KIIT POLYTECHNIC

LECTURE NOTES

ON
ELECTRICAL INSTALLATION AND ESTIMATING

6th sem Electrical Engg

Compiled by

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CONTENTS

(Electrical Wiring & Installation)

Electrical Wiring system: A network of wires connecting various accessories for distribution of electrical energy from the supplier meter board to the numerous electrical energy consuming devices such as lamps, fans and other domestic appliances through controlling and safety devices is known as a wiring system. A typical house wiring circuit is shown in the fig.-1.

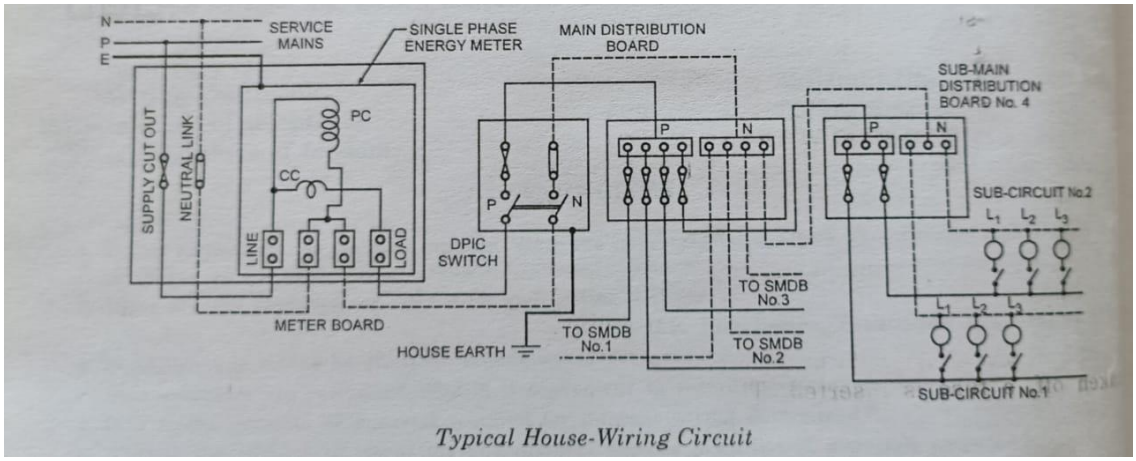


Fig.-1

Systems of distribution of electrical energy: Since as per recommendation of Indian Standards the maximum number of points of lights, fans and 5A socket outlet that can be connected in one circuit is 10 and the maximum load that can be connected in such a circuit is 800 W, 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.

Distribution Board System: In distribution board system, which is most commonly adopted for distribution of electrical in a building, the fuses of various circuits are grouped together on a distribution board, sometimes simply known as fuse board. Connections necessary for connecting two or more than two circuits, each consisting of 10 or less number of lamps is shown in fig.-2.

The two copper strips known as bus bars fixed in a distribution board of hardwood or metal case are connected to the supply mains through a double pole iron clad (D.P.I.C) switch so that the installation can be switched off. A fuse is inserted in the positive or phase pole of each circuit so that each circuit is connected up through its own particular fuse. The number of circuits and sub-circuits is decided as per number of points to be wired and load to be connected to the supply.

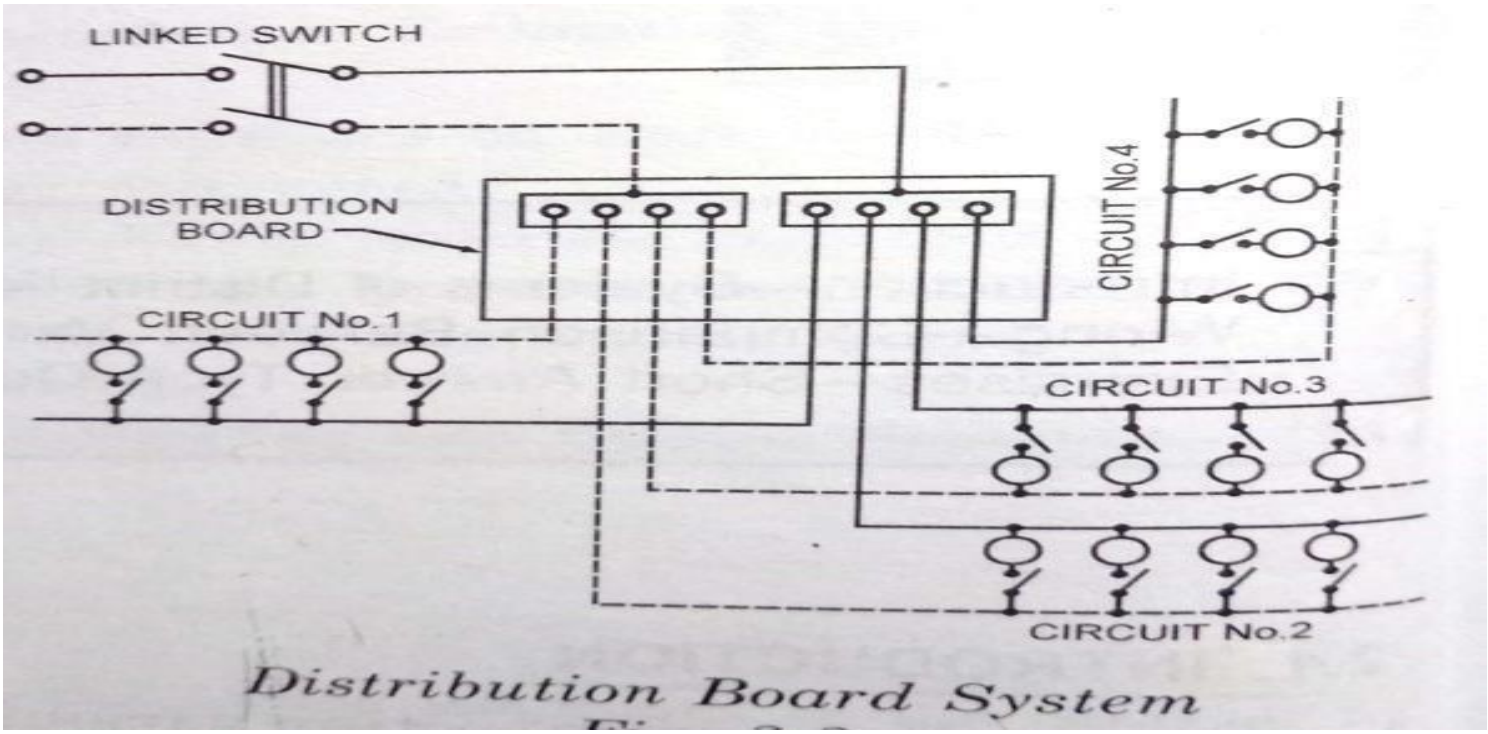

LINKED SWITCH
DISTRIBUTION BOARD
CIRCUIT No.1
CIRCUIT No.4
CIRCUIT No.3
CIRCUIT No.2
Distribution Board System

Fig.-2

Tree system: Another system of distribution of electrical energy in a building is a tree system. In this system smaller branches are taken from the main branch as shown in fig.-3 and the wiring system resembles a tree. As each branch is taken off, a fuse is inserted. This system used to be employed in early days. Now a days it is no more adopted due to the following drawbacks.

(i) The voltage across all the lamps does not remain the same.

(ii) A number of joints are involved in every circuit.

(iii) Fuses are scattered.

(iv) In case of occurrence of faults all the joints have to be located.

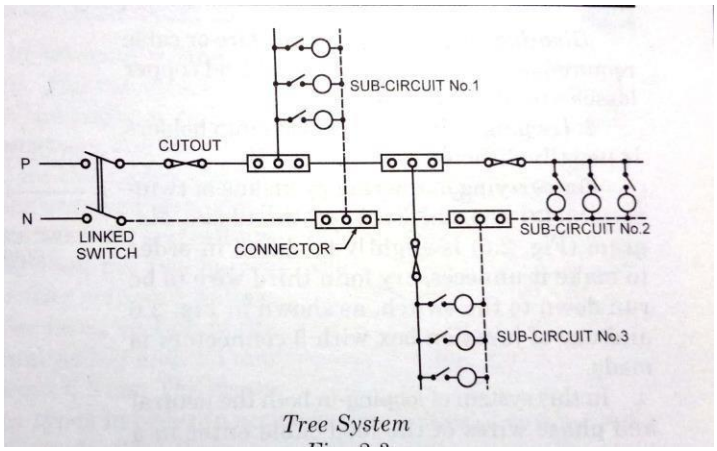


Fig.-3

Methods of Wiring: There are two **methods** of wiring known as joint box system (or Tee system) and loop in system.

(i) **Joint Box or Tee System:** In joint box system the connections to the lamps are made through joints made in joint box by means of suitable connectors or joint cutouts. In this method though there is a saving in the quantity of wire or cable required but the same is offset by the extra cost of joint boxes. The other disadvantage is the number of 'T' connection made in wiring system results in weakness if not properly made. Now a days the use of this system is limited to temporary installations only as its cost is low.

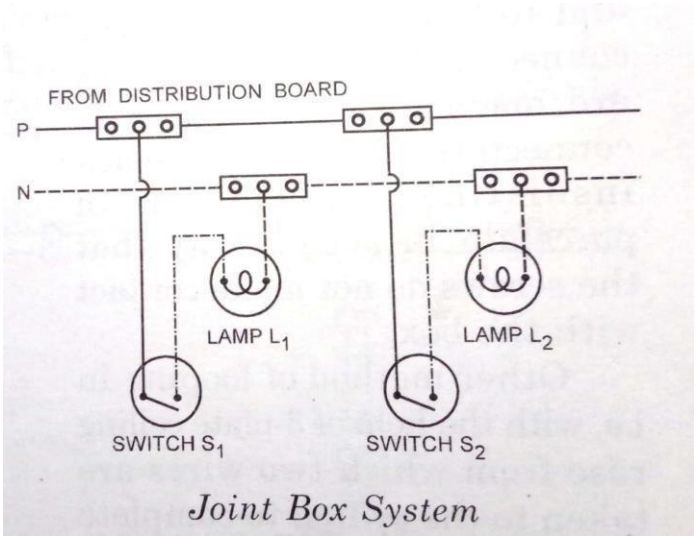


Fig.-4

(ii) **Loop-in System:** this system is universally used for connections of various lamps or other appliances in parallel. In this system when a connection is required at a light or switch, the feed conductor is looped in by bringing it direct to the terminal and then carrying it forward again to the next point to be fed as shown in fig.-4. The switch and light feeds are carried round the circuit in a series of loops from one point to another until the last point on the circuit is reached.

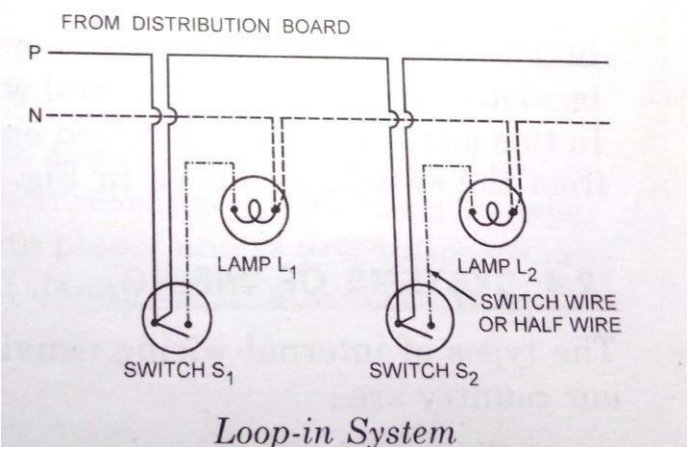


Fig.-5

The phase or line conductors are looped either in switch board or box and neutrals are looped either in switch board or from light or fan. Line or phase should never be looped from light or fan.

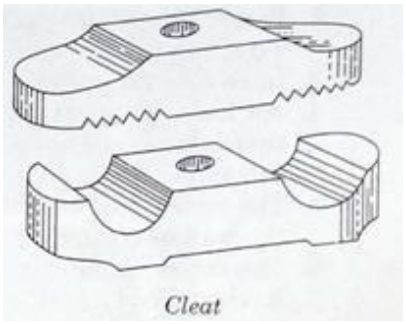
Selection or choice of wiring system:

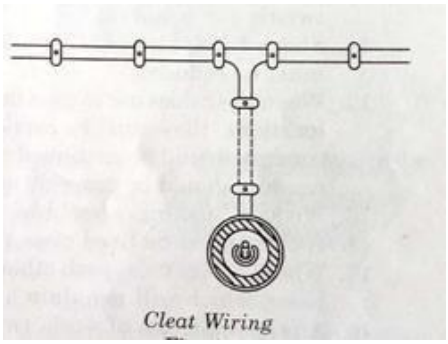
(i) Safety
(ii) Durability
(iii) Appearance
(iv) Mechanical protection
(v) Accessibility
(vi) Low initial cost
(vii) Low maintenance cost

Types of Electrical wiring systems:

(1) Cleat wiring system
(2) TRS wiring system
(3) Lead sheathed wiring system
(4) Wooden batten wiring system
(5) Plastic Casing-capping system
(6) Conduit wiring system
    (i) Conduit surface wiring
    (ii) Concealed conduit wiring

1. **Cleat wiring system: I**n this system of internal wiring the cables used are either vulcanized Indian Rubber (VIR) of Polyvinyl chloride (PVC) type. The cables are held by porcelain cleats about 6 mm above the walls or ceiling. The cleats are made in two halves, one base and the other cap. The base is grooved to accommodate the cables and the cap is put over it and the whole of it is then screwed on the wooden plugs (gut ties) previously cemented into the wall and ceiling. The cleats used are of different sizes and different types in order to accommodate cables of various sizes and different number of cables respectively. The cleats are of three types; one groove, two grooves and three grooves to accommodate one, two and three cables resp4ectively.


Cleat


Cleat Wiring

Advantages:

(i) It is the cheapest system of internal wiring.
(ii) Its installation and dismantlement is easy and quick.
(iii) Material is recoverable after the dismantlement.
(iv) Inspection, alterations and additions can be easily made.
(v) Skilled labour required is little.

Disadvantages:

(i) It is not good looking.
(ii) The wires are exposed to mechanical injury.
(iii) Oil and smoke are injurious to VIR insulation.
(iv)

2. **Casing-Capping wiring system:** This is one of the simplest form of electrical wiring system. This is little bit old/conventional wiring system. Now a days, we often use this wiring system. PVC insulated cables are placed in plastic casing and covered with cap. The casing is of rectangular cross section.
The colour of casing channel and cap are normally white or grey. The casing channel and cap are normally made of plastic. The casing channels and caps are available in market in standard sizes.

Advantages:

(i) It is the cheapest wiring system as compared to concealed wiring system.
(ii) It is strong and long lasting wiring system.
(iii) Replacement and alteration of defective wire is easy.
(iv) It provides protection against mechanical damage.
(v) It is safe from oil, steam, smoke and rain.
(vi) No risk of electric shock due to covered wires and cables in casing and capping.

Disadvantages:

(i) Since it requires better workmanship, the labour cost is high.
(ii) This type of wiring can be used only on surface and cannot be concealed in plaster.
(iii) Internal condensation of moisture may cause damage to the insulation.

