

General principles

* Estimating: Estimating is an art by which we can get an approximation of the material, investment involved, and the time taken for the completion of electrification project we are planning to do.

By estimating the material cost and the time required for the completion of the project, we can get help in making the right and firm decision while a contract with any firm.

* Purpose of Estimating and Costing:

The estimating and costing have following objectives.

- 1.) to ensure that the list of material is completed before starting the job, so that there are very sleek chances of shortage of any necessary material after starting the work.
- 2.) To ensure that money is not misused in the projects under implementation.
- 3.) The time is saved i.e. the work is completed well in time as planned.

The following problems can appear in the way of the work started without estimating and costing.

1). It becomes very difficult to purchase necessary material in the absence of the list of material due to which the work is not continued uninterruptedly.

2). The money is misused by purchasing smaller or excess quantities of material from market and the shortage of money can cause the stoppage of work in midway.

3). Due to the above mentioned hurdles, the work can take more time for completion and it can affect the other project which is related to existing project in hand.

* Catalogues:

For an upto date estimating and costing, an estimator should always have quotation and a bunch of price lists provided by wholesale dealers and manufactures of the specific materials. The quotation and price list along with specifications of materials are called as Catalogue.

We can get the complete details of all the products of a manufacturing firm from the catalogue. An intelligent and experienced estimator can do the job by using the catalogue for prices and other relevant information.

The estimator can further save time, if the information regarding the net price of each item after deducting commission and adding the local taxes etc. available in the catalogue. This information in the form of a catalogue should be available with every estimator.

* Essential elements of estimating and costing

- 1) Specification of materials
- 2) Latest market cost of material
- 3) Price list and net prices.
- 4) Calculation of material and labour cost
- 5) Knowledge of purchase system.
- 6) Labour cost.

1) Specification of Cost of Material:

The specification and the ^{necessary} cost of a material should be known at the time of preparing report on estimating. It will be very difficult to purchase the material from market without the knowledge of specifications.

For example, it is very difficult to buy 'holder' out of different holders to be installed in an electrical installation, because there are many holders such as pendent, angle, batten holder available in the market.

2. Latest Market Cost and Material:-

The market cost of material is that cost of the material at which it can be purchased or brought to the store at any time. For the purchase of material, market surveying is important.

Without market survey, purchase will add cost of electrical installation along with addition of time in completion of the project.

After market survey, quotations are invited for the enlisted necessary materials from related shops. The costs given in quotations of different shops are compared and the material is purchased at the lowest rates offered by suppliers.

3. Price List and net prices:

By market survey, the estimator gets the price list of the materials from the shopkeepers in which the shopkeeper give the retail and wholesale prices according to

Excise duty: Tax implemented on the amount of total business done.

local market. This list is updated according to market rate from time to time. Hence, at the time of estimating and costing, the price list available at that time of the market should be taken into consideration.

Net price of an item includes taxes such as Sale tax, Central Sale tax, excise duty and other local taxes included. Normally, above taxes are not included in price list.

* Recording of estimates:

Recording of estimates is the important task for the estimator. This recording of estimate is called 'project report' which should be bound and preserved in the form of a booklet by the estimator.

With the help of recording of estimates in the book form, actual cost of the complete job can be more easily compared with the estimated costs, - an essential operation.

Moreover, much labour is saved in preparing new estimates for a similar job, which is only possible in case the estimates are kept together in a book form.

④x Determination of Required quantity of material.

While determining the quantity of material for any building it is essential to prepare the plan of building, marking electrical points, switch board and main boards (energy meter and main switch board) on the plan through approved electrical symbols. The control route starting from main switch board to each switchboard and from switchboard to electrical points on the plan. This plan becomes the basis of the estimate. A wiring diagram is separately prepared showing connections to each point.

(i) The material on main board is then calculated such as selection of main switch, board for the main switch, wire required for wiring the main board, apart from selection of distribution board.

(ii) The conduit or batten required is calculated on the basis of installation plan.

(iii) The wire for wiring the building is then calculated sub-circuit wise on the basis of installation plan.

(iv) Lastly, the total length of wire required is calculated.

(v) The necessity of calculations for finding out quantity of other materials such as switches, socket out-lets, switchboards, lamp holders etc does not arise. Such materials can be found out directly from installation plan.

⊗ Determination of Labour Cost:

Determination of labour charges for wiring a particular building is very difficult. It is due to the reason that labour charges are different at the different places. For example, in cities, a trained electrician charges greater than that of trained electrician in rural areas.

The labour charges are decided as -

- (a) As per work duration and work amount.
- (b) As per unit work basis.
- (c) As per percentage of material cost.

(a) Work duration and work amount:-

If the wiring work is to be completed on the basis of work duration and work amount, then the skilled workers are employed on daily wages. The decision to employ number of persons depends upon the number of electrical points to be wired, assuming wiring of main board equivalent to four points and fitting of any switchboard equivalent to two electrical points.

The number of electricians, wireman and other person needed for the job can be determined on the basis of number of points to be wired and number of days the job is likely to be completed. The labour rates are decided on the basis of prevailing labour rates in the city or suburban area.

The number of days one wireman and one assistant will take to complete the work can be calculated as.

$$= \frac{\text{No. of Points to be Wired}}{\text{No. of Points they are likely to wire in one day}}$$

S.N	Class of labour	No. of days	Rates per day		Total Payment		Remarks
			Rs	Paise	Rs	Paise	
1.							
2.							
3.							

(b) On Unit work basis :-

This is very simple and prevalent system to determine labour charges for a work. In this system, the total number of points in the building are counted which includes installation of main board and switch boards. The labour rate per unit is paid to an approved contractor in the case of government buildings and to an individual trained wireman in the case of private building.

