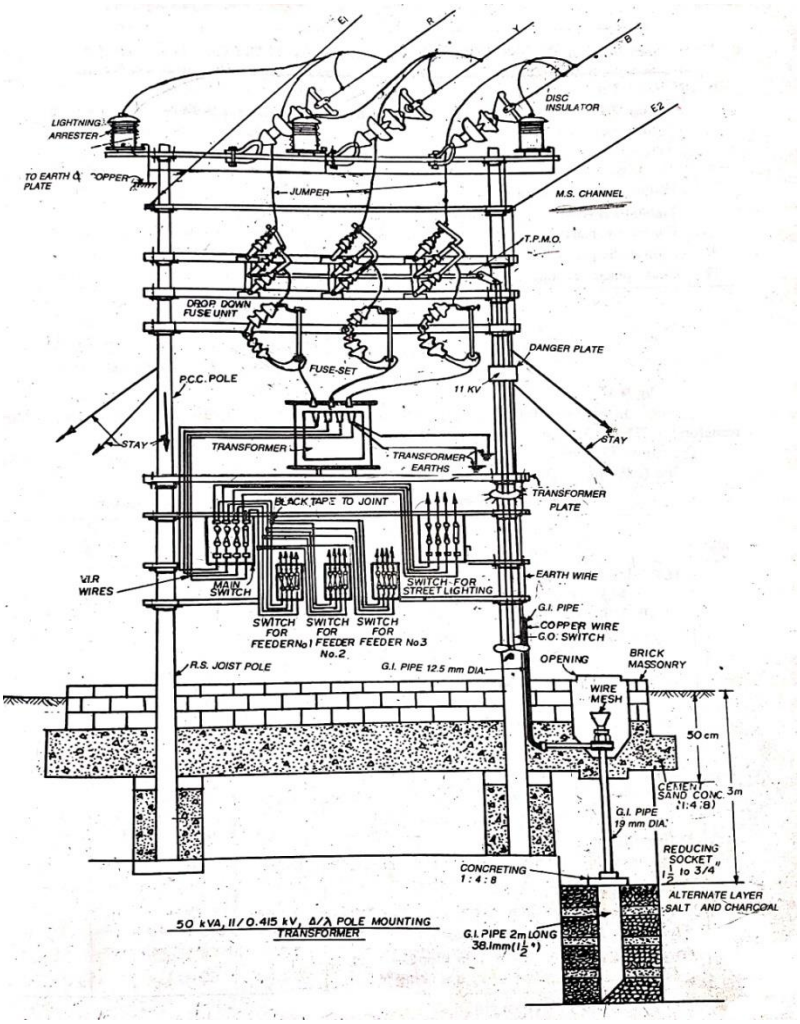
Solution

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	1no. 3nos.
	2. H.T ,11 KV Disc insulator with complete fittings	2 nos.
	3. Stay complete sets (clamps ,stay wire, egg insulators ,stay rod stay bow, stay plates)	2nos.
	4. Earth wire clamp	500 gms
	5. Binding wires	1 no.
	6. Clamps for M.S channel	2nos.
	7. Concreting for stay rod	

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