3 Conduit wiring system: In this system of wiring steel tubes or PVC pipes known as conduits are installed on the surface of wall by means of saddles or buried under plaster and VIR or PVC cables are drawn afterwards by means of GI wire.

Advantages:

(i) It provides protection against mechanical damage.
(ii) It provides complete protection fire due to short circuit.
(iii) The whole system is waterproof.
(iv) Replacement and alteration of defective wiring is easy.
(v) Its life is long.
(vi) It is shocked proof also if earthing is properly done**.**

Disadvantages:

(i) It is very costly system of wiring.

(ii) Its eraction is not easy and required time.
(iii) Experienced and highly skilled labour is required for carrying out the job.

Conductor materials used in cables: The function of conductor usually known as core in cable is to carry electrical current. Copper and aluminum are the materials used as conductors in power and lighting cables.

Copper: Though silver is the best conductor of heat and electricity but due to its high cost it is rarely used. The next bets conductor is copper. It is cheaper as compared to silver. The electrical conductivity of copper is comparatively high. The resistivity of pure copper is $1.786 \times 10^{-8}\ \Omega$. It is mechanically strong, hard, extremely tough, durable and ductile. It is highly resistive to corrosion, oxidation etc. it can be easily soldered and welded. The specific weight of copper is 8900 kg. Its melting point is 1083 ^{o}C.

Aluminum: Aluminum is frequently used in place of copper for electric cables used for long distance power distribution. The electrical conductivity of aluminum is about 60% of copper (resistivity being $2.87\times 10^{-8}\ \Omega$ at 20 ^{o}C) so for same resistance for a given length, the aluminum required will be 1.61 times that of copper in volume and 1,26times that of copper in diameter. The only application of aluminum cables for wiring in the buildings is for the 'continuous bus bar' system of distribution.

Classification of cables: The cables employed for internal wiring of building my be divided into different groups.
According to:

(i) Conductor used
(ii) Number of cores
(iii) Voltage grading
(iv) Types of insulation used.

(i) According to conductor:
  (a) Copper conductor cable
  (b) Aluminum conductor cable

(ii) According to number of cores:
  (a) Single core cable
  (b) Two core cable
  (c) Three core cable

(iii) According to voltage Grading:
  (a) 250/440 V cable
  (b) 650/100 v cable

(iv) According to type of insulation:
  (a) Vulcanized Indian rubber (VIR) cable
  (b) Polyvinyl chloride (PVC) cable
  (c) Lead sheathed cable
  (d) Weather proof cable
  (e) Flexible cable
  (f) Cross linked polyethylene (XLPE) cable
  (g) Tough rubber sheathed (TRS) cable

Insulating Materials: the conductor is covered with insulating material so that it may prevent leakage of current from the conductor i.e. the insulating material should be extremely high resistive to the flow of electric current through it. The insulating materials used in electric cables should possess the following properties:

(i) High insulation resistance to avoid the leakage current.
(ii) High dielectric strength to avoid electrical breakdown of the cable.
(iii) High mechanical strength to withstand the mechanical handling of cables.

Types of insulating Materials:

Rubber: Rubber may be obtained from milky sap of tropical trees or it may be produced from oil products. It has relative permittivity varying between 2 and 3, dielectric strength is about 30 kV/mm and resistivity of insulation is 10^{17} Ω . Although pure rubber has reasonably high insulating properties, it suffers from some major drawbacks *viz.*, readily absorbs moisture, maximum safe temperature is low (about 38ºC), soft and liable to damage due to rough handling and ages when exposed to light. Therefore, pure rubber cannot be used as an insulating material.

Vulcanized India Rubber (*V.I.R.*). It is prepared by mixing pure rubber with mineral matter such as zinc oxide, red lead etc., and 3 to 5% of sulphur. The compound so formed is rolled into thin sheets and cut into strips. The rubber compound is then applied to the conductor and is heated to a temperature of about 150ºC. The whole process is called *vulcanization* and the product obtained is known as vulcanized India rubber.
Vulcanized India rubber has greater mechanical strength, durability and wear resistant property than pure rubber. Its main drawback is that sulphur reacts very quickly with copper and for this reason, cables using *VIR* insulation have tinned copper conductor. The *VIR* insulation is generally used for low and moderate voltage cables.

Impregnated paper. It consists of chemically pulped paper made from wood chippings and impregnated with some compound such as paraffinic or naphthenic material. This type of insulation has almost superseded the rubber insulation. It is because it has the advantages of low cost, low capacitance, high dielectric strength and high insulation resistance. The only disadvantage is that paper is hygroscopic and even if it is impregnated with suitable compound, it absorbs moisture and thus lowers the insulation resistance of the cable. For this reason, paper insulated cables are always provided with some protective covering and are never left unsealed. If it is required to be left unused on the site during laying, its ends are temporarily covered with wax or tar.
Since the paper insulated cables have the tendency to absorb moisture, they are used where the cable route has a few joints. For instance, they can be profitably used for distribution at low voltages in congested areas where the joints are generally provided only at the terminal apparatus. However, for smaller installations, where the lenghts are small and joints are required at a number of places, *VIR* cables will be cheaper and durable than paper insulated cables.

Varnished cambric. It is a cotton cloth impregnated and coated with varnish. This type of insulation is also known as empire tape. The cambric is lapped on to the conductor in the form of a tape and its surfaces are coated with petroleum jelly compound to allow for the sliding of one turn over another as the cable is bent. As the varnished cambric is hygroscopic, therefore, such cables are always provided with metallic sheath. Its dielectric strength is about 4 kV/mm and permittivity is 2.5 to 3.8.

Polyvinyl chloride (*PVC*). This insulating material is a synthetic compound. It is obtained from the polymerization of acetylene and is in the form of white powder. For obtaining this material as a cable insulation, it is compounded with certain materials known as plasticizers which are liquids with high boiling point. The plasticizer forms a gell and renders the material plastic over the desired range of temperature.
Polyvinyl chloride has high insulation resistance, good dielectric strength and mechanical toughness over a wide range of temperatures. It is inert to oxygen and almost inert to many alkalis and acids. Therefore, this type of insulation is preferred over *VIR* in extreme environmental conditions such as in cement factory or chemical factory. As the mechanical properties (*i.e.*, elasticity etc.) of *PVC* are not so good as those of rubber, therefore, *PVC* insulated cables are generally used for low and medium domestic lights and power installations.

(1) PVC cables: These cables are available in 250/440 v and 650/1100 V and are used in casing-capping, wooden batten and conduit wiring system. In this type of cable conductor is insulated with PVC insulation. Since PVC is harder than rubber, PVC cables does not required cotton tapping and bedding over it for mechanical and moisture protection.

(2) Weather Proof Cable: These cables are used for outdoor wiring and for power supply or industrial supply. Theses cables are either PVC insulated or VIR insulated conductors. Being suitably tapped (only in case of VIR cable)

braided and then compounded with weather resisting material. These cable are available in 240/415 V and 650/1100 V. theses cables are not affected by heat or sun or rain.

(3) Flexible cords and cables: the flexible cords consist wires silk/cotton/plastic covered. Plastic cover is popular as it is available in different colours. Flexible cords have tinned copper conductors. Flexibility and strength is obtained by using conductors having number of strands. These wires or cables are used as connecting wires for such purposes as from ceiling rose to lamp holder, socket outlet to portable apparatus such as radios, fans, lamps heaters etc. These must not be used in fixed wiring.

Fuse: Fuse is a current interrupting device which breaks or opens the circuit (in which it is inserted) by fusing the element when the current in the circuit exceeds a certain value.
Fuse Element or Fuse wire: It is that part of the fuse which actually melts when an excessive current flows in the circuit and thus isolates the faulty device from the supply circuit.

Principle of Operation: The action of a fuse is based upon the heating effect of the electric current. In normal operating conditions, when the current flowing through the circuit is within safe limits, the heat developed in the fuse element carrying this current is readily dissipated into the surrounding air, therefore, fuse element remains at a temperature below its melting point. However, when some fault such as short circuit occurs or when the load connected in a circuit exceeds its capacity, the current exceeds the limiting value, the heat generated due to this excessive current cannot be dissipated fast enough and the fusible element gets heated, melts and breaks the circuit.

Current Rating: This rating is specified by manufacturer. It is defined as the rms value of the current which the fuse wire can carry continuously without deterioration, and with temperature rise within specified limit.
Fusing Current: It is defined as the minimum value of current at which the fuse element or fuse wire melts.
For a round wire the approximate value of fusing current is given by

constant, depending upon the metal of the fuse element. Sir
W.H. Preece has given the value of the constant k as indicated in the table.

S.No.	Metal	Melting point in ^oC	Specific resistance in □Ω − □□	Value of fuse constant k for d in m
1	Silver	980	16	-
2	Tin	240	112	12.8
3	Zinc	419	60	-
4	Lead	328	210	10.8
5	Copper	1090	17	80
6	Aluminum	665	28	59

Fuse Element Materials: The materials used fuse element must be of low melting point, low ohmic losss, high conductivity (or low resistivity), low cost and free from deterioration. Experience has shown that the most generally suitable material for the fuse element is a low melting point material such as tin, lead or zinc.
The materials commonly used for fuse elements are tin, lead, silver, copper, zinc, aluminium and alloy of lead and tin. An alloy of led and tin (lead 37% and tin 63%) is used for small current rating fuses(say not beyond 15A). for current exceeding 15 A this alloy is not used as the diameter of the wire will be larger and after fusing the metal released will be excessive.
Advantages of Fuse:
(a) It is the cheapest form of protection available.
(b) It needs no maintenance.
(c) Its operation iss completely automatic.
(d) It interrupts an enormous short circuit current without noise, flame, gas or smoke.

Disadvantages:
Considerable time is lost in rewiring or replacing a fuse element after operation.

ELECTRICAL INSTALLATION & ESTIMATING

Electrical Installation: It is all the wiring accessories, fittings, current Consuming device control & protective switch gear & other apparatus associated with the wiring situated in an residential building in which electricity is supplied.

Estimating & Costing : Estimating means assessment of the quantity of material (i.e. list of materials required with their specification) andapproximate cost required for any work.

Wiring : Wiring is the method of connecting wires or cables for various accessories & fittings for distribution of electrical energy from energy meter to electrical consuming device such as lamp, fan and other domestic appliances through controlling and safety device.

System of Distribution of Electrical Emergency for Internal Wiring:

1. **Tree System**
2. **Distribution System**

Tree System: Wiring looks like a tree. In this system sub-circuits are tapped off from main circuit at convenient places. Each branch is taken off and fuse is inserted. Now a day, it is out of practice because there are many joints in sub-ckt.

Advantage: Length of cable requirement is less for installation so initial cost is less

Disadvantage :-

1. Fuses in installation are scattered.
2. Fault location is not easy
3. Voltage across all lamps will vary
4. Appearance is not good.

Distribution System:-

Most commonly used now a days for distribution of electrical energy in a building. Fuses are inserted in phase of each circuit. Distribution board may be wood or metal case. Distribution board is also known as fuse board. Now a day's M.C.B (Miniature Circuit Breakers) are used instead of fuses.

Advantages:

i) Fault finding is easy

ii) Extension is easy

iii) Voltage available at different points in a sub ckt will bethe same.

Disadvantages :

Length of cable required for the installation of wiring is more.So initial cost increases.

Method of Wiring

There are two methods of wiring

i) **Tree system: -** In this system the connections to the lamps are made through joints made in joint boxes by means of connectors. In this method of wiring length of cable required reduces but extra cost due to cost of joint box. The number of 'T' in this wiring made the system weak if it is not properly made. Now a days this

ii) **Loop System :- I**t is universally adopted system. Various lamps and other electrical appliances are connected in parallel. In this system switches & lights are carried around the circuit in a service loop from one point to another until the last point of the circuit is reached. In the loop in system there is no joint.

Advantages :-

a) Joint boxes are not required.

b) Fault location is easy.

Disadvantage:-

a) Length of cable requirement is more

b) Loop in switches are difficult.

Essential Elements of Estimating & Costing

1) Calculation of material

2) Specification of material

3) Cost of material

4) Labour Cost

Points to be Considered Before Selection of Particular Wiring-

i) Type of building

ii) Life of Wiring

iii) Future extension

iv) Type of cable used

v) Nature of load i.e. power load / light load

vi) Dampness

vii) Cast

viii) Appearance.

Other factors are type of building and voltage to be employed.

Fuse Unit: A Fuse unit essentially consists of a metal fuse element, a set of contact between which it is fixed and a body to support and isolate them. Types of fuse unit most commonly available

i) Round type of fuse unit

ii) Kit Kat type fuse unit

iii) Cartridge type fuse unit

iv) HRC (High rupturing capacity fuse unit)

INDIAN ELECTRICITY RULES

Indian Electricity Rules are framed to –

i) Ensure safety of operator or user

ii) Satisfactory operation of equipment

iii) To avoid risk of fire.

Certain regulation and code of practice have been laid down in ourcountry which is known as Indian Electricity Rules.

These rules made by central electricity board in 1910 called IndianElectricity Rules in 1956

Indian Electricity Rules for Wiring.

Voltage: Voltage means difference of electric potential measured in voltbetween two conductors or between one conductor and earth.

Low Voltage: Voltage should not exceed 250v under normal condition.

Medium Voltage: Voltage does not exceed 650v under normal condition.

High Voltage : Voltage does not exceed 33 KV **Extra High Voltage :**

Voltage exceed 33 KV. **Colour of PVC insulated Cable:**

- For 3 phase AC Supply – R- Phase-Red colour

  Y- Phase –Yellow colour

  B- Phase –Blue colour

  Neutral- Black Colour

- For Single Phase AC Supply Phase – Red colour

  Neutral – Black colour

  Earth – Green colour

- For D.C Supply +ve = Red

  -ve = Black

1. Weather proof Cable should be selected for service connection to a building.
2. Energy meter should be protected from rain, Sun and mechanical damage.
3. The wire used for wiring connection to main switch and distribution board should be of rating based on load requirements of the building.
4. PVC insulated wires used for conduit wiring
5. Every Sub-circuit should commence from distribution board and switch board.
6. Every phase wire should be protected by a fuse or MCB
7. Height of the Main Switch, distribution board and switch board = 1.5m from ground
8. Socket outlet should be installed in switch board. Socket outlet should be controlled by individual switches.
9. Sufficient number of socket outlets is provided at different places in all rooms to avoid long length of flexible wire.

10 Each sub circuit should not have more than 10 points. The load oneach sub circuit should be restricted to 800 watt (light, fan, tube light) socket should be 5A, 230V.

11. In power sub circuit (AC, Geyser, Induction cooker, Oven, Electric iron) total number of points limited to 2. The load on each Power sub circuit should be within 3000 watt or 3 KW. Socket should be 15A, 230V .
12. Only 3 pin 5A socket outlet are used in light and fan sub circuit.

    Also 3 pin 15A, socket outlet are to be used in all power sub circuits.
13. The earth terminals are socket (Bigger hole) permanently connected to earth wire.

14. 14 SWG – G.I wire is used as continuous earth wire in wiring and 8 S.W.G G.I or 10 S.W.G copper wire is used to connect earth electrode.

