Electrical Estimation & Costing - 15EE553

Module - 1 : Principles of Estimation

Introduction to Estimation and Costing

Estimating is an art of assessment of quantities of different items and cost thereof to plan the amount required for executing a work before actually carrying out the work.

The estimate is prepared to help in taking a right and definite decision while entering into a contract with any firm but does not in itself setup tender or Contract. The functions of an estimator are so interconnected in various parts of estimating programme that it is difficult to outline them. In general, however, this can be listed under four headings

1) Estimation of quantities of the material required and the cost involved
2) Analysis of costs
3) Maintaining proper records
4) Providing selling aids.

Purpose of Estimating and Costing

As per good management practices, we must know the material required with complete specifications and quantity of each item and the cost to be incurred thereon before taking up any new programme in hand.

For this, it becomes necessary to prepare a complete project for the given programme as it will act as a guide in the successful implementation of the programme. The project report includes complete details of the work to be carried out such as detailed drawings of the work complete details of the required materials with costing & the sequence of operations to be performed.

Estimating is also essential as it provides us an accurate assessment of the amount of money required, availability of material etc. In case any programme is taken in hand and started without preparing project report and without estimating and costing, it will be difficult to complete the work uninterruptedly because of shortage of money and/or non-availability of materials may cause interruption in the work.

Before accepting or offering tender or to decide the terms of contracts, it is necessary that, estimate must be prepared revealing to an approximate cost of the job. Every organization should have seperate department of estimating The person preparing the estimate is known as an estimator. If guess work is made to workout the cost of the job, there is a possibility either of quoting too high prices resulting in no order or of quoting too low prices resulting in heavy losses instead of profit.

The estimator must build himself a library containing catalogues and price lists of all the products of his own organisation and of those items or goods, which are likely to be associated with his work. He should pay continual attention to keep prices and other related information up-to-date.

Electrical Schedule:

An electrical schedule is that list or plan of building which provides us the information regarding the number of points (Ceiling outlets, bracket outlets, single pole 3 way and 4 way rotary switches, wall plugs and other special plugs) in each room of a building under estimation.

Catalogues:

Catalogue is nothing but a price list of particular material with its varieties. For the pricing of the estimate up-to-date catalogues, quotations from manufacturers and wholesale dealers for the special material must be available with the estimator. The estimator saves time by making judicious selection of standard catalogues, which are most useful for his work.

Further saving in time and trouble can be achieved if the estimator prepares his own price lists consisting of net figures (printed price in Std. catalogues less discount allowable) or by preparing special

price lists giving the net price per each article or per ten or per 100 or per metre according to his own requirements. By doing so he can save himself from repeated labour of translating the available list of prices into practical figures.

Apart from printed catalogues and special price lists the estimator should prepare special schedules such as schedule of the cost of conduit per metre run, complete with conduit accessories. Such schedules are prepared from the manufacturers net cost of each type and size of conduit with a percentage added to cover unavoidable waste, average cost of accessories and materials. By preparing such a schedule the estimator can save the time which he would have spent in taking the quantities separately and pricing the various accessories.

Similarly other schedules such as schedules giving the cost of the cable per metre run or giving the cost per metre run of mains and submains and the cable runs for power points can be obtained.

Market Survey and Source Selection

Good estimating is possible only with an update knowledge of

i) availability of products
ii) Sources for production, vendor selection
iii) New products and their quality
iv) Prices of products, discounts etc

A market survey for collection of the above information and retention of the same in a library helps in easier estimation and decision making for selection of materials and Vendors. The surveys carry greater importance to ensure timely availability of materials essential for completion of projects within stipulated time requirements. Non-receipt of materials in time may result in production/job hold-ups and receipt of materials ahead of time would be a burden on the cash flow of the organization/company and add to inventory carrying costs.

It is a healthy engineering practice to conduct a market survey of the availability of products and also to obtain necessary approvals of approved supplies/vendors to avoid poor quality of products being used at any stage. For early reference the estimator should preferably

i) retain a list of approved supplies/vendors both in alphabetical order and also product wise and
ii) retain a list of approved standard products

In addition to the market survey of materials sources advantage/assistance can be taken of the similar surveys

being conducted by the State or Central PWDs or MES standard Schedules of Rates / Specifications.

In order to make a survey easily accessible categorisation / classification of products can be made in a format as given below.