S.N	Description of unit work (Conduit/Botton system of wires)	No. of Points	Rates per point (Rs)	Total Paymed (Rs)	Remarks
1.	Main board installation	4	20.00	80.00	
2.	15 Switch board @ 2 points for each switch board	30	20.00	600.00	
3.	Installation of bell Push button and laying underground wiring upto main gate @ 6 points per bell	6	20	120.00	
4.	Total points light/ Fan sockets	46	20	920.00	

(c). As Per Percentage of Material Cost:

In this system, a fixed percentage of the total material cost is counted towards labour payment. This percentage may be 15%, 20% or 25% depending on type of wiring.

The payment of labour is calculated from the table given below:

S.N	Description of Material	Rate			Amount
		Cost (say)	% of total material	Cost	
1.	total cost of wiring material	6115.00	15%	Rs. 917.25	317.25

⊗ Contingencies:

This is for vague and unforeseen items. The amount is provided under the head of contingencies to cover the unforeseen expenditure, such as to cover extra costs on account of delays in delivery, minor accidents and unforeseen variations from the plans of estimating department. The amount to be allowed is too variable and depends upon the exactness of the specifications. The looser the specifications, the more doubtful the conditions in which it will be carried out and greater the risk of delays and difficulties and measures such as overtime, the greater

obviously must be the allowance to cover them. It is usually expressed as a percentage of total cost (material + labour cost) say, 5%.

⊗ Overhead charges

The overhead charges cover all the expenditure necessary to carry out the business in addition to the special expenditure incurred in carrying out a particular job. These can be classified as rent of office and workshop, allowances for wear and tear of buildings, plant and machinery, general expenses, rates and taxes, lighting and heating, advertising, insurance, postage and telephone, carriage and travelling costs etc. Since these charges can not be charged against any one contract, a definite percentage (10 to 15%) is added to the net cost of each estimate party (Supplier Company or manufacturer or Contractor)

"Tender is defined as an offer made from a party to make supply or undertake some work at its quoted rates on some specified companies".

* Tender:

An offer in terms of rates made by the supplier or manufacturer on a prescribed form enclosed in a sealed enveloped in reply to a tender notice for supply of material on the basis of some terms and conditions is called tender. Some money is deposited along with the tender, which is called earnest money. The earnest money is a guarantee by the tenderer that the party is bound to supply the material if its tender is found to be competitive but on predetermined conditions only.

Tender notice

The information to be made available for certain heavy purchases through the newspapers is called 'Tender notice'.

The tender notice is given for large scale purchases or for purchase of costly equipment such as installation of power wiring in a large industry, for installation of sub-station, for purchases of heavy duty generators etc. The tender notice contains information of material to be purchased i.e. complete specifications, its approximate cost, quantity, last date for receipt of sealed tenders,

Cost of tender form and earnest money to be deposited along with the tender. The supplier can quote rates only on tender form prescribed by the department.

* Guide-lines for inviting tenders:

1. The tenders are invited on a tender form prescribed by the purchase department. Once the tender notice is published in news-papers, the changes or amendments if any also get published in the same news-papers.
2. The sealed tenders are invited publicly through news-papers.
3. The tender notice should have following information mentioned clearly.
 - a) on what dates and timings the work site or further details of purchases can be seen and examined by the supplier or contractor. The offices where tender forms or relevant information is available. The amount of earnest money.
 - b) The date, time and place where tenders are to be opened.

- c) The amount of money + security deposits and mode of deposit i.e. through bank draft, cheque etc.
- d) The officer authorised to accept, reject or open the tender.
- 4) For heavy purchases, the contractors or Suppliers should be given at least one month time from the date of issue of tender notifications to file their tenders.
- 5) All tenders for the concerned work should be opened in the presence of Contractors or their representatives by the officer: officially authorised by the department on the date and time as mentioned in newspaper notification.
- 6) The earnest money to the Contractors or Suppliers should be returned at the earliest, probably on the same day after disposal of the tender.
- 7) Normally, tender offering lowest rates is accepted but the Contract can be rejected if full earnest money is not deposited

with the tender. If the Contractor offering lower rates has complaints of poor performance in the past contracts (it should be officially on record) his tender can be rejected.

* Specimen tender: Terms and Conditions ~~for~~ of the contract for electrical works are:

1.) Only those Contractors, whose names are on the approved list of the electrical inspector to the government of "A" State, may tender and not more than one tender should be submitted by one firm.

2. back

2.) Tenderers are expected to be fully conversant with the general and special conditions of contract. (they must see site of work, schedule materials. fluctuation of rates in the market)

3.) The department is not responsible for arranging any materials whatsoever and the Contractor will have to complete the work within the specified time with specified material and accessories.

4.) Conditional tenders and tenders not accompanied with proper earnest money are liable to be rejected.

5.) Contractors will not be paid for sales or any other extra.

⑥ Tenders must be submitted on the prescribed forms duly signed by the tenderers on every page.

⑦ All entries by tenderers should be in one ink only.

8.) Rate should be given for each item of work.

9.) The Superintendent engineer reserves right to reject all tenders or accept any tender without assigning any reason to the tender.

10.) The tenderer whose tender is accepted must sign Contract bond.

⑪ The sealed tenders will be accepted unsealed tenders will ^{not} be accepted.

Unit: 3

Design Consideration of Electrical Installation in building.

3.1 Electrical Supply System:

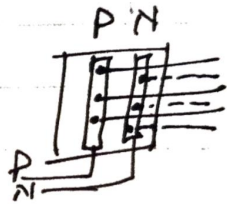
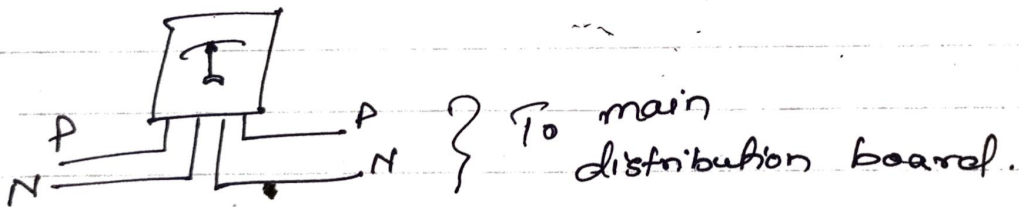
Electrical supply system feed power to the load connected.