15. Fuse and switch are not provided in earth conductor or earth wire.

16. The metal part of electrical apparatus metal part of switch board, and all metal covering should be properly earthed in order to avoid danger of electric shock due to leakage or failure of insulation.

17. Height of the building 3.5 m

Height of Switch board =1.5 m from the ground Height of bulb

point = 3 m from the ground Height of ceiling from 2.75m from the

ground. Height of Horizontal run= 3 m from the ground.

INSPECTION AND TESTING OF INSTALLATION

1. On completion of house wiring, the following tests should beconducted –

   i) Insulation resistance test for (a) between conductors

      (b) Between earth & Conductor.

   ii) Polarity test of switches.

   iii) Un-breaked earth circuit test.

   iv) Resistance test of earth electrode.

2. Leakage current in consumers installation should not exceed(1/5000) part of maximum current required by the consumer.

3. Permissible voltage drop for light and fan circuits

   = 2% of supply voltage +1

   = 2% of 230 V + 1

   = 4.6 V + 1V= 5.6 volt

4. Verification of Declared Voltage & frequency of Supply:

a) Voltage verification should not be more than 5% of declared supply voltage for medium (650V) and voltage (230V) for low voltage variation is within 241.5 V to 218.5V for medium voltage variation.

b) Frequency variation = 3% of declared frequency(50 Hz)

Earthing:

1. All metal support and other metallic fittings should be properly earthed.
2. Earth wire on overhead lines should be earthed at four points in every 1.609 km or in one mile.
3. Neutral point should be earthed by not less than two separate earthing having their own electrode at the (a) Generating Station (b) Sub-station.

Earthing:

Earthing means connecting non-current carrying metal part used in electrical distribution system to general mass of earth by wire of negligible resistance.

(Electrical appliances, metal covering of cable, earth terminal of socket,frame of generator or motor)

1. To avoid electric shock to human body
2. To avoid risk of fire due to earth leakageCurrent through unwanted path
3. To protect the equipment and building from lightening

Types of Earthing.

1) Pipe earthing 2) Plate earthing3) Strip earthing
4) Rod earthing

Q- What are the factors on which the earthing depends?

Factors affecting the value of earth electrode resistance.

1.Electrode material

2.Electrode size
3.Material and size of earth wire

4.Moisture content of soil

5.Depth of electrode of underground

6.Quantity of Salt & charcoal in the earth pit

7.Size and spacing of earth electrode

Indian Standard Specification regarding earthing of electrical Installation.

1. **Distance of earth from building** – An earthing electrode shall not be situated within a distance of 1.5m from the building whereinstallation system is to be earthed.

Resistance of Earth:-

1 There is no hard of fast rule. The volume of earth resistance doesnot remain constant but changes with weather. If depend on moisture content of the soil and is maximum during dry (Summer) season. But following value of earth resistance

Large Power Station =0.5 Ohm Major

Major power Station=1 Ohm

Small sub-station=2Ohm

In all other cases = 8 Ohm

Q- Earth continuity inside insulation from earth plate to any point inthe installation.

2. Earth wire and earth electrode should be of same material (Copper or G.I)

3. It is necessary that earth wire connection to earth electrode is run along the whole wiring system (wire =14 S.W.G)

What Equipment is to be Connected to Earthing

1. Earth pin of 3 pin plug socket should be earth power plug.

2. The frame of generator, motor and other metal part of equipment used for controlling energy should be earthed.
3. All metal parts, metal conduit enclosing PVC cable light fittings, I.C.D.P switches Distribution boards, heater, refrigerator, shouldering iron should be earthed.
4. Steel transmission tower, tubular pole, rail pole, concrete poles used in overhead transmission lines should be earthed.

Earth Electrode :

Any wire, pipe, rod, metal plate embedded in earth for the purpose of making an effective electrical connection with general mass of earth is known as earth electrode.

Earth Continuity Conductor:- The conductor running between the distribution board and various plugs and appliances is known as earth continuity conductor. (14 S.W.G)

Earthing Lead or the main Earthing Conductor :- The earth wire which connect the overhead earth wire or any other apparatus to be earthed to the earth electrode is known as earthing lead or the main earthing conductor (8 S.W.G)

Earthing : - Earthing means connection of a metallic body with the general mass of earth for the purpose of safety from shock.

Q. In A.C system why is neutral earthed?

Ans:

1. In an AC system neutral is earthed for following reasons.
2. Safety from electric shock.
3. To stabilize the voltage in all three phase.
4. To obtain single phase supply between phase & neutral.

Pipe Earthing:

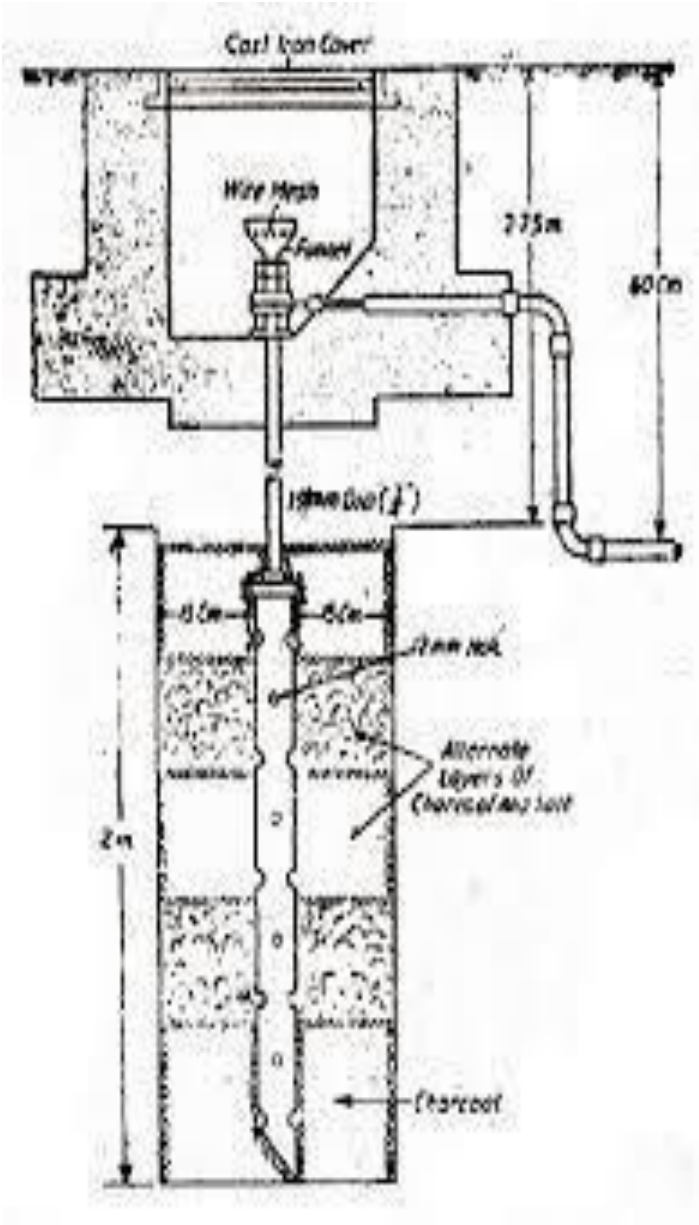
It is the best form of earthing. In this method a galvanized and perforated pipe is 38 mm dia and 2m length for ordinary soil and dry rocky soil length of pipe =2.75m. The depth at which the pipe should be buried depends upon condition of soil and moisture. According to ISI the pipe should be placed at depth of 3.75m-4.75m. The pipe is taped at bottom to facilitate driving. The charcoal and salt are

filled in the pit alternately in layers up to 2m to 3m from the bottom for a distance of 15 cm. Generally alternate layers of charcoal and salt are used to increase the effective area of the earth and to decrease the earth resistance respectively.

Another pipe of 19 mm diameter and of length 1.25m is connected to GI pipe through reduced socket.

At the top a cement concrete work with Cast Iron cover is done to facilitate water pouring arrangement for provision of dampness. Funnel with wire mesh is also provided in concrete work so that water should be put into the funnel connected to main G.I. pipe.

Another G.I. pipe is taken from funnel towards outside for its connection to earth wire, diameter of pipe 15mm. According to ISI the size of G.I. wire should not be less than 8 S.W.G. The size of continuous earth wire used with cable in domestic installation should not be less than 14 S.W.G.



ESTIMATE THE MATERIALS FOR A G.I. PIPE EARTHING

S.No.	List of materials with specifications.		Quantity
1	38 mm dia. 2.5m long G.I. pipe with 12 mm holes at an interval of 15 cm threaded one end.	-	1 No
2	38mm x 19mm Reducer	-	1 No
3	19mm GI pipe 1 mm threaded both ends for Watering .	-	1 m.
4	Funnel with wire mesh	-	1No
5	Cast iron cover 30cm x 30cm	-	1No
6	G.I Nuts 19 mm	-	3 No
7	GI wire 8 S.W.G	-	4 m
8	Charcoal and salt	-	20 kg each
9	Cement concrete (1:4:8)	-	$0.15m^3$
10	30 cm x 30cm Cast Iron frame	-	1 No
11	30 cm x 30 cm Cast Iron cover	-	1 No

Plate Earthing

This is also common system of earthing. In this type of earthing G.I plate or copper plate can be used.

Size of G.I plate =(60cm x 60cm x 6mm)

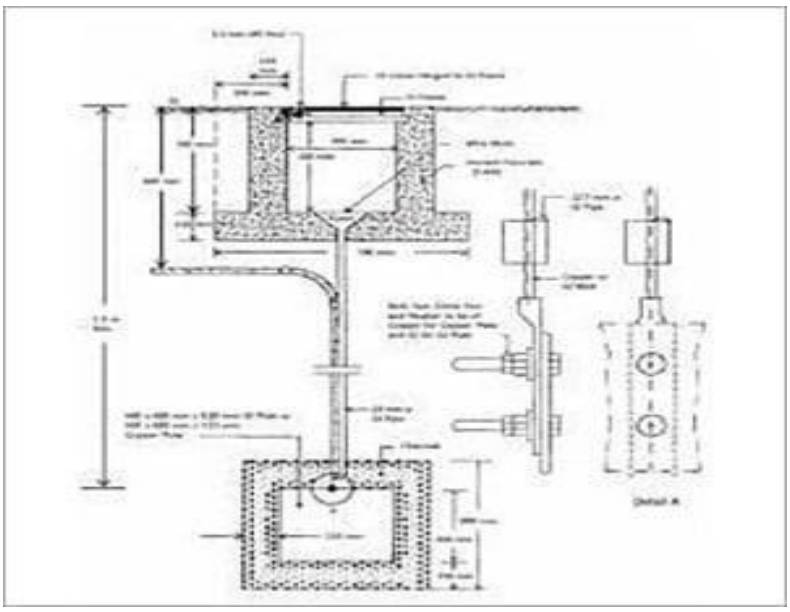
Size of Copper Plate = (60 mm x 60mm x 3mm) Due to high

copper cost it is rarely used.

Pit is dug about 4 m deep (3 m to 4 m) according to coil condition.

Plate is burried to the ground with its face vertical. Space around that plate is filled with alternate layers of salt and charcoal of thickness of 15 cm. The plate is connected to G.I pipe of 12.7 mm dia for carrying G.I (8 S.W.G) earth wire for connection to earth electrode. The earth wire is bolted to the earth plate with help of bolts and nuts. The pit carrying salt and charcoal is connected to a pipe for pouring water to increase the dampness of soil. Small concrete wall with cast iron cover on the top is provided at the top for pouring water and for carrying periodical inspection and tests.

For smaller installation G.I pipe earthing is used and for large station and for transmission line plate earthing is used.



Estimate the Materials Required for Plate Earthing

S.No.	List of materials with specifications		Quantity
1	60 cm x 60 cm x 3mm Copper Plate or (60cm x 60cm x 6mm) G.I Plate	-	1 No
2	29 mm dia G.I pipe	-	1 NO
3	30cm x30cm Cast Iron Cover	-	1 No
4	12.7mm dia G.I pipe for protecting the earth conductor	-	1 No
5	12.7mm bend	-	1 No
6	5/16 Nuts and bolts with spring washer	-	1 each
7	No 8 S.W.G bare copper or G.I earth lead for external		As required

	connection		
8	Salt	-	20kg
9	Charcoal	-	20 kg

Electric Shock : When electric current suddenly passes through the human body he feels electric shock causing contraction system of the body. Heavy pain in nerves produced which may stop heart beating causing death.

Result of Electric Shock :

i) Damage of heart pieces causing stopping of breathing

ii) Stoppage of breathing caused by blockage of nervous system

iii) Burning of body due to over heating.

Factors on which Intensity of Electric Shock Depends.

1) The length of current

1- 8 milli ampere

8-15 milli ampere – Painful shock

15-20 milli ampere- Painful shock

20-50 milli ampere –Severe muscular contraction (Difficulty in breathing)

50-100 milli ampere- Possibility of death.

200 milli ampere and above – Death , severe burn

I = E/R where E= Supply voltage

R=Resistance of body

2. Body resistance: Body resistance is different in different condition. When dry resistance is 70,000 Ω to 10,000 Ω per square cm. But when wet body resistance is reduced to 700 Ω to 1000 Ω

The average resistance of body is taken 50000 ohm when dry and 1000 ohm when wet.

High voltage causing current beyond 200 mA punctures outer skin causing burns.

Therefore in wet situation resistance of body is low.

3. Frequency of Current: When the frequency is low, the electric shock is more severe and dangerous and direct current shock is more severe.

4. The Path taken by the Current: through the body of the path of the leakage current is without involving the heart, survival is possible

5. Duration of contact: If the duration of contacts is far a more time the situation becomes dangerous.

6. Area of contact: Resistance decreases with the area of contactwith live parts.

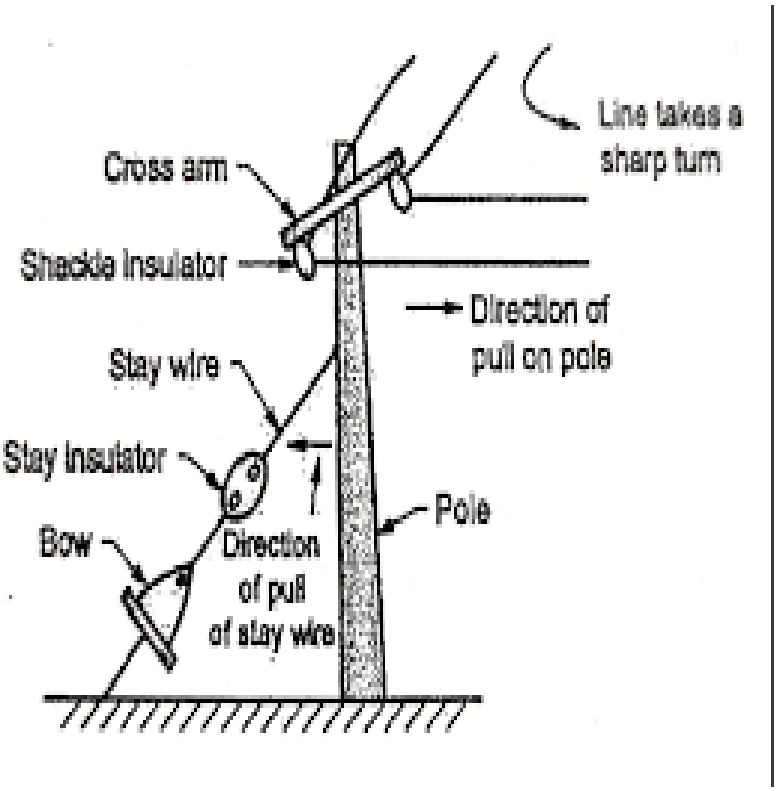
Q. What preventive precautions should be taken to avoid electricshock.