Format for Categorisation of Products

Sl No.	Product	Specifications	Acceptable Makes	Acceptable Vendors	Rem
1	Tumbler Switches	5A, 240V, 1way			
2	Piano switches	— do —			
3	Copper Conductor Cable	1 mm^2, single core PVC insulated 650V grade			
4	Aluminium Conductor	1.5 mm^2 single core PVC insulated 650V grade			
5	Main switch	TCDP 240V, single phase, 16A			

Recording of Estimates

All estimates must be written in a book, kept for this sole purpose. It is preferable to write estimates on loose sheets in order to file them with the contract papers. With the help of estimates prepared on loose sheets and collected in the book form, actual costs of the complete job can be more easily compared with the estimated costs. In case of writing estimates in a book other than loose leaf one, it should be indexed. The most convenient ruling for estimate book is shown below. First column is for serial no. the second for description of material with specifications, third for quantities, fourth for rates, fifth for amount and last for useful marginal notes.

*

Sl no.	Description for material with complete specifications	Quantity Required		Rate			Amount		Remarks
		Quantity	Unit	₹	p	Per	₹	p	

Determination of Required Quantity of Material

The determination of quantity of casing - capping, batten or conduit and wire for house wiring is very tedious job. The first step is to decide the layout to be adopted, because this will affect the measurements.

It may not be usual to measure all the lighting circuit runs for these an average value can be allowed of 6 to 7.5 metres of casing - capping, batten or conduit, as the case may be and 18 metres of cable per point. This will be found to be very good average for domestic layouts. The cables and conduits to fuse boards and main switches should be allowed for separately.

The conduits (casing-capping or batten) and cables for heating circuits are separate runs and should be actually measured because they differ much more in length. Some runs may contain two pairs of cable and for this allowance should be made. A steel tape can be run over the floor to measure the lengths of casing - capping, batten or conduit runs, and vertical rising and falling runs can also be measured. These cannot be shown on the plan.

It is usual to allow a certain amount in excess of the run to allow for wastage. Wiring for heating circuits will consist of a separate circuit for each socket and there will be two conductors, so that the floor measurements will be doubled. The boxes will be easy to count and a few additional drawing boxes may be allowed for in the longer runs.

Small accessories costing only a fraction of rupee are not counted separately, but are allowed in bulk by adding a few rupees.

The above has accounted for all conduit, boxes (casing - capping or batten) and cables and the figures should be totalled with an allowance for the labour to form the rough estimate.

Now prepare a list of switches, switch boxes, pendants, sockets and other items. The list may be prepared exactly as all these items will be mentioned in the schedule. The only variable items are flexible cords, but an allowance of 0·6m per pendant is sufficiently accurate. A small amount is added to cover the cost of screws, rawl plugs and other minor requirements.

Labour Conditions

The most difficult item to estimate is labour and there are several factors in the construction of building which affect it. This is where experience is required and the helpful use of data collected from other jobs.

If the building is being wired during the constructional or carcass stage, then the rough work will proceed twice as fast owing to the freedom of movement, there being no floor boards to hinder the work and very few awkward corners that are not accessible. To ensure economy of time, the chases should be marked out and the builder's supervisor advised well in time so that cutting does not hold up the work progress.

It should be realized, however, that carcass work will have its own difficulties. There is a long break after the rough work has been finished and the job is usually

left for some period before the time comes for drawing in the cables. This is not done until all Constructional work and plastering is finished and the job swept out and in a dry condition. Wiring up is usually done just prior or just after the priming coat of the paint goes on. Then there will be another break until all decoration work is finished.

The fitting up of the switches and pendants is nearly the last part to be completed, so that they may not be spoiled with paint or distemper. The wiring of a completed house takes longer time than a carcass job.

Determination of cost of material and Labour

Best way to determine the cost of material required for wiring is to prepare a table with the columns as discussed in *recording of estimates. Then rates for all items from standard catalogues, the total cost item wise and finally the totalling. To determine the labour cost one of the following methods must be adopted.

1) Determine the total number of points taking two points for main board and one point for each sub-circuit in addition to the total number of points to be installed. Then findout the total labour cost charging @ ₹65, ₹105, ₹75 & ₹125 per point for cleat casing-capping, batten & Conduit wiring respectively.
2) Determine the labour required and then estimate the total labour cost with the help of Labour wages as applicable
3) Provide the labour charges as 15%, 20% or 25% of material cost.