Two kinds of supply system is discussed below:

(i) Single phase Two wire (1- ϕ ~ 2 wire).

In this supply system ~~at~~ two wires are connected to the main distribution board via energy meters. One is the Phase wire and another is Neutral wire.

This type of supply is commonly provided for residential buildings.



(ii) Three phase 4 wire System.

This supply system consists of 4 wire in which there are 3 phase wire and 1 neutral wire.

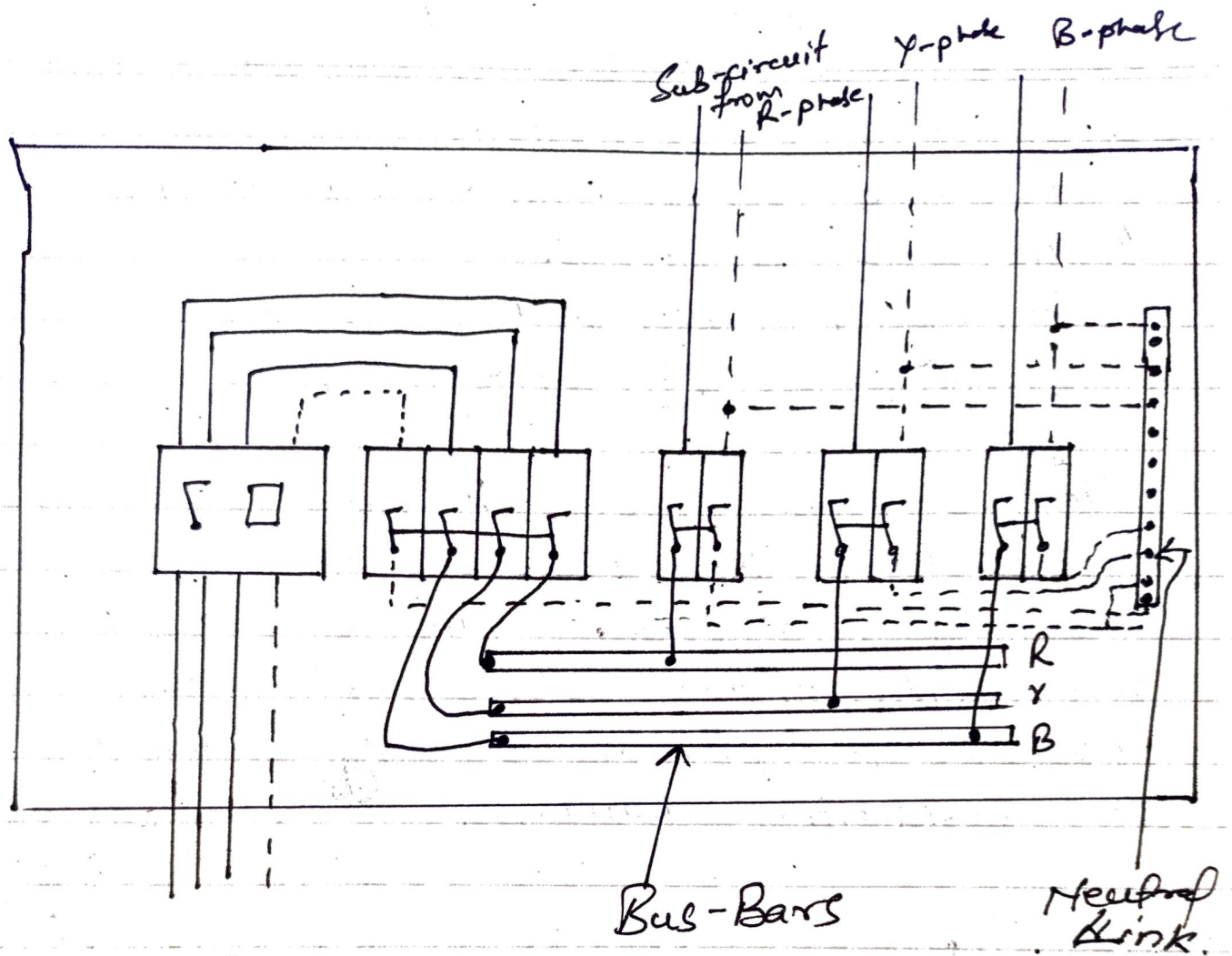


Fig: Main distribution Board with Energy Meter.

(*) Protection against overload:

The wire sizes of different parts of an electrical installation are selected according to certain expected load. If the load exceeds this value, the system will draw excess current, the value of which will depend on extent of overload.

Overload on an electric installation could be caused either by switching on heating loads or lights of higher power ratings or by switching on a larger number of heating loads or lights than what the wiring is designed for. When installation is supplying power to motors overloads could occur due to mechanical overloading of motors or due to mechanical faults in the motors causing large friction at the bearing or due to jamming of the motors. So, overload causes excessive I^2R loss in the installation which results in heating. Therefore, it is necessary to protect the electrical installation against overload. The overload protection relays can be used for protection of motors against overloads.

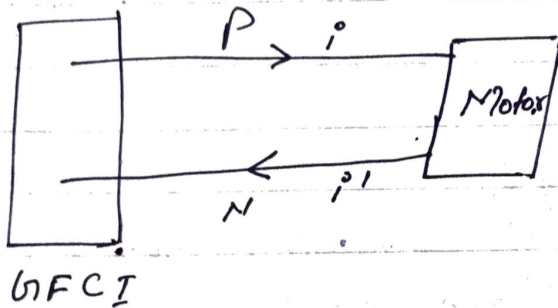
* Protection against Short Circuit:

When two phase wires or one phase wire and the neutral wire make direct contact due to insulation breakdown, an exceedingly large current will flow in the circuit. This condition is called short ckt. To prevent damage to the wires of the circuit and to prevent outbreak of fire, fuses & MCB are provided. Fuses, besides providing protection against overload also provides against short circuit currents by blowing up in the shortest possible time as soon as short circuit occurs.