1. Proper insulation
2. proper earthing
3. proper handling
4. proper fuse

Write the Rules for Earthing:

1. Earth wire used in house wiring 14 S.W.G G.I or 16 S.W.G Copper.
2. All metallic covering of the main switch along with the earthterminal of wall socket is earth.
3. The earth resistance should not be more than 5 Ω in ordinary soil and 8 Ω for rocky soil.
4. All three phase machines should be double earthed.
5. Area of earth wire should be double of wiring wire. That is why the terminal of earth in a three pin wall socket is thicker.

Prepare list of material required to provide a stay :



1. Mild steel anchor plate 30cm x 6mm (not galvanized) = 1 No
2. MS stay rod 16 mm diameter 2.42m long = 1 No
3. Stay bow made out of mild steel rod 12 mm, diameter =1 No
4. Stay insulator = 1 No
5. Stay wire =(7/8 SWG GI wire)
6. Stay clamp= 1 No
7. 16 mm diameter, 76 mm long bolts and nuts fixing
8. M S thimble= 1No
9. Cement concrete (1:3:6)

Q. What do you mean by double earthing? Give its advantages.

A.- When any apparatus is earthed at two different places this method is called double earthing. If one earth fails the second earth will do the purpose.

The second reason it offers minimum resistance if they are connected in parallel

.1/R, 1/R1, 1/R2

R2 total resistance of earth

R1 & R2 resistance of 1st earthing& second earthing.

Types of Wiring:

1. Cleat wiring
2. Batten wiring -
   i. CTS Wiring (Cab Tyre Sheathed)
   ii. TRS wiring(Through Rubber Sheathed)
   iii. Lead sheathed wiring
3. Casing capping wire = wooden/PVC
4. Conduct pipe wiring
   i. Surface conduit/open conduit wiring
   ii. Concealed conduit wiring.

Cleat Wiring:

Very simple and cheapest method of wiring used for temporary wiring at dry places. Single core P.V.C or V.I.R cables are used in this system of supply voltage of 250v. It is used 1.5 m above from the ground. Cables are held by porcelain cleat. The cleats are made of porcelain. The

Cleats are made in to two halves, 1) Base ii) Cap. Cap is put over it and the whole is screwed. The Cleat is screwed over wooden gutties previously cemented into wall.

Cross Section of Gutties = 38mm x 38mm (Big end)

= 25mm x 25mm (small end)

Length = 65mm

The Cleats are different sizes and different types to accommodate different number of cables.

Types of Cleats (1) One groove to accommodate one cable

(2) Two grooves to accommodate two cables

(3) Three grooves to accommodate three cables.

Distance between two cleats should be between 30 cm to 60 cm to avoid sag on the cable. Used for temporary power connection for marriage.

Advantages:

1) Less cost
2) Easy to work
3) Fault can be easily located
4) Fault location is easy
5) Installation on dismantling is easy

Disadvantages:

1. It is not good looking.
2. It is purely temporary.
3. No protection from mechanical injury, fire, gas, water.

Precautions:

1. Two wire should not be placed in one groove of porcelain cleat.
2. Cleat should not be loose or over tightened.
3. This system of wiring is not used in wet walls.

Applications:

1. Suitable for temporary installation
2. Used in dry places where appearance is not important and cheap is required.

Batten Wiring :-Suitable for low voltage installation. In this type of wiring plain strip of teak wood (Batten) are used so it is called batten wiring. The wire used may be single core twin core, three core, T.R.S, C.T.S,P.V.C or lead sheathed cable – usually single core P.V.C wires are used which is chemically proof, water proof, steam proof. The thickness of batten 10 mm to 13 mm . The width of batten depends on the number of conductors carried by it.

Width of batten x thickness = No of wires carried by it.

Wooden battens are screwed to the walls by wood screw to wooden gutties which are previously cemented to walls. The interval of wooden gutties should be 75 cm.

Joint clips are fitted on the batten before fitting it on the wall.

Cables are held on wood batten by means of tin coated brass link clips already fixed on the batten with brace pins and spaced at an interval of 10 cm in case of horizontal run or ceiling run or 15 cm in case of vertical run.

Other Materials Required:

(1)Teak wood batten,

(2)Round block for light point & ceiling rose,bend, clips, nails and other wiring accessories

When wiring is to be taken out from one room to another room the wireshould be drawn through inside conduct pipe.

After wiring, it should be pained by paints two times after erection.

Advantages:

1) Easy to install and repair
2) Cheap as compared to other wiring
3) Easy to inspect
4) It can withstand the action of most chemicals and salt
5) Iife is longer

Disadvantages :

1. It can be used in places open to Sun and rain.
2. There is risk of fire

Application: (CTS/TRS)

Suitable for low voltage in domestic , Commercial building

Casing Capping Wiring :- Wooden/PVC

This system of wiring is most commonly adopted for residential building.The wire used may be P.V.C or V.I.R type. It consists of rectangular wooden block led casing which has two or more grooves to carry the cable. The casing is covered by wood of some width called capping and is

screwed to it with the help of wood screw to wooden gutties which is fixed previously to walls.

The size of casing/capping depends on the number and size of the cables to be accommodated. Now a days wooden casing and cappingare replaced by PVC casing and capping.

Use ::-This type of wiring is suitable for low voltage installation (Upto250V) where there is no risk of fire hazard. Length, casing & capping = 2.5 m to 3 m

Advantage:

1. Long life
2. Easy to install & repair
3. Less costly (Cheap)
4. It can withstand the action of Acid & Chemical

Disadvantage:

1. Wood is very inflammable, there is risk to fire.
2. Wire replacement is difficult
3. Wood is not damp proof, so it is not used in damp and wet areas.

Lead Sheathed Wiring:

In this type of wiring the conductor used is insulated with VIR and covered with an outer sheath of lead aluminum alloy containing about 95% of lead. The metal sheath gives protection to the cable from mechanical injury, dampness and atmospheric corrosion. The cable are run on wooden batten and fixed by means of link clips as CTS/TRS wiring.

Advantages:

1. It provides protection against mechanical injury
2. It can be used in situation exposed to sun and rain provided no joint is exposed.

Disadvantage:

1. More costly than CTS/TRS wiring due to increase in cost of cable
2. Not suitable for places where chemical corrosion may occur.
3. Wiring is suitable for low voltage up to 250V

Conduit Wiring:

1. Surface conduct wiring
2. Concealed conduit wiring

Types of conduct	i)	PVC conduit	-	Non metal
	ii)	Flexible conduit	-	Non metal
	iii)	Metal conduit	1) Light gauge conduit	
			2) Heavy gauge conduit.	

Sizing of the conduit is stated in terms of its outside diameter(12mm, 19mm, 38mm, 50mm, 63mm) .This system is suitable for low and medium voltage wiring installation.PVC cables are run in PVC or metal pipes known as conduit which provides good mechanical protection to insulation of cable. Conduits arefixed to walls with the help of hooks or saddles. The cables are drawn through the conduit pipe by means of steel wire known as fish wire. Sizeof conduit to be selected for the wiring depends on the diameter of conduit and number of cables to be corrected through the conduit. The conduit should be electrically & mechanically continuous and connected to earth .There are two types of conduits

1) Light gauge conduit
2) Heavy gauge conduit.

Light gauge are used upto 250V. It is not water tight, nor damp proof. Heavy gauge conduit are used for all medium voltage 250V to 650V .

Advantages:

1. Long life
2. No maintenance
3. Costly
4. Whole system is water proof
5. It gives protection against fire due to short ckt.

6. Gives protection against mechanical damage.
7. It is shock proof if earthing is properly done.

Disadvantages:

1. Very costly system
2. Its erection is not easy and requires time.
3. Highly skilled labour is required for carrying out the working.

Application :

1. Used in workshop building, Industries

Light gauge conduit is prepared from sheet of steel and theseare thin. So threading cannot be done. Sizes are 12 mm, 16mm, 19mm, 25mm, 38mm, 50mm.

Heavy Gauge conduit pipes are prepared from mild steel,threading can be done with help of die set.

Comparison Between Various System of Wiring

	Cleat	**Batten**	**Wood/PV casing**	**Concealedconduit**
Cost	Very low/ cheap	Expensive	Capping Medium	Very costly
Voltage	Upto 250v	Upto 250v	Upto 250v	Low and medium upto650v
Life	Very short	Long	Long	Very long
Protection against fire	Poor	Fair	Wood-No PVC- Fair	Very poor
Appearance	No good	Good	Fair	Very good
Dampness protection	No	Good	Poor	Very good
Mechanicl protection	No	Good	Good	Very good
General reliability	Poor	Good	Good	Very good

Types of labour required	Semi skilled	Skilled	Skilled	Highly skilled
Repair	Very easy	Easy	Difficult	Most difficult
Field of application	For temporary installation, function like	Residential building, Commercial office	Residential building, Commercial office	For go down, workshop, private andpublic
	marriage, building under construction	building	building	Building where economic factor doesnot apply.

Wiring System:

A network of wires connecting various accessories for distribution of electrical energy from supplier meter Board to the numerous electric energy consuming devices such as lamps, fan, other domestic appliances through centre and safety devices is known as wiring system.

Choice of Wiring

The following factors should be considered before particular types ofwiring.

1. Safety – Safety to a person using electricity
2. Mechanical Protection – It must be protected in workshop.
3. Permanency – The wiring must not be by effected by weather,fumes, dampness.
4. Appearance – The wiring should be good looking.
5. Durability - The wiring should be durable
6. Accessibility –The wiring system should be flexible for extension,renewal and alternation.
7. Material cost should not be more
8. Maintenance cost should be less.

Procedure For Internal Electrification

The following general points are to be considered

1. Types of wiring
2. System of distribution of wiring
3. Methods of wiring
4. Particulars of load
5. Calculation of total current
6. No of sub ckts
7. Selection of Branch Distribution Board (BDB)
8. Distribution points in the sub ckt
9. Line diagram (Lay out)
10. Selection and size and length of cable (wire) required frommain switch to BDB
11. Size and length of cable required from BDB to different sub ckt
12. Size and length of cable required from BDB to different load points based on voltage drop calculation.
13. Selection of size of conduit pipe
14. Selection of main switch
15. List of materials and other fittings.

In A.C colour of wire used – R (Red), Y (Yellow), B(Blue) for Phase & black wire for neutral wire.

In D.C for(+ve) Red colour wire and for (–ve) Black colour wire.

Internal Wiring

Domestic & Industry -

1. **Batten Wiring**
2. **Conduit Wiring**
   i) Concealed wiring
   ii) Surface conduit wiring
3. **Case capping wiring**
   i) Wooden casing capping ii)PVC casing capping

Batten Wiring: In batten wiring wood strip size is selected accordingto the number of wires are fitted on the batten

The battens are fitted with the wall on wooden gut ties with screws.Gutties are spaced 75cm apart inside walls. For holding the wirestinned link clips are fitted in batten by nails.

Wires are fixed to the batten & link clips with help of linking eye.

Prepare the estimate for the materials required for the service connection to a residential building for a Load of 2kw at 230v, 50 hz at 0.9 p.f. The service pole is situated 15m along the street. Taking into account I.E rules allow the ground clearance. Assume anyother items if required.

ANS: Load calculation:

Load=2kw, Supply
voltage=230v,Power Factor=0.9

Load current=2x1000/230x0.9 =9.66A

Considering safety factor=1.5

Therefore load current I =9.66X1.5=14.49 A

Therefore from conductor chart PVC insulated aluminum conductor of size (1/8),2.5 square mm current carrying capacity 15 A,250v grade, 1 volt drop distance 2.5 m is selected.

Distance of pole from building=15m

Considering 3 m inside bend pipe total conductor length=15m+3m=18m

Voltage drop calculation:

Actual distance=18m, 1 volt drop distance=2.5m Actual current=14.49A

Current carrying capacity of conductor=15A

Voltage drop= Actual distance/1 volt drop distance x Actual current/Current carrying capacity of conductor =18/2.5x14.49/15=7.3 volt

As per I.E rule voltage drop should not exceed 5.6 volt

But calculated voltage drop is 7.3 volt which is more than permissible voltage drop

So the selection of cable is not satisfactory, so consider next higher size of conductor.

From conductor chart aluminum conductor nominal area 4 square mm,1/2.24 current carrying capacity 20A, 1volt drop distance 2.9 m is selected.

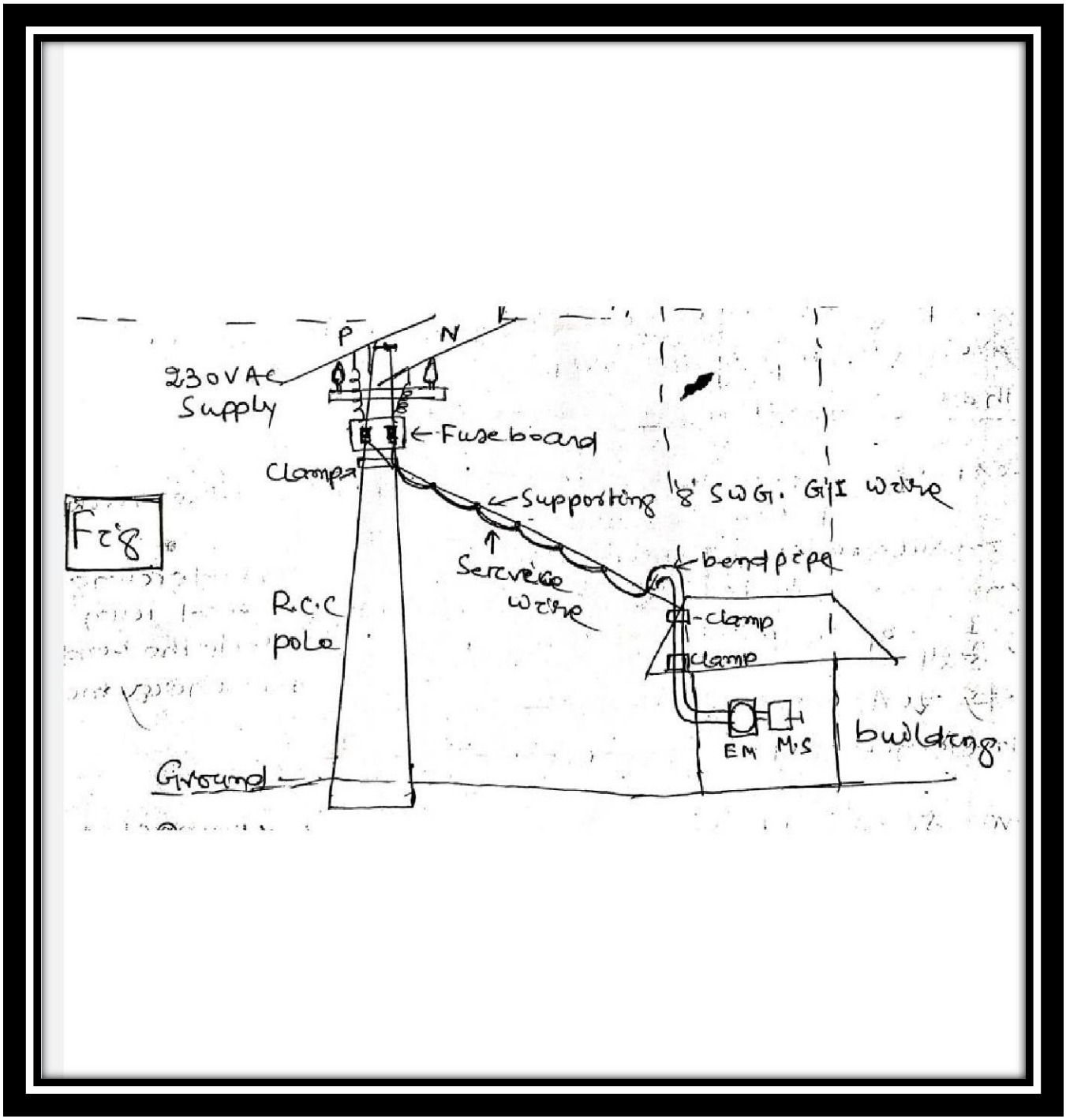
Voltage drop=18/2.9x14.49/20=4.5volt

As per I.E rule it is within permissible voltage of 5.6 volt.