After totalling the material cost and labour cost provide some percentage of the above cost under the heading of Contingencies & arrive at the final cost of the wiring work.

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 the estimating department. The amount to be allowed is too variable and depends upon the exactness of the specifications. It is usually expressed as a percentage of total cost (material + Labour cost), say 5%.

The contingencies fully compensate additional material cost, Labour cost and other allied expenses which could not be accounted for. Such expenses may be due to natural calamities such as floods, earthquakes, storms, etc.

Overhead charges:

The overhead charges or standing charges of the business cover all expenditure necessary to carryout the business, in addition to the special expenditure, incurred in carrying out a particular job. These can be classified as

- Rent of offices and workshop
- allowances for the wear & tear of buildings, Plant & machinery (depreciation)
- Wages of clerical staff
- General expenses, - rates & taxes - Lighting & heating,
- advertising - insurance - postage and telephone
- carriage and general travelling expenses, legal cost & bad debts etc.

Since these charges cannot be charged against any one contract, these are spread proportionately against all the jobs. To arrive at the true cost of the job, a definite percentage (10 to 15%) is added to the net cost of each estimate

Profit

This is usually added in the form of percentage to the gross or true cost of the job in order to determine the selling price of the job. This amount is purely on the discretion of the contractor, and his decision is usually governed by the following factors

i) Size of the job with him
ii) Degree of competition
iii) The state of turnover &
iv) His anxiety to secure a particular job

If estimate has been prepared accurately definite percentage has been allowed for contingencies and standing charges then, however, small the percentage of profit is added, it will be a profit and never loss.

Purchase System

Purchase system may be divided into three major heads viz objective, functions and setup (or organisation)

* Purchase Objective

The purchase procedure enlists the following objectives

1) To purchase competitively and wisely authorised requirements as per desired specifications from approved/reliable sources at available reasonable prices within the time schedule to support the project plans.
2) To ensure that fair & oper purchase practices are followed and a healthy and good relationship develops with suppliers/vendors to foster the commercial interests of the firm/organization in the local, national & international market, if need be.

3) To ensure timely formulation and commitment of purchase budget requirements
4) To serve as information centre on materials knowledge prices, sources of supply detailed technical specifications, Catalogues etc for all departments of the organisation
5) To serve as internal ensure that investment made on inventory is at an optimum level.
6) Training of purchase personnel in the latest techniques of Materials Management.
7) To keep Management/Concerned authority appraised of the likely shortfalls in purchase performance by introducing appropriate reporting systems with a view to seek management's/Concerned authority intervention at the right time.

Purchase Functions:

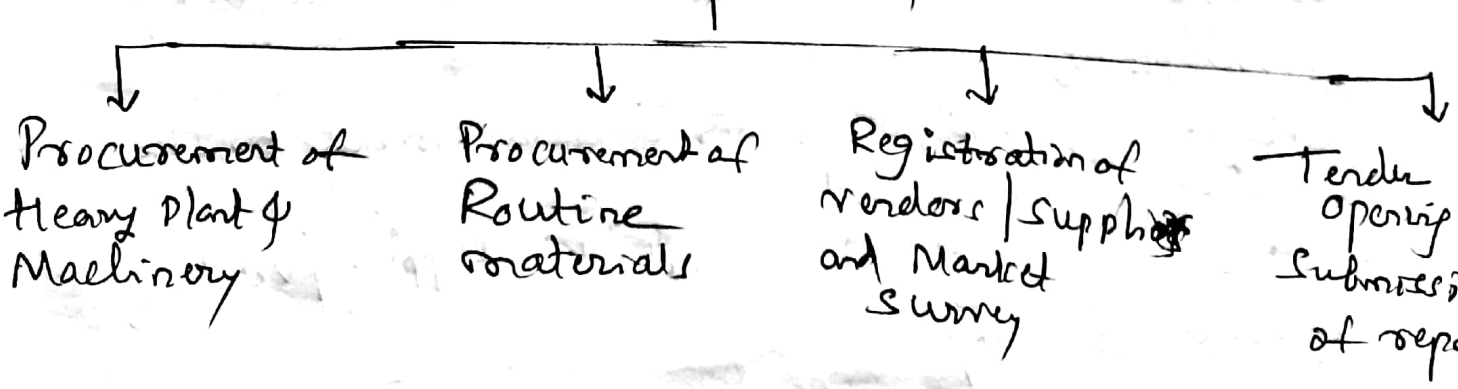
Purchase department is responsible for the following activities