* Protection against earth fault:

When one of the phase wires makes contact with earth or any conducting material which is earthed, a short circuit exists between the wire and the earth, leading to the same consequences as in a short circuit. Since exceedingly large current may flow due to earth fault, fuses are provided to interrupt this current just as in short circuit.

GFCI (Ground fault circuit interrupter) is also used for protection against earth fault. or RCCB (Residual Current Circuit breaker) or ELCB (Earth leakage circuit breaker)



$i \approx i'$
GFCI compares i & i'

* Earthing:

Earthing is the process of connecting the neutral point of a supply system or the non-current carrying part of a conductor apparatus, such as metallic frame to the ground, is called earthing.

Types of Earthing:

① System Earthing:

The process of connecting neutral part of the power system to the ground, is called as system earthing.

Advantages:

i) It provides greater safety to person and equipment.

- 2
- (ii) The overvoltages due to lightening are discharged to earth.
- (iii) Voltage of healthy phases do not exceed line to ground voltages i.e. they remain nearly constant.
- 10) It provides improved service reliability.

② Equipment earthing:

The process of connecting non-current carrying frame of the equipment to ground, is called as equipment earthing.

Advantages:

- ① It protects the equipment from high current due to insulation failure.
- ② It protects person from electric shock when he/she touches the equipment with insulation failure.

③ Methods of Earthing:

- 1) Rod earthing: In this system of earthing, 12.5mm diameter solid rods of Cu or solid rods of galvanised steel (16mm) or hollow section of 25mm. GI pipe of length not less than 2.5 meters are driven vertically into earth.

Perforated:
hole cut through
②

This system of earthing is suitable for areas which are sandy in character. It is cheap as no excavation work is necessary.

② Pipe earthing:

In this method of earthing, a galvanised steel and perforated pipe of approved length and diameter is placed upright in a permanently wet soil.

This is most common and best system of earthing as compared to other system available for the same earth condition & moisture conditions.

③ Plate Earthing:

In this type of earthing, plate of Cu having dimension $60\text{cm} \times 60\text{cm} \times 3\text{mm}$ or galvanised iron $60\text{cm} \times 60\text{cm} \times 6\text{mm}$ is buried into the ground with its face vertical to a depth not less than 3m from ground level.

This type of earthing is commonly used in substations.

Pto fig

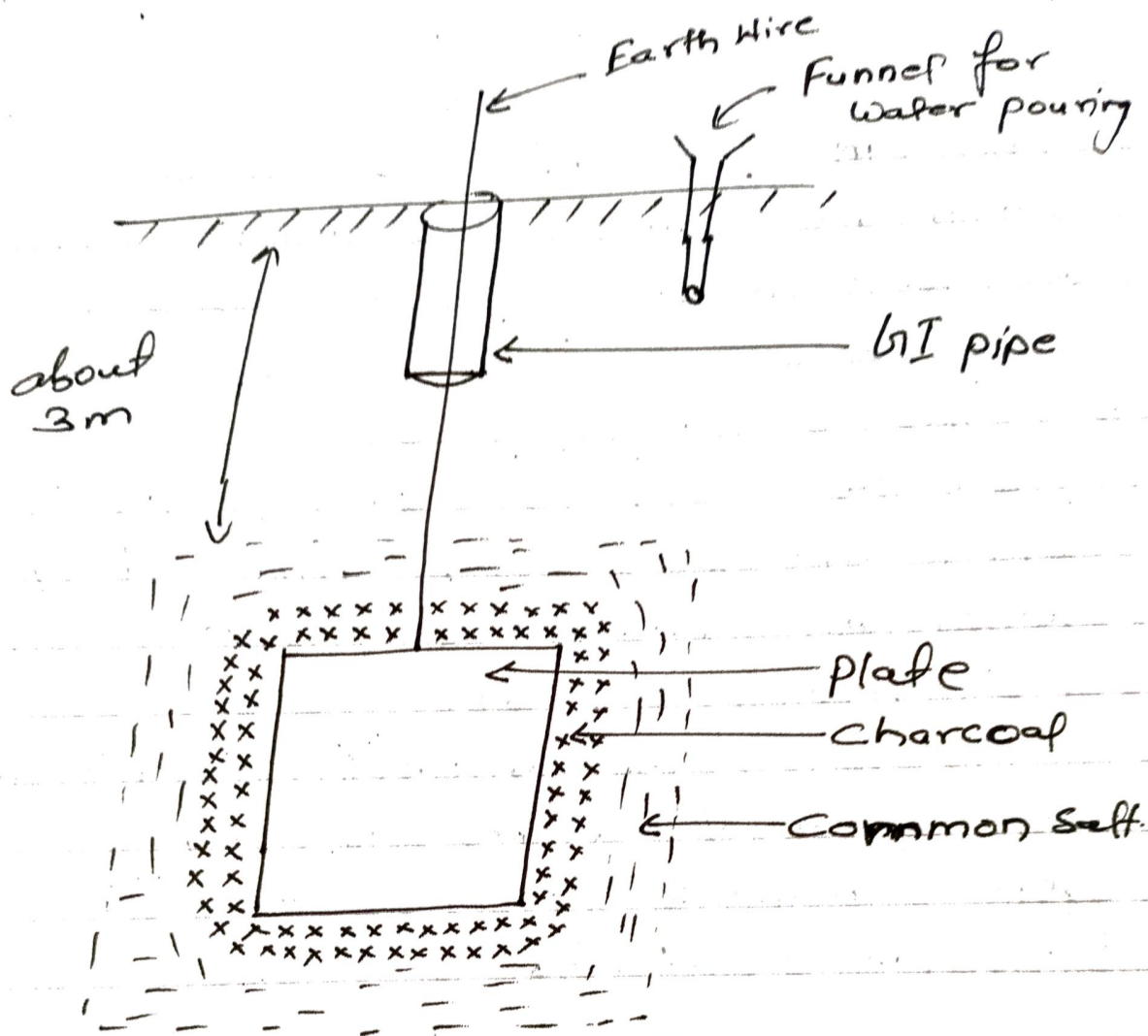


Fig: Plate Earthing

3.4) General rules of Electrical Installation/wiring:

- 1) Every installation is to be properly protected using fuse, MCB, earthing etc.
- 2) The conductor used is to be of such a size that it may carry load current safely.
- 3) Fuse or Switch should be always provided on phase wire only.
- 4) The circuit should be designed with a provision for 20% increase in load due to future modifications.
- 5) In any building light and fan wiring and power wiring are to be kept separate.
- 6) All the outer conductors should be properly insulated.
- 7) All sockets, outlets or switch boards should be placed at proper places with proper ratings.
- 8) Generally, lamps are hung at a height of 2.5 m and fan 2.75 m.
- 9) Every circuit or apparatus should be provided with separate switches.
- 10) Adequate illumination should be provided all over the working plane.

3.6 Design of Sub-Circuits:

Sub-Circuits are divided into two parts:

(a) Light and Fan Sub-Circuit:

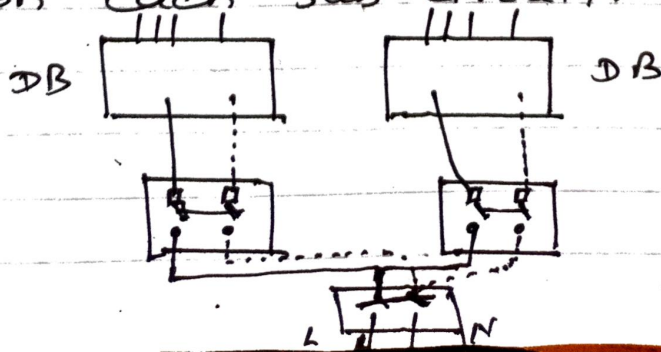
(b) Power Sub-Circuit

(a) Light and Fan Sub-Circuit:

Lights and Fans may be wired on a common circuit. Each sub-circuit should have not more than a total of 10 points of lights, fans and SA socket outlets. This is because when the number of load points is large, the voltage available at the farthest end will be low due to voltage drop in the line. It is advisable to provide two lighting sub-circuits in each house so that in case of fault in one sub-circuit the whole house is not plunged into darkness.

(b) Power Sub-Circuit:

The load on each power sub-circuit should normally be restricted to 3 kW. There should not be more than two outlets on each sub-circuit.

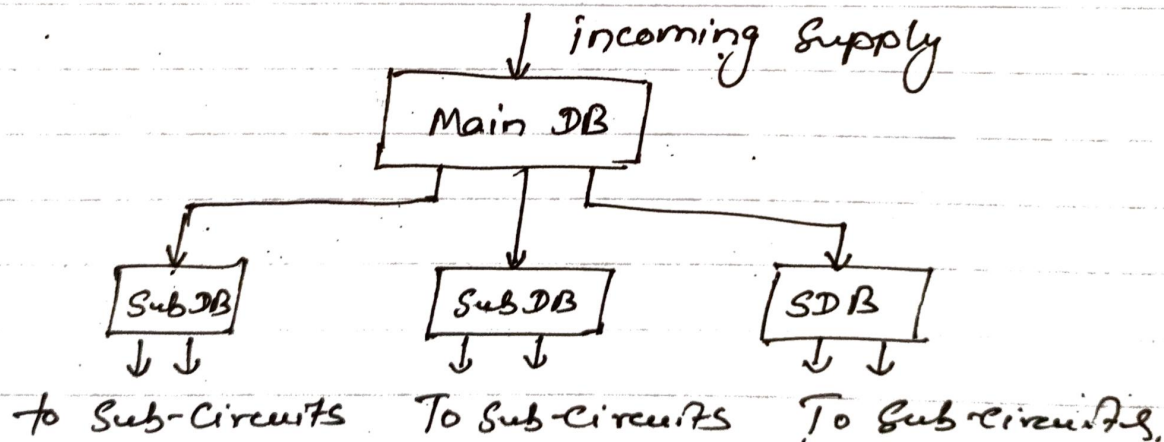


3.5

(*) Design of Main board (MDB) & Sub-distribution Board (SDB)

The main board, where the supply enters the energy meter and then ~~then~~ the main switch, should be near the entrance of the building.

The distribution board from where the supply is taken to the different sub-circuits, should be located adjacent to the main switch board. In case of large buildings, supply is taken from the main distribution board to sub-distribution boards. The SDB are located near the centre of loads.



* Location of Outlets:

The location and number of light points and other outlets are determined from the size of building and utility. To a great extent, it is also a matter of personal preference. A minimum of four outlets per average ^{size} room should be provided. Light points may be provided on walls or ceilings or both but should be such that it should provide uniform illumination and cause minimum glare. Fan points should be provided @ one fan per 16m^2 area. Other outlets such as sockets should be provided upto requirements.

* Location of Control Switches:

Control switches for lights and fans should be located near the entrance of rooms. For large room, hall, corridors having more than one entrance, provisions should be made for controlling the light points from more than one point with the help of two way switches. The controlling switches for other outlets should preferably be near the outlets.

* Load assessment :

for determination of load of an installation the following rating may be assumed unless the values are known or specified.