So this cable is selected.

Sl No.	List of Materials with Specifications	Quantity	Specifications
1	PVC insulated twin core aluminum conductor of size 4 mm sq ,1/2.24 of current carrying capacity 20A having one volt drop distance 2.9m is selected.	20m	Considering sag and run inside the bend pipe up to energy meter.
2	Above cable but single core aluminum conductor made in coil	3m	To connect the bare conductor of pole to the Ariel fuse board.
3	G.I fuse board with fuse unit(100mmx150mm)	1 No	For Ariel fuse board
4	G.I fuse board with fuse unit(250mmx350mm)	1 No	For energy meter

5	Ariel fuse base and bridge made of glazed porcelain.	1 set	For fitting in the Ariel fuse board
6	Mild steel U shaped clamp with nuts and bolts	1 set	To fix the fuse board on the pole
7	Mild steel clamp	2 sets	To hold the bearer wire at both end. One at the pole and other at the bend pipe.
8	G.I bearer wire of 8 SWG	18m	Considering bending at both ends.
9	G.I bend pipe, 20 mm dia, as per I.ESpecifications.	3m length	To protect the service wire through wall
10	PVC bushings for 20 mm dia G.I pipe.	2 No	At both end of bend pipe
11	Lasing rod	50 pieces	Used to support the bearer wire with twin core cable.
12	Ear thing wire(8 SWG Copper)	8m	To connect the Earthling
13	Fuse unit,30A,230V	1 Set	For fixing at fuse.
14	Conduit pipe with conduit shaddle	As required	For connection from bend pipe to energy meter.
15	Other items like nails, cement	As required	


P
N
230VAC
Supply
Fuse board
Clamp
Supporting '8' SWG. G/I wire
Fig 8
Service wire
bend pipe
R.C.C
pole
clamp
clamp
EM
M.S
building
Ground

Q. A farmer desires to connect 50 hp, 400V,50 Hz motor to 400V/230V from a three phase 4wire over head line. The distance of the service line is 15 m from farmer's structure. The motor at full load has efficiency 85% at power factor 0.85.Estimate the quantity of materials required.

Solution: load of motor= 50 hp=50x746 watt (1hp=746 watt)
Full load efficiency=0.85

Power factor=0.85

Full load current=P/ Vx.Cosϴ.x efficiency

=50x746/ 400x0.85x0.85

=79A

Considering safety factor=1.5

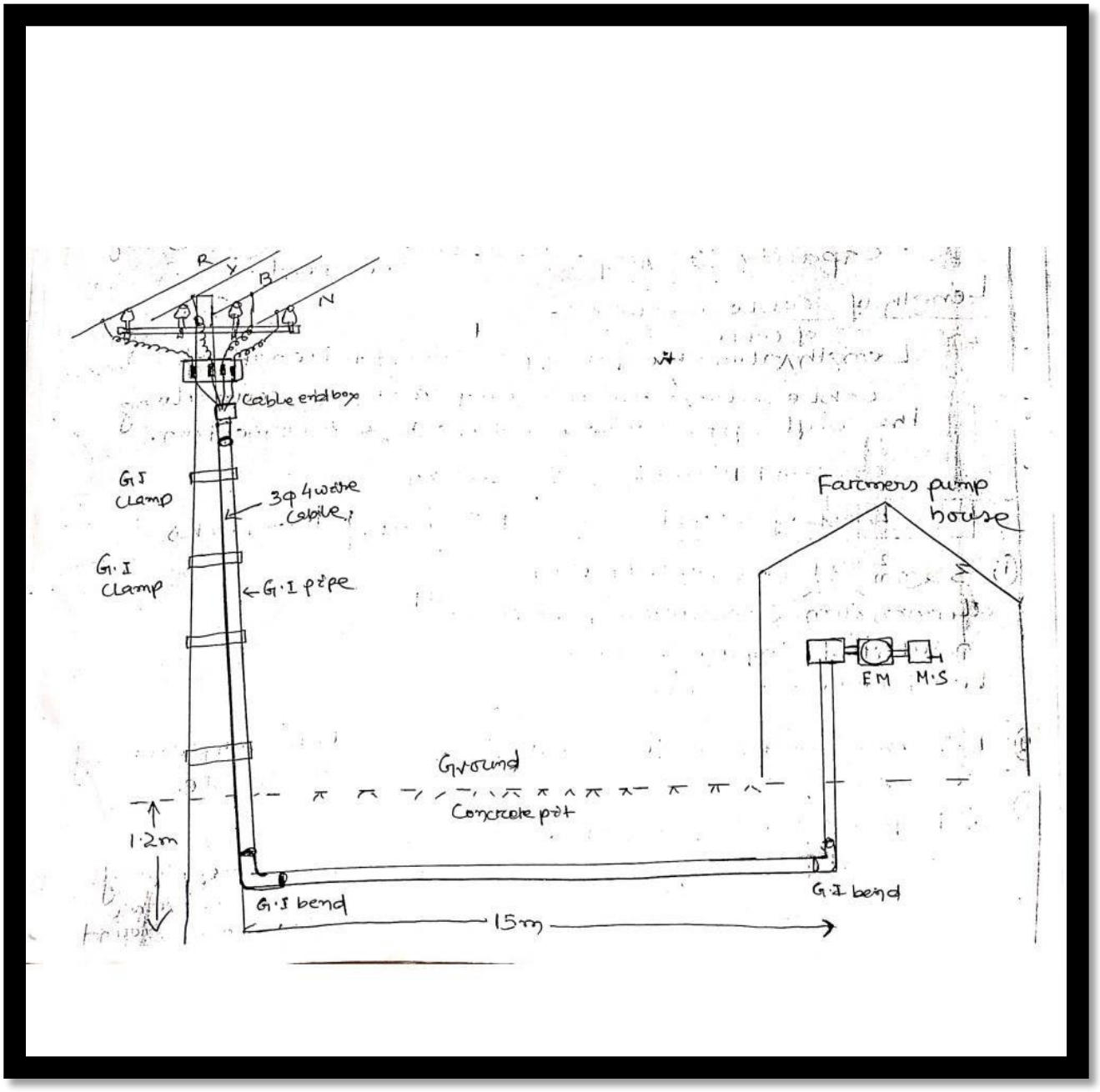
Total current=79x1.5=110A

Service connection is given by underground cable

From conductor chart 35 square mm , 7/5.50, multi core underground cable having current carrying capacity of 128 A is selected.

Length of cable required=Length along the pole up to ground + along with the trench + vertical run along with the wall up to cable end box + wastage & connection.

Length of cable required for service connection =6m+15m+2m+1m=24m


R
Y
B
N
Cable end box
GI clamp
3φ 4 wire cable
G.I clamp
G.I pipe
Farmers pump house
EM
M.S
Ground
Concrete pit
1.2m
G.I bend
15m
G.I bend

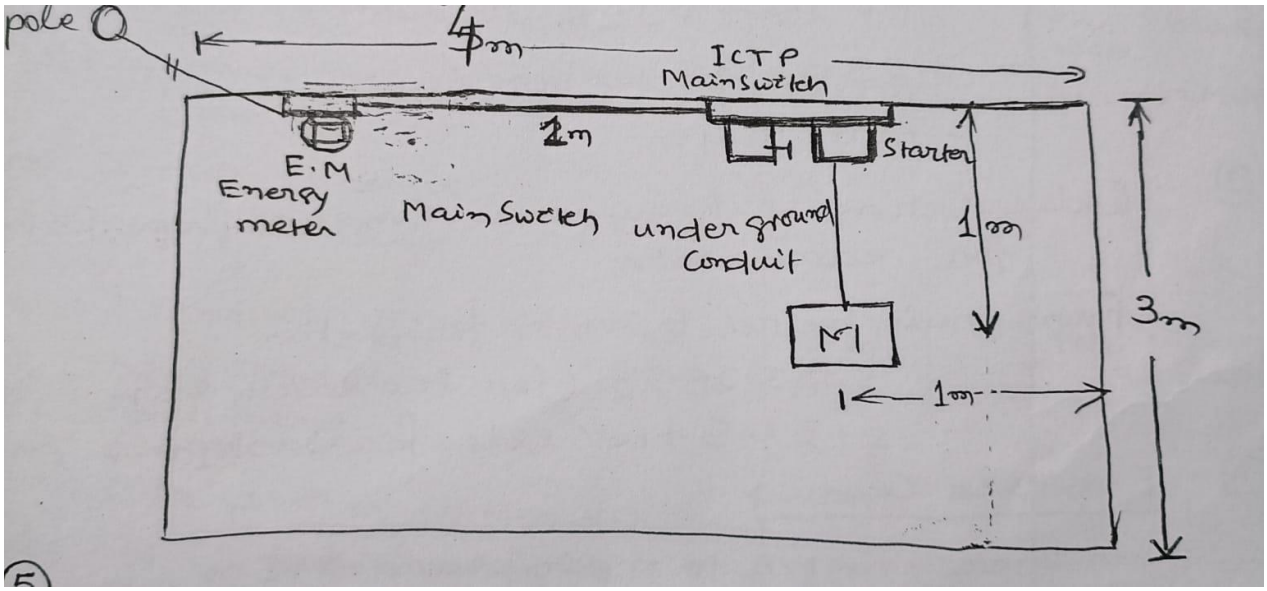
Sl. No	List of materials with specifications	Quantity	Remarks
1	Aluminum conductor paper insulated mass impregnated lead covered cable 35 mm sq,4 core cable	24m	To provide under ground service connection.
2	L.T box suitable for above cable	2 No	For both ends of the cable
3	G.I pipe for above cable with bend pipe	24m	For protection of cable above and under ground.
4	G.I Clamps	3 Sets	For fixing pipes on the pole
5	Cable end box(out)	1 No	At Pole
6	Cable end box (in)	1No	At pump house
7	Fuse unit,150A,250V	3 Set	To be fixed at pole
8	I.C board with nuts and bolts	1 No	To fix the fuse unit
9	I.C board with nuts and bolts	1 No	To fix the energy meter
10	8 SWG Earth wire	20m	To provide Farthing
11	Farthing set	1 No	Plate ear thing
12	Stay set	2 No	For pole
13	Sand	As required	For protection of cable inside trench
14	Cement	As required	
15	Bricks	As required	

Q. It is purposed to install a power connection of 3 phase 5 H.P induction motor for an tube well in a room (5mx3mx3m) .The motor is 1 meter away from two nearer wall. Prepare the estimate in the following order.

1. Draw the installation plan. Showing location of main meter board & motor. Also mark path of wiringby a thick wire.

2. Draw single line diagram showing earth wire.

3. Decide the rating and specification of cable, conduit pipe, earth wire (Use surface conduit wiring)



Ans: 1) Separate connection for each motor

2) Surface metal conduit (Heavy gauge conduit) is used

3) Two earth wire will run side by side for earthing of motor in 15 mm dia G.I pipe.

4)The main switch, motor switch and starter shall be mounted at a height of 1.5 m fromground level.

5)The motor with pump set is installed 0.25 meter above floor on a suitable foundation.

Calculations: Load of motor= 5hp =5x746 watt, Assuming efficiency 75%, Power factor= 0.85
Load current=5x746/1.732x400x0.75x0.85=8.44 A

Considering safety factor=1.5

Hence total load current=8.44x15=12.7 A

So motor switch & main switch (I.C.T.P) of 32 A, 500V Grade is selected.

Selection of cable: From conductor chart single core PVC insulated 660V, 6 square mm, 1/2.80 size, Current Carrying capacity 27 A is selected.