1) Creation of a comprehensive and continuously updated lists of selected reliable vendors
2) Maintenance of vendor evaluation and rating records
3) Conducting market surveys with a view to establish/develop new reliable & better sources of supply by making available information on latest products/developments
4) Analysing bids/offers for decision-making by the competent technical authority
5) Arranging negotiations with the suppliers/vendors, when necessary

6) Issue of Purchase order in time
7) Obtaining Government clearances / licenses, where necessary
8) Follow-up of Purchase orders to ensure arrival of materials ensure after-sales service during warranty and Post-warranty periods
9) Finalization of rate Contracts for regular stock items
10) To workout procurement lead time for various categories of items and advise to indenting departments to enable timely action in initiating purchase requests.
11) Maintaining Library of product catalogues, manufacturers / distributors price lists.
12) Maintaining updated information regarding Govt. laws on Sales tax, excise, customs duty, service tax, income tax etc
13) Submission of MIS reports on performance of purchase
14) Entering into service contracts for transport, customs clearance, advertising, Packing material handling etc
15) Entering into Transit Insurance agreements for goods in transit.

Purchase setup (or Organisation)

The Purchase setup of a large organisation may be as given below



Purchase Enquiry and Selection of Appropriate Purchase Mode

The invitation to tender and instructions at enquiry stage are an important step as the vendor's offer is based upon these instructions. Any ill-conceived, indifferent and thoughtless action at this stage will result in unnecessary delays, increase in paper work and rush purchases. The enquiry shall be carefully prepared indicating requirements in clear terms.

a) The enquiry tender shall indicate complete description and specification of the required materials
b) Drawing, wherever available, shall be enclosed with the enquiry / tender
c) Enquiry / Tender must be invited to ISS / other standard specifications as far as possible. Under no circumstances, terminology such as 'best quality', 'commercial quality' or as per previous supply etc shall be used
d) Where no drawing is available and which cannot be correctly described, a sample is to be shown to the vendors or they may be requested to submit their sample.
e) In cases where an option to supply materials is to be exercised the tenderers must be asked to give alternative offers with their own supply of materials and with supplied materials
f) Delivery expected shall be realistic and specifically indicated
g) In case quantity required is not readily marketed, minimum order quantity stipulation shall be requested in the tender enquiry

Separate offers for Technical / Commercial Quotes

In cases where technical requirements / specifications are not clearly established offers should be obtained in two parts - Part I containing technical details and Part-II containing price / commercial details. The tenderer / firms be informed clearly that commercial offers would be opened after the equipment is selected on the basis of offer NO. I.

Modes of Tendering : The usual modes of tendering are

1) Oper tendering
2) Global tendering
3) Limited tender
4) Single tender
5) Proprietary tender
6) Spot tendering

Oper / Public Tendering is a system whereby ever non-registered dealers are free to participate. Under this system all the known and possible sources for the supply of a particular material are made aware of the requirements and allowed to quote. to this end, are of the following methods shall be adopted :

i) Giving an advertisement in at least three leading English language newspapers of all India circulation and, where time permits, also in the Indian Trade Journal / Indian Export Service Bulletin (IESB). Simultaneously copies of the advertisement may be sent to all the known and likely sources.

ii) Addressing all the known and likely sources for a particular product.

Where items to be procured are not indigenously available, Global tendering shall be resorted to. Advertisements may be released in leading National Newspapers as well as in the Indian Trade Journal/Indian Export Services Bulletin. In addition, copies of the tender documents may be made available to the Indian Embassies in potential vendor countries abroad for issuing to the tenderers besides making the documents available to the Trade Commissioners of Foreign Embassies in India.

In limited tender only the most likely and suitable sources are addressed. To invite adequate competition, it is necessary that at least five sources of supply are addressed. The suppliers to be addressed shall be decided based on past experience. The selection of suppliers shall be carefully made based on vendor rating or past experience.