- (i) Fluorescent Lamp - 40 W
- (ii) Incandescent light point - 60 W
- (iii) Ceiling fans - 60 W
- (iv) Light Socket (5A socket) - 100 W
- (v) Power Socket (15A) - 1000 W

Determination of Size of Conductor:

There are 3 points taken into consideration while determining the size of conductor which are as:

(i) Minimum Size of Conductor:

For ordinary light and fan sub-circuits the size of cable used is generally $1/1.40 \text{ mm}$ (1.5 mm^2) in aluminium or $1/1.12 \text{ mm}$ (0.96 mm^2) in copper wire unless the length of any sub-circuits is exceptionally large.

(ii) Current carrying capacity:

The wire or cable should be of size sufficient to carry the maximum current continuously without overheating. The size of cable can be determined corresponding

to maximum current of the circuit from the table of cables current rating.

(iii) Voltage drop
Maximum voltage drop from supply terminals to any point on the installation should not exceed the prescribed limit eg. 2% of the supply voltage plus 1 volt for light load wiring and 5% of declared supply voltage for power load wiring.

Q) Determine the size of cable used for a light sub-circuit. The supply voltage may be taken as 240 V AC.

⇒ Maximum Load of a light sub-circuit
= 800 W

Let, $P.F. = 1$

∴ Current in the sub-circuit

$$= \frac{800}{240}$$
$$= 3.33 \text{ A}$$

So, from table

Al	Cu	Conductor	of size	1/1.12 mm
"	"	"	"	1/1.40 mm

Carrying capacity
5 A
10 A

Q) Determine the size of conductor for two core cable required to carry maximum current of 60 A. It is given that length of cable is 60 m and supply voltage is 240 V.

⇒ Here,

Lead & Return.



total ampere-turns = 60×120

$$= 7,200 \text{ A-m}$$

Permissible Voltage drop

$$= 2\% \times 240 + 1$$

$$= \frac{2}{100} \times 240 + 1$$

$$= 5.8 \text{ V}$$

Ampere meters per Volt of permissible

$$\text{drop} = \frac{7,200}{5.8} = 1,240$$

$$\left[\frac{\text{Tot. A-m}}{\text{Permissible V. drop}} \right]$$

From table, Cable Size = 19/1.32 mm

Since the Cable of size 19/1.32 mm

Selected is 74 A, then,

Voltage drop caused by Cable

$$\frac{7,200}{1,475}$$

$$= 4.88 \text{ V}$$

which is less than
permissible voltage drop.

Q1. Determine the size of cable required to carry the maximum current of 50 amperes. It is given that length of cable is 500 meters and allowable voltage drop is 5% of declared supply voltage. Declared voltage is (i) 400 Volts a.c.
(ii) 400 Volts d.c.

Solⁿ: Maximum current to be carried, $I_{\max} = 50 \text{ A}$
length of cable, $l = 500 \text{ metres}$
Total ampere-metres in the circuit = 500×50
 $= 25,000 \text{ ampere-metres}$
Declared voltage, $V = 400 \text{ Volts}$.
The permissible voltage drop, $V = 400 \times \frac{5}{100}$
 $= 20 \text{ Volts}$.

Ampere-metres per volt of permissible
voltage drop = $\frac{\text{Total ampere-metres in the circuit}}{\text{permissible voltage drop}}$
 $= \frac{25,000}{20} = 1,250$

∴ When supply voltage is d.c., Copper conductor cable of 19/1.32 mm (from table) of current carrying capacity of 53 amperes and causing 1 volt drop per 1475 ampere-metres will be most suitable.

Voltage drop with the cable of size 19/1.32 mm

$$= \frac{25,000}{1,475} = 17.0 \text{ volts, less than}$$

permissible voltage
drop of 20 volts.

(ii) - When supply voltage is ac copper conductor cable of 19/1.32 mm (from table) of current carrying capacity of 59 amperes and causing 1 volt drop per 1,327 ($0.9 \times 1,475$) ampere-metres (taking into account inductance & capacitance of the cable) will be most suitable.

Voltage drop with the cable size 19/1.32 mm

$$= \frac{25,000}{1,327} = 18.0 \text{ volts less than permissible voltage drop}$$

* Introduction :

The power is supplied to the various consumers, both domestic and industrial from the secondary substations by means of distribution lines.

Generally, Distribution of power is carried out by 3-phase 4-wire system over poles or towers. The primary distribution voltage may be 11 kV, 66 kV or 3.3 kV depending on the requirements of consumers and for secondary distribution usable voltage is 415/240 V. The power may be transmitted on overhead distribution lines or Underground distribution cables according to requirement. Underground system is suitable for thickly populated areas or where O/H distribution is not possible. Underground distribution costs higher than O/H distribution system.

* Supports for O/H distribution lines:

The function of supports or poles is to support the insulator cross arms and conductors. The different types of poles used for erecting overhead lines are described below while the supports should have the

following properties:

- (i) High mechanical strength to withstand the weight of conductors and wind loads.
- (ii) Light in weight.
- (iii) Cheaper in cost.
- (iv) Low maintenance cost.
- (v) Longer life.

The different types of poles are:

① Wooden poles:

These supports are cheapest, easily available, provide insulating property and therefore are extensively used for distribution purposes in rural areas. The wooden poles are generally made of seasoned wood, sal and painted with creosote oil at the bottom which prevents it from rotting. Such poles are generally used up to 22 kV and for short spans about 60m.

Average life : 25 to 30 years.

2) Steel poles:

Steel poles possess greater mechanical strength & permit use of longer spans (50-80)m but cost is higher. Their life is longer than that of wooden poles. Its average life

is 40 years. It is used for voltage upto 33 kV. require regular painting.

3) RCC poles: (Reinforced Cement concrete)
It is used for distribution line upto 33 kV. These poles give good appearance, require no maintenance, good insulating properties, longer life and can be used for longer spans 80-200 m.

4) Lattice steel towers:

Steel towers are used for voltages beyond 33 kV. Steel towers are mechanically stronger and have longer life. Span for steel towers is 300 m or above. The height of the tower depend on the line voltage and length of span.