Calculation of length of heavy gauge conduit pipe 25mm dia:

1) From main switch to motor main switch=1m

2) From motor switch & starter to top of motor foundation= 1.5m+ 0.25m (depth of trench) + 1m along

3) The trench+0.25m+0.25m =3.25m+10% extra for wastage= 3.75m

Calculation of length of heavy gauge conduit pipe 15 mm dia for earth wire:

From main board to meter foundation=3.25 m x 2 (for two earth wire) =6.5 m+10% extra forwastage = 7m

Calculation of flexible conduit:

From energy meter to maim board=1.5m

From main switch to starter=0.5m

From starter to conduit mouth=0.25m

From motor foundation to motor terminal box=0.25m

Total flexible conduit=1.5m+0.5m+0.25m+0.25m=2.5 m+ 10% extra=3m

Length of insulated conductor 6 square mm (three conductors for R, Y, B

Phase

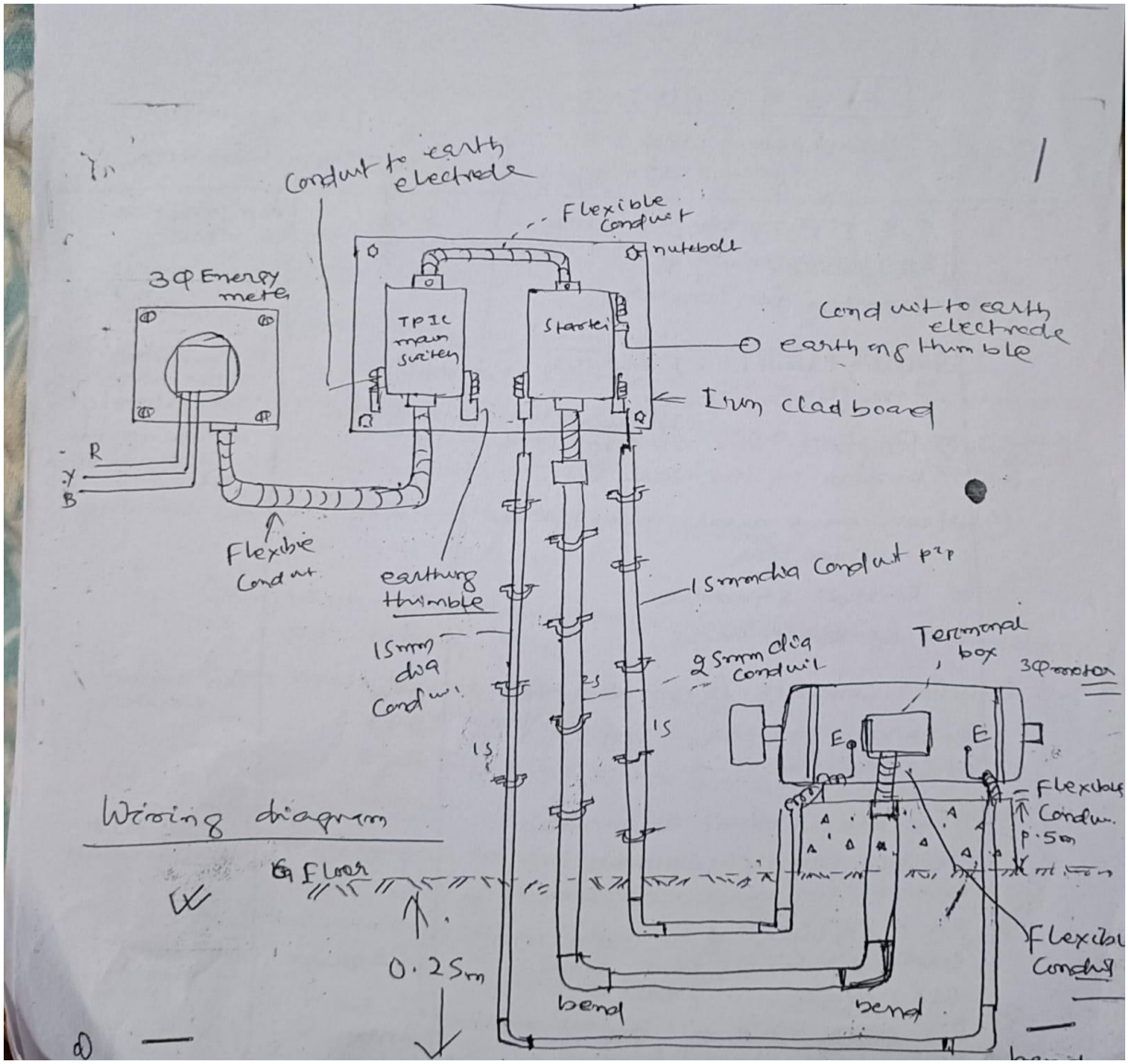
= (length of heavy gauge conduit +length of flexible conduit) x 3

= (4m+3m) x 3=21m+10% extra for wastage=23m

Length of 8 S.W.G earth wire (G.I) = Length of conduit pipe x 2= 4mx2 = 8m +2m extra=10m

SL.no	List of materials with specifications	Quantity	Remarks
1	I.C.T.P main switch,32A,500V	1No	For motor switch
2	Starter for motor	1No	Star/Delta starter
3	I.C Board size(45 cmx30 cm)	1No	For fixing motor switch
	I.C Board size (45 cmx 30 cm)	1 No	For fixing starter
	Rag bolt.	5No	For fixing the board on the wall
4	Heavy gauge metal conduit pipe,25 mm dia	4 m	For wiring
	Conduit shaddle	5 No	For wiring
	Conduit bend	2No	For wiring
5	G.I conduit 15 mm dia for earthing	7m	For wiring
	Conduit shaddle	5 no	For wiring
	Conduit bend	2 No	For wiring
6	Flexible conduit,25 mm dia	3m	To connect metal conduit.
	Flexible conduit coupler to connect heavy gauge metal conduit.	4No	For wiring
7	PVC insulated, aluminum conductor single core	23m	For wiring connection to

	6 mm sq ,660 V grade		motor
8	G.I Earth wire,8 S.W.G	10m	For connection to earthing
9	Danger board	1 No	


Conduit to earth electrode
Flexible Conduit
nutebolt
3φ Energy mete
TPIC main switch
Starter
Conduit to earth electrode
earthing thimble
Iron clad board
R
Y
B
Flexible Conduit
earthing thimble
15mm dia Conduit
Terminal box
3φ motor
E
E
Flexible Conduit
P.S m
Wiring diagram
Floor
0.25m
bend
bend

Q: Prepare the material estimate for 11KV/400V or 250V distribution pole mounted substation across the line with provision of 100 KVA distribution transformer with provision of Air break switch, Horn gap fuse,11 KV Lightening arrestor, L.T circuit breaker with earthing installation?

Ans: Rating of transformer=100 KVA, H.T side voltage=11 KV , L.T side voltage=400V

H.T side calculation of conductor:

Rating of Transformer=100

KVA Transmission

voltage=10000V

HT side current=100000/1.732 x11000=5.25A

So HT side fuse unit (Horn gap fuse) selected is of 10A capacity.

Selection of A.C.S.R conductor:

From conductor chart A.C.S.R conductor size(6/1x1.2.11) having current carrying capacity 97A is selected.

Length of conductor= 10mx3 = 30m

L.T side conductor calculation-

L.T side current=100 x1000 / 1.732x 400=144.33

ASo L.T fuse unit is three phase,150 A .

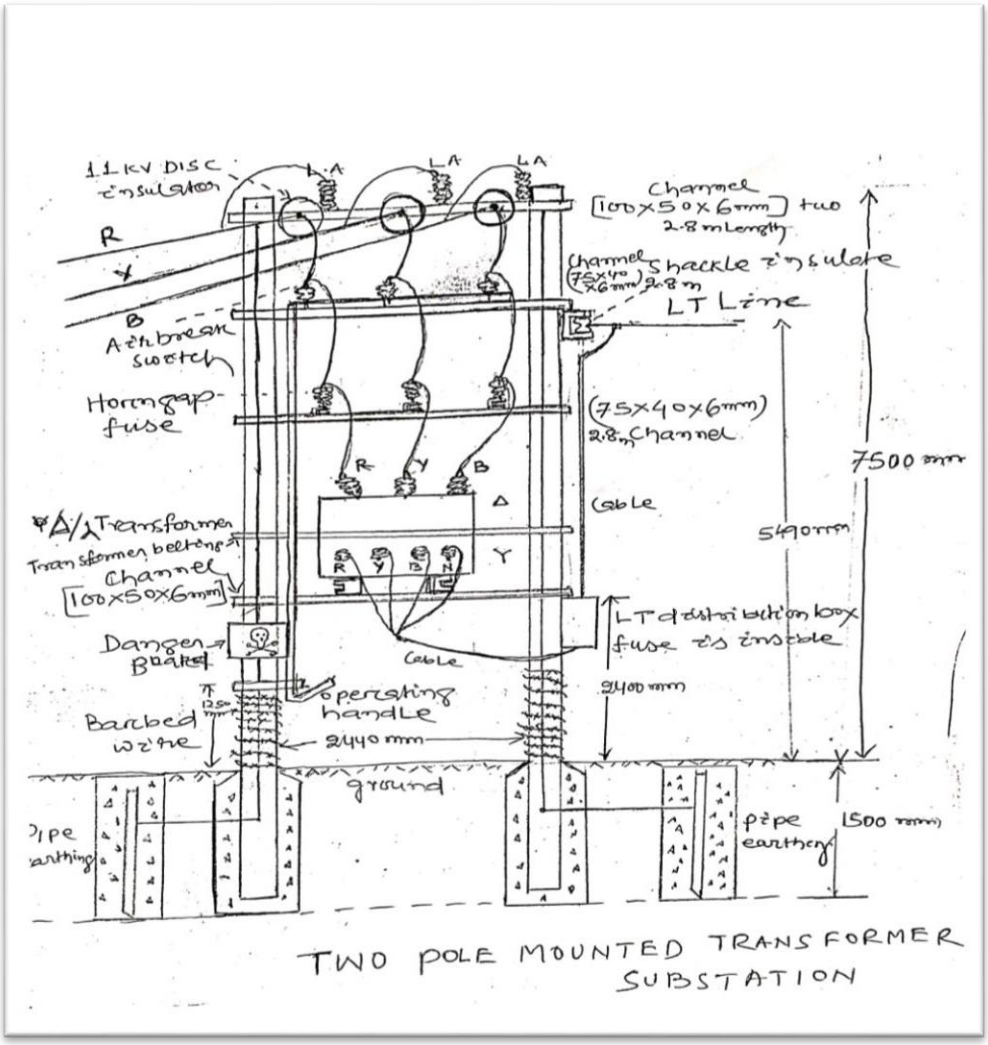
Selection of the cable from conductor chart which is lead in air:

So from conductor chart cable of aluminum conductor paper insulated mass impregnated lead covered 1100V underground cable nominal area 50 square mm ,current carrying capacity 150 A is selected.

Length of the cable required=11m.(from transformer to L.T service line)

	List of materials with specifications	**Quantity**	**Remarks**
1	Three phase core type delta/star step down 11KV/400V,100 KVA Transformer with suitable fittings and other standard accessories.	1	To be fixed on double pole structure
2	ACSR conductor size 50 mm sq ,6/1x2.11 current carrying capacity 97 A	24m	For connection for 11 KV disc insulator to

			Horn gap fuse and Horn gap fuse to input terminal of 100 KVA Transformer.
3	Aluminum conductor paper insulated mass impregnated lead covered 1100V under ground cable.	11m	From transformer output terminal to fuse unit and from fuse unit to 3 phase 4 wire distribution line.
4	R.C.C pole/Steel pole of 9m length.	2 No	For support of Air break switch, Horn gap fuse, Lighting arrester &Transformer.
5	11 KV Disc insulator made from porcelain with nuts and bolts.	3 No	For fixing at the top of the pole.
6	11KV Lightning arrestor with nuts and bolts.	3 sets	To protect the transformer from lighting surge.
7	Air break switch(G.O.A.B) with operatingpipe & handle and lock.	3sets	For making & breaking contact the supply of LT side.
8	400V,150A Fuse unit for LT distribution line.	3 sets	For use in LT distribution box.
9	Top channel for fixing disc insulator(11KV),Lightning arrestor (100mmx50mmx6mm) Length 2.8m	2 set	For support of 11kv disc insulator and Lighting arrestor.
	Channel for support of Trans former (100mmx50mmx6mm) Length 2.8 m	2 set	For support of Transformer
	Channel for fixing Air break switch (75mmx40mmx6mm) Length 2.8 m	2set	For support of G.O.A.B switch
	Channel for Horn gap fuse	2 set	For support of Horn gap fuse
	Channel for belting the Transformer	2 set	For belting Transformer.
10	Earthing set	2 set	For providing proper plate earthing
11	Stay set	4 set	For fixing the pole rigidly.
12	Danger plate with clamps	1 No	To save people from danger of high voltage
13	Stone peg for spreading in the floor	As required	For spreading inside substation
14	Gate with lock and key	As required	
15	Jumper wire	As required	
16	Binding wire	As required	
17	Sand ,Cement,Chips	As required	



TWO POLE MOUNTED TRANSFORMER SUBSTATION

Q-Prepare the material estimate for a 100KVA, 11KV/400V/250V Plinth mounted distribution substation. Draw sketch, Provide G.O.A.B, Circuit breaker, Horn gap fuse, Lightning arrestor with Eathing installation.

Ans: Rating of transformer=100 KVA, H.T side voltage=11KV , L.T Side voltage= 400V

H.T side calculation of conductor:

Rating of Transformer=100 KVA, Transmission voltage=11000V

HT side current=100000/1.732x11000=5.25A

So HT side fuse unit (Horn gap fuse) selected is of 10A capacity.

Selection of A.C.S.R conductor:

From conductor chart A.C.S.R conductor size(6/1x1.2.11) having current carrying capacity 97A is selected.Length of conductor=10mx3=30m

L.T side conductor calculation:

L.T side current=100x1000/1.732x400=144.33 A

So L.T fuse unit is three phase, 150 A .

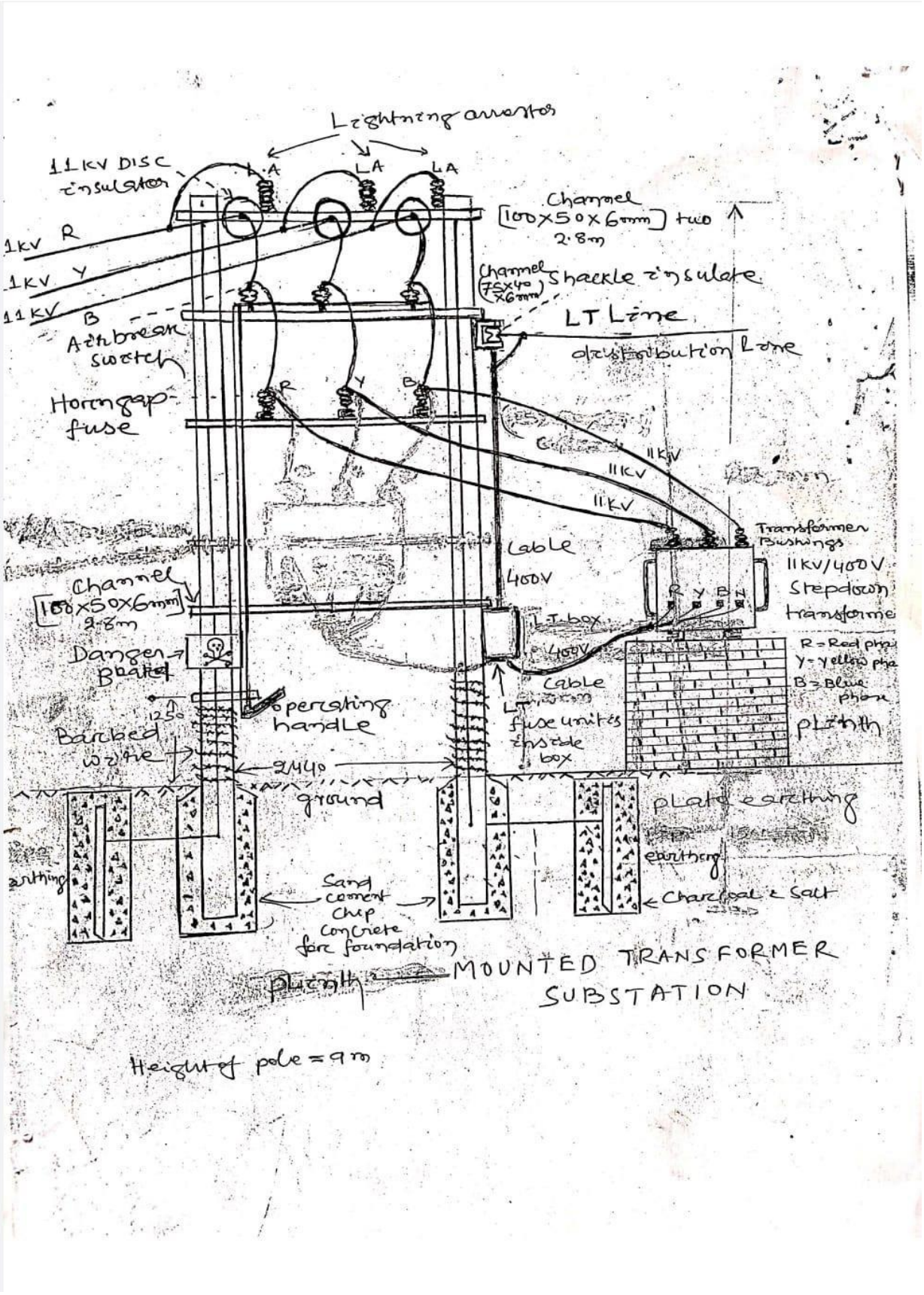
Select the cable from conductor chart which is lead in air.