When the purchase is finalised on the basis of a single offer or an offer from a single source is invited, this is called a 'Single Tender Purchase'. Common occasions of this category are given below:

a) When market research reveals that there is only one known reliable source of supply.
b) When the management in the interest of real long term economy and quality assurance and assured service standards of delivery etc. standardises on a particular brand/make.

c) There is a single party ready to undertake the risk of provisioning/development of item required and the value of order is such that it is not economical to develop alternative sources of supply.

d) The manufacturer/Government has canalised the supply only through a single source.

e) The item is known to be in short supply and its stocks happen to be available only with one source at the time of purchase.

f) Suppliers from fair price shops, super-bazars, Government, Semi-Government, Co-operative undertakings

g) Direct purchase from reputed manufacturers or their accredited dealers.

As far as possible offers shall be invited from the manufacturers/their authorised agent general stockist of repute.

Proprietary tender is a tender which is addressed only to a proprietary manufacturer/his authorised agent because no equivalent or near equivalent is available from any other source and/or all possible suppliers quote only the product of one manufacturer.

Spot tendering is to be resorted only for emergent requirements. All the readily approachable and well-known vendors are requested to assemble and their offers are obtained after the requirement is explained/shown to them on the spot.

Petty Purchases

Items of nominal value, say upto ₹500, could be purchased directly from the market by the purchase assistant without issuing a formal order.

Imprest Purchase System

The purchase department arranges for each purchase of urgent production/Project items as well as other items of low value. In this case also no formal offers are invited. The concerned person is authorised to record rates of minimum of three suppliers and approve the purchase. Under this system of purchase the value of each item may be restricted to ₹1,000.

Comparative Statement

This is an important document to evaluate the offers received against an Enquiry. Utmost care must be exercised while preparing the comparative price statement of tenders. Any deviation from the tendered specifications, delivery conditions assistance etc. stipulated by the tenderers should be highlighted. A sample of format of comparative price statement (CPS) is as given in Format-I

Format - I Comparative Price Statement (CPS)

1. No. of Enquiries Issued : _____ Enquiry no. _____
2. No. of Tenders Received : _____ Date _____
3. Date of Opening of Tenders : _____ Due Date _____

Item No.	Description	Qty Req.	Previous Purchase			Current offers				
			order no.	Date	Unit Price	1	2	3	4	5
Sales tax										
Excise Duty										
Discount										
Is the offer in conformity with out requirements ? (Yes/no)										
Validity for acceptance										
Prices Quoted (Firm/variable)										
Prices quoted Ex-works / F.O.R / FAs / C & F CIF etc										
Condition of the material offered (Factory new used or surplus etc)										
Delivery offered (Weeks / Days / Months)										
Terms of Payment L/C / DOCS through Bank / Advance etc										
Local Candidates if any / Agency Commission										

Evaluation of Tender

Following points shallbe paid speeral attention while compiling information on the tender evaluation sheet.

1) The offer was received in time and is not an unsolicited or qualified offer and the offer is accompained by earnest money deposit if required as per tender conditions
2) Basic price and the quantities for which it is valid. Also whether the price is firm and/or any escalation formula is offered.
3) Sales tax, Excise duty and any other imports/ taxes that are payable
4) Terms of delivery i.e ex-factory, projectsite and other terms and conditions
5) Packing and forwarding charges
6) Acceptance of penalty/ compensation clause for late delivery/ Contract Conditions
7) Specifications offered are the same as demanded/ alternative offered and benefits claimed for it.
8) Terms of payment and request for advance payments/ Willingness to offer bank guarantee
9) Assurance/ Methods to replace defective supplies.
10) After-sales-service arrangement and cost of such services, if any
11) Samples if required are submitted with the offer or alternatively tenderer agrees to submit samples as required in the enquiry
12) Validity period is adequate.

Based on above factors, a net price comparison of the valid tenders only should be prepared and tender evaluation sheet shall be endorsed L_1, L_2, L_3 etc to indicate 1st lowest, 2nd lowest, 3rd lowest and so forth.

In this tender evaluation statement, the tenders which are not meeting technical specifications and where the tender formalities have not been complied with, and which were received late/delayed shall not be included. An endorsement with reasons for non-consideration/non-inclusion of parties should be separately made on the Comparative price statement in red ink. The Tender Evaluation Statement shall be signed by the Purchase Assistant who has prepared the statement and shall be vetted and countersigned by an officer of the Purchase Department and approved by the Purchase Manager

It is normal to accept the lowest offer conforming to the requirements in regard to specifications, delivery and other terms. When for valid reasons it is necessary to accept a tender other than the lowest, the reasons for overlooking the lowest offer must be clearly recorded.