* Distribution Lines Materials Used:

The main materials used for HT (11 kV) and LT (415 V) distribution lines are listed as follows:

- (i) Poles and their fittings (cross-arms)
- (ii) Conductors
- (iii) Earth wire
- (iv) Insulators
- (v) Danger Sign boards
- (vi) Guarding wires
- (vii) Stays (bays)

* Conductors:

The conductor is one of the important materials in a transmission and distribution system of electric power. The cost of conductor materials accounts for a major part of the total cost. The conductor materials may be made of Cu, Al, Steel-Cored Al, galvanised steel, Cadmium Cu etc. Generally used conductor material is ACSR (steel reinforced aluminium conductor) are made up of galvanised steel core surrounded by stranded aluminium wires. Due to higher strength of ACSR, the span length can be increased. Hence, ACSR conductors are widely used in transmission & distribution of electrical energy.

* Earth Wires:

All metal supports of overhead lines and metallic fittings should be permanently and efficiently earthed. Earthing can be done in two ways -

- (i) A continuous earth wire is run over the supports and then connected to earth at four points in every 1.6 km.
- (ii) In second method, every pole is earthed and the earth wire is run along the pole to the ground.

* Insulators:

In order to prevent short circuit between the different phase conductors of the line and also to prevent leakage of currents to earth through cross-arms on poles and towers. Insulators are provided between conductors and supporting structures.

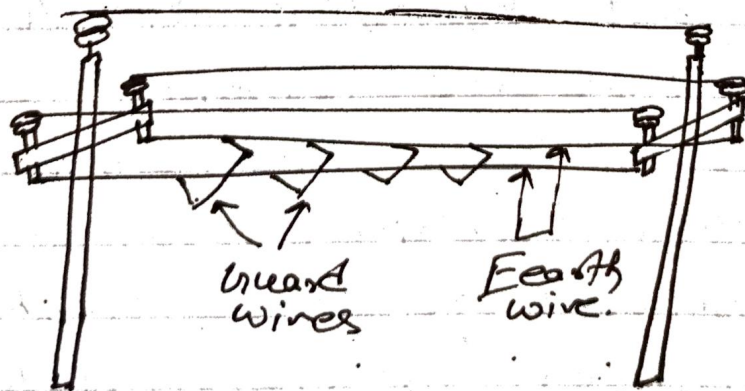
Pin insulators are commonly used for 11 kV distribution lines. These can be used up to 33 kV. Disk insulators are used as suspension insulators for lines of 66 kV and above. At dead end or sharp bendings, disk insulators are used.

* Guy (Stays):

In case of an HT line using poles, a terminal pole experiences a pull on one side only and tends to tilt the pole in a direction of line. To prevent this a stay or guy is provided.

* Guarding Wires:

A guarding is provided for safety of life, installation & communication circuits. The guarding for 11KV lines is provided at road crossings, canal crossing, railway crossings, crossing over LT lines etc. For LT lines, the guarding is provided throughout. When guard wires are provided, if a line conductor breaks, it becomes earthed before falling on the earth.



Selection of Size of Underground Cable:

for selection of cable of correct size and type for particular application, the factors to be considered are as follows:

1) System Voltage:

The type of operating system such as dc (2-wire or 3-wire) or ac (1-phase, 3-phase), earthed or unearthed and operating voltage such as 415/240 V, 11 kV, 33 kV, 66 kV, 132 kV etc.

2) Current Carrying Capacity:

The different types of cables are selected according to the current carrying capacity which can be obtained from table of cable selection.

3) Permissible Voltage drop:

The selection of the cable size should be such that the voltage variation in the cable should be within permissible limits i.e. $\pm 5\%$ of the declared voltage.

4) Short - Circuit rating:

If a phase to phase or phase to earth short-circuit occurs, a very high short circuit current flows. The cable should be selected that it can withstand the stresses and the resulting increase in temperature caused by the maximum short-circuit current produced by the phase to phase short circuit up to a period of one second.

5) Economic Considerations:

While selecting the size of cable, a detailed study is made of three or four approximate sizes which are satisfactory in respect of current carrying capacity and permissible voltage drop.

* Testing of Electrical Installation:

Before any installation may be connected to the supply, a number of tests have to be carried out to ensure that ~~they~~ there are no defects which may cause danger. The following tests should be conducted.

(i) Testing of Insulation Resistance

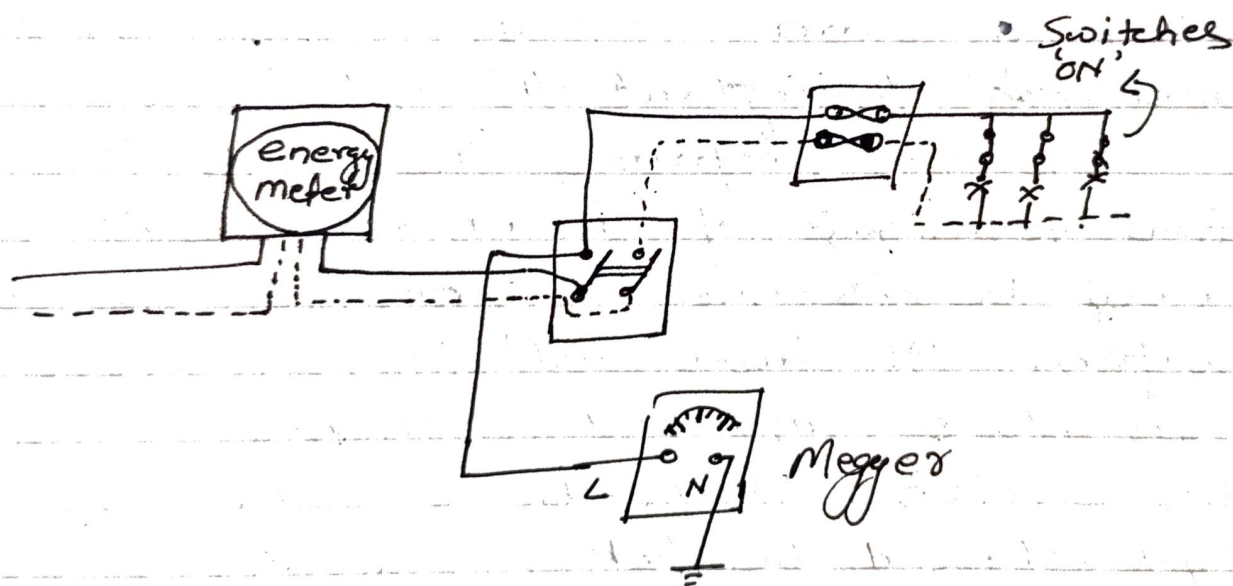
For the purpose of safety, it is necessary to ensure that there is no significant leakage of current through the insulation ~~installation~~ throughout the installation.