So from conductor chart cable of aluminium conductor paper insulated mass impregnated lead covered 1100V underground cable nominal area 50 square mm ,current carrying capacity 150 A is selected.

Length of the cable required = 11m. (From transformer to L.T. service line.)

Sl.No	List of materials with specification	Quantity	Remarks
1	Three phase core type delta/star step down 11KV/400V, 100 KVA Transformer with Suitable fittings and other standardaccessories.	1No	To be fixed on double pole structure
2	ACSR conductor size 50 mm sq ,6/1x2.11 current carrying capacity 97 A	24m	For connection for 11KV disc insulator to Horn gap fuse and Horn gap fuse to input terminal of 100KVA Transformer.
3	Aluminum conductor paper insulated mass impregnated lead covered 1100V underground cable.	11m	From transformer output terminal to fuse unit and from fuse unit to 3 phase 4 wire distribution line.
4	R.C.C pole/Steel pole of 9m length.	2 No	For support of Air break switch, Horn gap fuse, Lighting arrester & Transformer.
5	11 KV Disc insulator made from porcelain with nuts and bolts.	3 No	For fixing at the top of the pole.
6	11 KV Lightning arrestor with nuts andbolts.	3 sets	To protect the transformer from lighting surge.
7	Air break switch (G.O.A.B) with operating pipe & handle and lock.	3sets	For making & breaking contact the supply of L.T side.
8	400V,150A Fuse unit for LT distribution line.	3 sets	For use in L.T distribution box.
9	Top channel for fixing disc insulator(11 KV),Lightning arrestor (100mmx50mmx6mm) Length 2.8m	2 set	For support of 11 KV disc insulatorand Lighting arrestor.
	Channel for support of Trans former (100mm x 50mm x 6mm) Length 2.8 m	2 set	For support of Transformer
	Channel for fixing Air break switch (75 mm x 40mm x 6mm) Length 2.8 m	2set	For support of G.O.A.B switch
	Channel for Horn gap fuse	2 set	For support of Horn gap fuse
	Channel for belting the Transformer	2 set	For belting Transformer.
10	Earthing set	2 set	For providing proper plate earthing
11	Stay set	4 set	For fixing the pole rigidly.
12	Danger plate with clamps	1 No	To save people from danger of high voltage
13	Stone peg for spreading in the floor	As required	For spreading inside substation
14	Gate with lock and key	As required	
15	Jumper wire	As required	
16	Binding wire	As required	
17	Sand ,Cement, Chips	As required	

a


Lightning arrestor
11KV DISC insulator
LA
LA
LA
Channel [100×50×6mm] two
2·8m
1KV R
1KV Y
11KV B
Channel (75×40×6mm)
Shackle insulate
LT Line
distribution line
Air break switch
Horngap fuse
R
Y
B
11KV
11KV
11KV
Transformer Bushings
11KV/400V
Stepdown transforme
Cable
400V
Channel [100×50×6mm]
2·8m
J box
R Y B N
R = Red phase
Y = yellow phase
B = Blue phase
Danger Board
400V
Cable
LT fuse units inside box
plinth
1250
operating handle
Barbed wire
2440
ground
plate earthing
earthing
earthing
Charcoal & Salt
Sand cement chip concrete for foundation
plinth
MOUNTED TRANSFORMER SUBSTATION
Height of pole = 9m

SL.NO	List of materials with specifications	Quantity	Remarks
1	A.A.A.Conductor (Rabbit) current carrying capacity 207A (7/3.31)	4250m	Considering three phase & neutral wire
2	R.C.C pole (8m long)	16 No	Including bend point
3	Mild steel channel for cross arm with provision of holes to be fitted with insulator and pole	16 No	Considering bend point
4	Back clamp (mild steel)	16 No	To fix the cross arm
5	Pin insulator,650 V,Glazed porcelain with pins with thread & nut& bolt fix with the pole.	52 No	Excluding bend point, start point and end point.
6	L.T Shackle insulator made from glazed porcelain with strap for U clamp fittings	16 No	For starting point, bend point and end point.
7	Cast iron knob with fittings	16 No	For running earth
8	A.A.A.Conductor of size 1/2.56m	32m	For binding of running conductor with insulator.
9	Jumper wire made from A.A.A.Conductor	10m	At the bend point of one insulator
10	Plate earthing	2 Sets	At both ends of distribution system.
11	Stay set	3 No	One at start point, One at end point, One at bend point.
12	Cement	21 Bags	
13	River sand	As required	
14	Unforeseen items	As required	

Q-Prepare the material estimate for L.T distribution substation for distributing the power of 80kw in a radius of 1km from a pole mounted substation 400v/250v three phase supply at 0.85 p.f. Assume any other items required .Use A.A.A.C conductor for this purpose. System has one bend at 60 degree.

ANS: Total distance of distribution=1 Km=1000 m

In A.A.A.C conductor span length=67m , so Number of poles=1000m/67m + 1= 15+1 =16 No

Foundation calculation:

Total number of poles= 16, Total number of stay=3

Total number of foundation= 16+3=19

Volume of each foundation=0.5x0.5x1.5=0.375

cubic meter. Total volume of 19

foundation=19x0.375=7.125 cubic meter.

Nature of foundation is mixture of Cement: Sand: Chips at a ratio(1:3:6)

So Cement=7.125/10=0.7125cubic m

Sand=0.7125x3=2.1375 cubic meter

Chips=0.7125x6=4.275 cubic meter

1 cubic meter cement=1440kg

Total volume of cement is=1440x0.7125=1026 kg

One bag cement=50kg, Total number of bag of cement =1026/50=21 bags

Sand=0.7125x3=2.137 cubic meter(two tractor)

Chips 0.7125x6= 4.275cubic meter (20 mm grade chips)

Conductor Calculation: Given

Power=80 KW, Voltage=400V,Power

factor=0.85

Current=80000W/1.732x400x0.85=135.84 A

Given safety factor=1.5, So total load current=135.84x1.5=204A

From conductor chart the A.A.A.Conductor (RABBIT)

current carrying capacity 207A, nominal 50 square mm ,span length 67 m is selected.

Total span=15, So total length of A.A.A. Conductor is=67x15=1005 m

Considering three phase(R,Y,B) and Neutral Total length of conductor=1005mx4=4020m+10% (extra for Sag)

SL.NO	List of materials with specifications	Quantity	Remarks
1	Steel pole	95 No	9m long
2	V cross arm made from mild steel angles.	92 No	
3	Cross arm at end point and bend point	4 No	Two at end point and two at bend Point.
4	Mild steel back clamp for cross arm	92 No	
5	11K.V Pin insulator made from glazed porcelain	276 No	Excluding bend points
6	11K.V Strain insulator with clamps	12 No	At both end and bend point
7	A.C.S.R Conductor 6/1x1.2.11,currentcarrying capacity 97A	30500m	Considering sag
8	Jumper wire(A.C.S.R) conductor of size (6/1x2.11) current carrying capacity 97A	6m	
9	Earthing set	2 sets	Plate earthing at both end of distribution system
10	Stay set	2 sets	
11	Cement	As required	
12	Sand	As required	
13	Chips	As required	
14	Other items	As required	

Q. Estimate the materials required for H.T distribution system of length 10Km from a substation in three phase system at 11KV for transmission of power using A.C.S.R conductor .Calculate the size ofconductor required for transmission line, voltage regulation,sag for a load of 150 KVA.There is a bend of angle 55 degree after 6th pole, Consider power factor 0.8.Us A.C.S.R conductor.

Ans: Total distance of Transmission line=10 Km=1000 m

Considering span as 107 m for ACSR conductor from Conductor chart

Number of poles required=10000/107=94+1=95

Foundation calculation:

Total number of poles=95, Total stays required=4

So total number of foundation required=95+4= 99

Considering height of foundation = 1.5m, Breadth of foundation=0.75m, Width of foundation=0.75m

Volume of each foundation =1.5mx0.75mx0.75m = 0.844 cubic meter

So total volume of 99 foundation is = 0.844x99 = 83.566 cubic meter

The concrete mixture to be used at the ratio 1:3:6 (Cement:Sand:Chips)So

total volume of Cement=83.556/10=8.3566 cubic meter

1 cubic m Cement is=1440 Kg,So Weight of 8.3556 cubic meter

cement=1440x8.3566=12032 Kg ,One Bag cement=50Kg,So total Cement=12032/50=241

Quantity of sand=8.3556x3=26 cubic meter.

Quantity of Chips=8.3566x6=50.1336 cubic

meter**Selection & Calculation of conductor:**

Load=150KVA,Voltage=11KV

Current=150x1000/11000x1.732=7.87A

Considering safety factor=1.5,Total load current = 1.5x7.87 = 11.805A

Therefore from conductor chart A.C.S.R conductor current carrying capacity 97A is selected.Total length of conductor for three phase supply(R,Y,B)=(10000 m x 3)+ 10% extra for Sag.

SL.NO	List of materials with specifications	Quantity	Remarks
1	Steel pole	95 No	9m long
2	V cross arm made from mild steel angles.	92 No	
3	Cross arm at end point and bend point	4 No	Two at end point and two at bend point.
4	Mild steel back clamp for cross arm	92 No	
5	11KV Pin insulator made from glazedporcelain	276 No	Excluding bend points
6	11KV Strain insulator with clamps	12 No	At both end and bend point
7	A.C.S.R Conductor 6/1x1.2.11,currentcarrying capacity 97A	30500m	Considering sag
8	Jumper wire(ACSR) conductor of size6/1x2.11 current carrying capacity 97A	6m	
9	Earthing set	2 sets	Plate earthing at both end of distribution system
10	Stay set	2 sets	
11	Cement	As required	
12	Sand	As required	
13	Chips	As required	
14	Other items	As required	

CONDUCTOR CHARTS AND DATA ON ELECTRICAL ESTIMATING

Compiled By:

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Bhubaneswar

Current ratings and voltage drop for vulcanized rubber, PVC or polythene insulated or tough rubber, PVC lead sheathed single core aluminium wires or cables

Size of Conductor		2 Cables d.c. or Single-phase a.c.		3 or 4 cables of balanced 3 - phase		4 Cables d.c.	
Normal area in sq. mm.	Number and diameter of wire in mm.	Current rating in amperes	Approx. length of run for volt-drop in metres	Current rating in amperes	Approx. length of run for 1 volt-drop in metres	Current rating in amperes	Approx. length of run for volt-drop in metres
1.5	1/1.40	10	2.3	9	2.9	9	2.5
2.5	1/1.80	15	2.5	12	3.6	11	3.4
4.0	1/ 2.24	20	2.9	17	3.9	15	4.1
6.0	1/ 2.80	27	3.4	24	4.3	21	4.3
10.0	1/ 3.55	34	4.3	31	5.4	27	5.4
16.0	7/1.70	43	5.4	38	7.0	35	6.8
25.0	7/2.24	59	6.8	54	8.5	48	8.5
35.0	7/2.50	69	7.2	62	9.3	55	9.0
50.0	7/3.0 19/1.80	91	7.9	82	10.1	69	10.0

Current ratings and voltage drop for vulcanized rubber, PVC or polythene insulated or tough rubber, PVC lead sheathed twin,three or four core aluminium wires or cables

Size of Conductor		One twin core cable D.C. or single phase A.C.			One 3 - core or 4 – core cable balanced three phase	
Nominal areas in sq. mm.	Number and diameter of wires in mm.	Current rating in amperes	Approx. length of run for 1 volt-drop		Current rating in amperes	Approx. length of run for volt-drop in metres
			D.C. metres	A.C. metres		
1.5	1/1.40	10	2.3	2.3	7	3.7
2.5	1/1.80	15	2.5	2.5	11	3.9
4.0	1/ 2.24	20	2.9	2.9	14	4.8
6.0	1/ 2.80	27	3.4	3.4	19	5.5
10.0	1/ 3.55	34	4.2	4.2	24	6.8
16.0	7/1.70	43	5.3	5.3	30	8.7
25.0	7/2.24	59	6.6	6.6	42	10.8
35.0	7/2.50	69	7.1	7.1	48	11.7
50.0	7/3.0 19/1.80	91	7.7	7.7	62	13.1
70.0	19/2.24	118	9.0	8.8	82	14.7
95.0	19/2.50	135	9.8	9.5	94	15.7
120.0	37/2.06	162	10.8	10.3	114	16.8

IC

Current Rating as per I.S.S. 692 – 1965 in amperes for aluminium conductor paper insulated mass impregnated lead covered 1100 V underground cable. (2)

Nominal area in sq.mm.	Number and size of wires in mm	Current Rating for cables laid in ground			Current Rating for cable laid in ducts			Current Rating for cable laid in air		
		Single core un-armoured	Twin core	Three and multi - core	Single core un-armoured	Twin core	Three and multi - core	Single core un - armoured	Twin core	Three and multi - core
6	1/ 2.80	50	57	48	42	44	40	56	48	40
10	1/3.55	70	74	62	56	60	51	72	66	56
16	7/1.70	90	96	81	76	80	68	94	88	72
25	7/2.24	115	122	107	98	108	90	124	117	97
35	7/5.50	138	147	128	116	130	105	151	141	119
50	19/1.80	172	180	158	140	159	128	184	177	150
70	19/2.24	208	219	192	170	190	156	227	220	182
95	19/2.50	244	262	224	198	224	184	272	258	224
120	37/2.06	278	302	257	222	254	211	312	298	258
150	37/2.24	316	346	296	249	287	243	358	339	300
185	37/2.50	359	398	336	279	323	278	412	387	348
240	37/3.00	430	485	413	335	397	340	520	492	437
300	61/2.50	466	536	438	358	422	364	570	524	475
400	61/3.00	553	618	513	412	515	425	680	635	545
500	81/2.80	595	--	--	445	--	--	760	--	--
625	91/3.00	670	--	--	490	--	--	895	--	--

Current Rating (full load current in amperes) for d.c. motors allowing allowance for efficiency.

H.P.	Supply Voltage							
	200	220	230	240	400	420	440	460
1	5	5	5	4	3	3	2	2
2	10	9	8	8	5	5	4	4
3	14	13	12	12	7	7	6	6
5	23	21	20	19	12	11	10	9
7.5	33	30	29	28	17	16	15	14
10	44	40	38	36	22	21	20	19
15	64	59	56	54	32	31	29	28
20	85	77	74	71	43	41	38	36
30	125	114	109	105	63	60	57	55
40	165	150	143	137	82	78	75	72
50	206	187	179	172	103	98	93	89
75	308	280	268	257	154	147	139	134
100	408	370	354	340	204	194	185	177
125	506	460	440	422	253	241	230	220

Current Rating, Resistance and Impedance of ACSR Conductor

Trade Name	Nos. of strand and size of each strand in mm	Nos. of strand and size of each strand in inches	Area in sq.mm.	Current carrying capacity		Resistance per km in ohms	Reactance per km in ohms	Impedance per km in ohms
				30°C	50°C			
Squirrel	6/1x2.11	6/1x0.083	20.71	70	97	1.366	0.320	1.400
Weasel	6/1x2.59	6/1x0.102	31.21	100	123	0.9047	0.308	0.955
Ferret	6/1x3.00	6/1x0.118	41.87	125	155	0.6760	0.298	0.738
Rabbit	6/1x3.33	6/1x0.132	52.21	148	183	0.5404	0.291	0.614
Mink	6/1x3.66	6/1x0.144	62.32	167	208	0.4540	0.285	0.536
Beaver	6/1x3.99	6/1x0.157	74.07	189	235	0.3820	0.2795	0.484
Otter	6/1x4.22	6/1x0.166	82.85	207	252	0.3418	0.2752	0.437
Cat	6/1x4.50	6/1x0.177	94.21	229	285	0.3005	0.2725	0.406
Hare	6/1x4.72	6/1x0.186	103.6	254	311	0.2722	0.2695	0.383
Leopard	6/1x5.28	6/1x0.208	129.7	286	367	0.2127	0.2625	0.340

INIC

Solid and Stranded Aluminium Conductor for Insulated Cables

Nominal Area	CIRCULAR CONDUCTOR				CIRCULAR OR SHAPED CONDUCTOR		
	Number and nominal diameter of wires	Overall diameter	Calculated electrical area	Calculated weight	RESISTANCE PER Km at 20°C		
					Standard	Maximum allowable for single core cables	Maximum allowable for twin and multicore cables
mm^2	mm	mm	mm^2	Kg/km	Ohm	Ohm	Ohm
1.5	1/1.40	1.40	1.539	4.161	18.48	19.03	19.41
2.5	1/1.80	1.80	2.545	6.878	11.18	11.52	11.74
4.0	1/ 2.24	2.24	3.941	10.65	7.219	7.436	7.580
4.0	7/0.85	2.55	3.906	10.92	7.284	7.503	7.653
6.0	1/ 2.80	2.80	6.158	16.64	4.620	4.759	4.854
6.0	7/1.06	3.18	6.074	16.98	4.684	4.825	4.922
10	1/3.55	3.55	9.898	26.75	2.874	2.960	3.019
10	7/1.40	4.20	10.59	29.62	2.685	2.767	2.822
16	7/1.70	5.10	15.62	43.68	1.821	1.876	1.914
25	7/2.24	6.72	27.12	75.84	1.049	1.080	1.102
35	7/2.50	7.50	33.78	94.47	0.8422	0.8675	0.8849
50	7/3.00	9.00	48.65	136.0	0.5848	0.6023	0.6143
50	19/1.80	9.00	47.45	133.2	0.5996	0.6176	0.6299
70	19/2.24	11.20	73.48	206.2	0.3872	0.3988	0.4068
95	19/2.50	12.50	91.54	256.9	0.3108	0.3201	0.3265
120	37/2.06	14.42	121.0	339.8	0.2352	0.2423	0.2471
150	37/2.24	15.68	143.0	401.8	0.1989	0.2049	0.2090
185	37/2.50	17.50	178.2	500.5	0.1597	0.1645	0.1678
225	37/2.80	19.60	223.48	627.8	0.1273	0.1311	0.1337
240	37/3.00	21.00	256.5	720.7	0.1109	0.1142	0.1165
300	61/2.50	22.50	293.7	825.3	0.09688	0.09979	0.108
400	61/3.00	27.00	422.9	1189	0.06728	0.06930	0.07069
500	91/2.65	29.15	492.2	1383	0.05780	0.05960	0.06072
500	61/3.25	29.25	496.3	1395	0.05732	0.05904	0.06022

AAAC :

Electrical Characteristics						Mechanical Characteristics			
Sl. No.	Equivalent Code	Nominal Aluminium area	Strandain & Wire Dia	Current Capacity at 75° in Amp.	Mass Weight	Span (in Metre)	Tension Kgf at wind pressure 75 kg per sq.m.	Sag (in Metre)	Remarks
1	Mole	20	7/1.49	76	40	67	211	0.33	1.48 Ω/ km
2	Squirrel	20	7/2.09	116	60	67 – 107	292	0.33	1.37 Ω/ km
3	Weasel	30	7/2.56	150	94	67 – 107	442	0.32	0.913 Ω/ km
4	Rabbit	50	7/3.31	207	149	67 – 125	690	0.33	0.5465 Ω/ km
5	Racoon	80	19/2.46	266	218	125	1040	1.05	0.3663 Ω/ km
6	Dog	100	19/2.79	311	273	125	1278	1.05	0.2768 Ω/ km
7	Wolf	150	37/2.49	409	474	260	2020	3.93	
8	Panther	200	37/2.88	490	637	320	2627	5.69	
9	Kundah	400	37/3.92	717	1102	350	4277	6.69	
10	Zebra	420	61/3.19	757	1281	350 – 380	4928	6.69	
11	Moose	520	61/3.55	862	1574	380 – 400	5549	8.13	
12	Morkulla	560	61/3.68	900	1771	380 – 400	6690	8.13	

XL

0.36

MAXIMUM OVERALL DIAMETER, MINIMUM THICKNESS OF COVERING AND STANDARD RESISTANCE OF SYNTHETIC ENAMELLED COPPER WINDING WIRE

(All dimensions in mm.)

Nom. Dia. of bare conductor	Gauge (SWG)	Maximum overall Dia. for			Standard resistance at 20°C Ohm/KM	Nom. Dia. of bare conductor	Gauge (SWG)	Maximum overall Dia. for			Standard resistance at 20°C Ohm/KM
		Fine covering	Medium covering	Thick covering				Fine covering	Medium covering	Thick covering	
.051	47	.061	.066	—	8506	.417	27	.462	.483	.500	126.5
.061	46	.074	.079	—	5907	.437	—	.485	.505	.526	115.0
.071	45	.084	.092	—	4340	.457	26	.505	.526	.546	105.0
.081	44	.092	.106	—	3323	.483	—	.533	.554	.574	94.25
.091	43	.107	.117	—	2625	.508	25	.559	.579	.599	85.07
.102	42	.119	.130	—	2127	.533	—	.584	.605	.625	77.15
.112	41	.132	.142	.155	1758	.559	24	.610	.632	.653	70.30
.122	40	.142	.155	.168	1477	.584	—	.638	.660	.681	64.31
.132	39	.155	.168	.180	1258	.610	23	.663	.680	.706	59.07
.142	—	.165	.178	.193	1085	.660	—	.716	.739	.759	50.33
.152	38	.175	.188	.203	945.2	.711	22	.770	.797	.815	43.40
.163	—	.188	.200	.216	830.7	.762	—	.820	.843	.866	37.80
.173	37	.200	.213	.229	735.9	.813	21	.874	.897	.919	33.23
.183	—	.211	.226	.241	656.4	.864	—	.925	.947	.970	29.43
.193	36	.221	.236	.254	589.1	.914	20	.980	1.006	1.029	26.26
.203	—	.234	.249	.267	531.6	.965	—	1.031	1.057	1.080	23.56
.213	35	.244	.259	.277	482.2	1.016	19	1.085	1.110	1.135	21.27
.224	—	.254	.272	.290	439.5	1.067	—	1.135	1.161	1.186	19.29
.234	34	.264	.282	.300	402.0	1.118	—	1.186	1.212	1.237	17.58
.244	—	.274	.292	.310	369.2	1.168	—	1.240	1.265	1.290	16.08
.254	33	.287	.305	.323	340.3	1.219	18	1.293	1.318	1.346	14.77
.264	—	.297	.315	.333	314.5	1.271	—	1.344	1.368	1.397	13.61
.274	32	.310	.328	.345	291.7	1.321	—	1.394	1.420	1.448	12.58
.284	—	.320	.338	.356	271.2	1.372	—	1.445	1.473	1.501	11.67
.295	31	.330	.348	.366	252.9	1.422	17	1.501	1.529	1.557	10.85
.305	—	.340	.358	.376	236.3	1.524	—	1.603	1.631	1.659	9.451
.315	30	.353	.371	.389	221.3	1.626	16	1.707	1.735	1.763	8.307
.330	—	.368	.386	.404	201.3	1.727	—	1.811	1.839	1.867	7.358
.345	29	.386	.404	.422	184.0	1.829	15	1.915	1.943	1.971	6.564
.361	—	.401	.419	.437	168.8	1.930	—	2.019	2.047	2.075	5.890
.376	28	.417	.434	.452	155.8	2.032	14	2.123	2.151	2.182	5.317
.396	—	.442	.462	.480	139.8						

Current ratings (amp) of aluminium conductor PVC insulated armoured & served cables as well as heat resisting PVC insulated armoured or unarmoured and PVC Sheathed cables for working voltage upto 1100 volts and Maxm. conductor Temp. 70°/85° c respectively shown in parallel columns.

Conductor area mm²	LAID IN GROUND				IN SINGLE WAY DUCT				IN AIR			
	Single core (3 Nos.)		Twin (Single)		3, 3½ or 4 core (Single)		Single core (3 Nos.)		Twin (Single)		3, 3½ or 4 core (Single)		Single core (3 Nos.)		Twin (Single)		3, 3½ or 4 core (Single)	
1.5	17	20	18	21	16	18	17	20	16	18	14	16	15	18	16	20	13	16
2.5	24	28	25	29	21	24	24	28	21	24	18	21	21	26	21	26	18	22
4	31	36	32	37	28	33	30	35	27	32	23	27	27	33	27	34	23	28
6	39	46	40	47	35	41	37	43	34	40	30	35	35	43	35	43	30	37
10	51	60	55	64	46	54	51	60	45	53	39	46	47	57	47	57	40	49
16	66	77	70	82	60	70	65	76	58	68	50	59	64	77	59	72	51	61
25	86	101	90	105	76	89	84	97	76	89	63	74	84	102	78	95	70	85
35	100	117	110	129	92	108	100	117	92	108	77	90	105	127	99	121	86	105
50	120	140	135	158	110	119	115	135	115	135	95	111	130	159	125	153	105	128
70	140	164	160	187	135	158	135	158	140	164	115	135	155	189	150	183	130	159
95	175	205	190	222	165	193	155	181	170	199	140	164	190	232	185	226	155	189
120	195	228	210	246	185	216	170	199	190	222	155	183	220	268	210	256	180	220
150	220	256	240	280	210	246	190	222	210	246	176	205	250	305	240	292	205	250
185	240	280	275	322	235	275	210	246	240	281	200	234	290	354	275	336	240	293
225	260	304	305	357	260	304	220	258	260	304	220	258	320	390	305	373		
240	270	316																

Chemical Composition of All Aluminium Alloy Conductors

ELEMENT	PERCENTAGE
Silicon	0.5 – 0.9
Magnesium	0.6 – 0.9
Iron	0.50, Max
Copper	0.10, Max
Manganese	0.03, Max
Chromium	0.03, Max
Zinc	0.10, Max
Boron	0.06, Max
Other elements (each)	0.03, Max
Other elements (total)	0.10, Max
Aluminium	Remainder

INFORMATION REGARDING CONDUCTORS USED IN E.H.T. LINES & SUB – STATIONS

Sl.No.	Types of Conductor	No. of Steel/Aluminium Strand & Dia of each strand	Dia of total Conductor	A.A.A.C. Equivalent
1	A.C.S.R. Panther	7 + 30 = 37, 3.0mm each	21mm	21.56mm
2	A.C.S.R. Zebra	7 + 54 = 61, 3.15mm each	28.62mm	29.07mm
3	A.C.S.R. Moose	7 + 54 = 61, 3.30mm each	31.77mm	32.04mm

WIND LOAD IN KG. PER METER RUN OF CONDUCTOR AND SOME OTHER INFORMATIONS

CONDUCTOR	CODE NAME	STRANDING AND WIRE DIA M.M.	NOMINAL ALLUMINIUM AREA MMSQ	ECTIONAL AREA OF ALL.MMSQ.	OVERAL DIA IN MM	WIND REGIONS 50 Kg/M²	75Kg/M²	100 Kg/M²	150Kg/M²	APPROX. MASS KG/KM	APPROX. ULTIMATE STRENGT KG.	RESISTANCE AT 20°C MAX. ohm/KM.	CURRENT RATING WITH 50°C RISE OVER 25°C AMBIENT	CONTINUOS CURRENT RATING	APPROX BREAKING LOAD KN.
AAC	GNAT	7/2.21	25	26.85	6.63	0.221	0.331	0.442	0.663	74	405	1.088	145	115	4.52
	ANT	7/3.1	50	52.83	9.3	0.31	0.465	0.62	0.93	145	832	0.5525	225	180	8.25
ACSR	squirel	6+1/2.11	20	20.98	6.33	0.211	0.331	0.442	0.663	85	771	1.394	97		7.61
	weasel	6+1/2.59	30	31.61	7.77	0.259	0.388	0.518	0.777	128	1136	0.9283	123	92	11.12
	Rabbit	6+1/3.35	50	52.88	10.05	0.335	0.502	0.67	1.005	214	1860	0.5524	183	122	18.25
	Mink	6+1/3.66			10.98	0.366	0.549	0.732	1.098	255	2207	0.4565	203		
	Racoon	6+1/4.09	80	78.83	12.27	0.409	0.613	0.818	1.227	318	2746	0.3712	245		28.91
	Dog	6/4.72+7/1.57	100	105	14.15	0.472	0.757	0.943	1.415	394	3299	0.2732	311	180	32.41
	Leopard	6/5.28+7/1.75			15.81	0.527	0.79	1.054	1,581	493	4137	0.2193	367		
	Coyote	26/2.54+7/1.91			15.89	0.529	0.793	1.059	1.588	521	4638	0.2214	367		
	Tiger	30/2.36+7/2.36			16.52	0.55	0.825	1.1	1.65	604	5758	0.2221	367		
	Wolf		146												
	Panther		200	211.7	21	0.7	1.05	1.4	2.1	974		0.1372		290	89.87
	Zebra			428.7	28.62	0.954	1.431	1.908	2.862	1622		0.673		425	130.32
	Moose			528.5	31.77	1.059	1.588	2.118	3.177	1998		0.054		480	151.2
AAAC	Squirel	7/2.0	20	21.99	6	0.2	0.3	0.4	0.6	60.13		1.541			6.457
Equivalent to	Weasel	7/2.5	30	34.36	7.5	0.25	0.375	0.5	0.75	94		0.93		92	10.105
ACSR	Rabbit	7/3.15	50	54.57	9.45	0.315	0.472	0.63	0.945	149.2		0.521		136	15.044
	Racoon	7/3.81	80	79.83	11.43	0.381	0.572	0.762	1.143	218.25		0.425			23.472
	Dog	7/4.25	100	99.81	12.78	0.425	0.639	0.852	1.278	272.85		0.333		200	29.344
		19/2.46		90.31								0.3663			25.27
		19/2.80		119.5								0.2578			33.39
	Panther				21.56	0.718	1.077	1.437	2.155	759		0.1204		315	77.04
	Zebra				29.07	0.969	1.453	1.938	2.907	1379		0.0665		440	115.83
	Moose				32.04	1.068	1.602	2.136	3.204	1676		0.0547		490	150.77