Before performing the test, the output terminals of the energy meter should be disconnected from the main-switch. All fuses and links should be in place and all switches excluding main switch shall be closed. All lamps should be taken out and lamp holders are short circuited.

Now, the line terminal of the Meggar is connected to the point where the conductors have been shorted at the main switch and E terminal is connected to the earth. Now, the insulation resistance is measured between wiring and earth.

Now, the insulation resistance is measured between wiring and earth. The measured insulation resistance should not be less than $50 \text{ M}\Omega$ divided by the number of outlets. If $\frac{50 \text{ M}\Omega}{\text{no. of outlets}}$ is

more than unity, one mega-ohm is taken as max^m working value but the insulation resistance in no case should be less than $0.5 \text{ M}\Omega$.



(ii) Testing of insulation resistance between the Conductors:

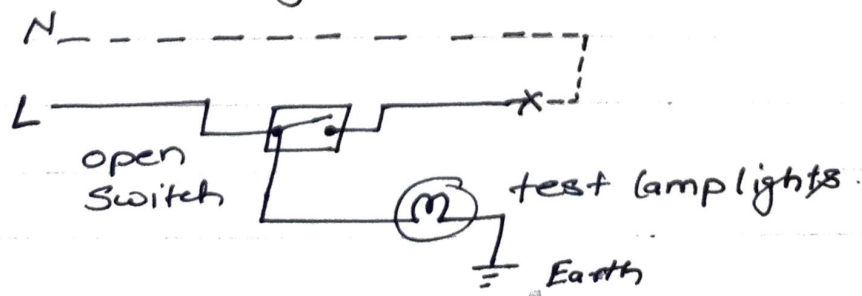
For this test, circuit diagram is same as above except that the **L** of meter is no longer connected to both the conductors and **E** is to Earth. Now, **L** and **E** of meter

~~The~~ are connected respectively to the two conductors between which the insulation resistance is to be found. Further, it is essential for this test that all the lamps from the holders and all the appliances from the outlets should be removed. The insulation resistance thus measured should not be less than $\frac{50 \text{ M}\Omega}{\text{No. of outlets}}$.

iii) Testing of Polarity of Single pole switches:

It is necessary that single pole switches are placed in phases only for safety. So, this test is performed.

A convenient method is to test with a small neon tube tester. While performing test, its one terminal is held in the hand and the other against the feed terminal of switch. If the switch is correctly connected, the neon lamp will glow, otherwise not glow.



④ Testing of earth Continuity Path:

For Safety of all, the metal pieces (of equipment) or metal coverings of switches etc. must be solidly grounded to earth.

To test earth continuity, the earth continuity conductor including metal conduits and metallic envelopes of cables in all cases shall be tested for electric continuity and electrical resistance of the same along with the earthing lead but including any added resistance or earth leakage circuit-breaker measured from the connection with the earth electrode to any point in the earth continuity conductor in the completed installation shall not exceed one ohm.

* Underground Distribution:

Electric power can also be transmitted by underground power cables instead of overhead power lines. Underground cables take less right-of-way than O/H lines, have lower visibility, and are less affected by bad weather. However, costs of insulated cable and excavation are much higher than overhead construction. Faults in underground system take longer to locate and repair.

Introduction / Substations

Substations serve as sources of energy supply for the local areas of distribution in which these are located. Their main functions are to receive energy transmitted at high voltage from the generating stations, reduce the voltage to a value appropriate for local distribution and provide facilities for switching.

At substations safety devices are installed to disconnect equipment or circuit in the event of fault.

Voltage on the outgoing distribution feeders can be regulated at a substation.

On the Design Basis Substation are classified as :

1) Indoor ^{type} Substation (floor mounted)

2) Outdoor Substation

(i) Pole Mounted

(ii) Foundation Mounted

* Pole-Mounted Outdoor Substation:

Such substations are erected for mounting distribution transformers of capacity upto 250 kVA. Such sub-stations are cheapest, simple and smallest of substations.

All the equipment is of outdoor type & mounted on the supporting structures of HT distribution line. Triple Pole Mechanically Operated (TPMO) switch is used for switching "ON" & "OFF" of HT transmission line. HT fuse unit is installed for protection of HT side. To control LT side iron clad

low tension switch of suitable capacity with fuses is installed. Lightning arresters are installed over the HT line to protect the transformer from the surges. Substation is earthed at two or more places.

Generally transformers of capacity upto 125 kVA are mounted on double pole structure & for transformers of capacity above 125 kVA & ^{upto} below 250 kVA 4-pole structure with suitable platform is used.

Maintenance cost of such substation is low and by using a large number of such substations in town it is possible to say

the distributors, at a lower cost.

④ Indoor Substation Floor Mounted.

The apparatus is installed within the ^{substation} building. Such substations are usually for a voltage upto 11 kV. But even erected for 33,000 V and 66,000 V when the surrounding atmosphere is contaminated with impurities such as metal corroding gases and fumes, conductive dust etc.

Imp

Q. List the estimate of requirements for a pole mounted Substation for 200 kVA transformer.