Purchase Orders :

All purchase orders (POs) shall carry the following information

1) Purchase order number and date
2) Detailed specifications of the items as quoted by the tenderer/ agreed additional specification, if any
3) Value of the purchase order
4) Name of the supplier
5) Due date of delivery
6) Quantity of items ordered
7) Taxes if any to be specified in the order
8) Despatch details as agreed to
9) Mode of payment as agreed to, advance, discount etc
10) Inspection system as agreed to.

Payment of Bills

In order to maintain credibility and Project a proper image of the Ordering Authority, it is of utmost importance that the bills of supplies/vendors are paid in an agreed time. All procedures/formalities to be taken up are to be properly co-ordinated so that payment is not delayed.

Tender form:

By tender is meant a form on which an offer is made from a party to make supply or undertake some work as its quoted rates on some specified conditions. The tender is usually accompained with an amount called as earnest money. Earnest money is the guarantee of the tenderer to deposit the required security and to enter into the required agreement on intimation of the acceptance of his tender. After acceptance of a tender, the tenderer deposits security, which is his guarantee for due fulfilment of his contract.

Module-2

Wiring Systems

Introduction:

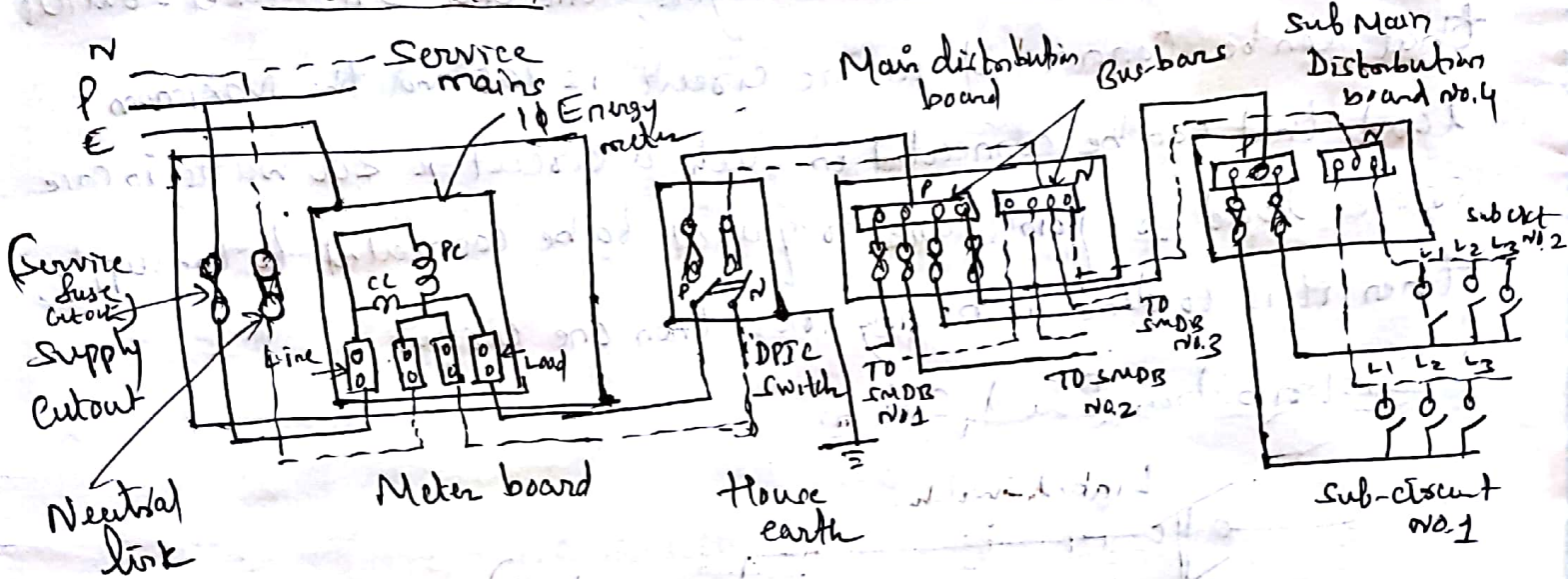


Fig ① Typical House-Wiring Circuit

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.

The supplier service cable feeding an installation terminates in <u>service fuse</u>. In an ordinary house the service fuse is called as <u>service cutout</u>. Such cutouts including service meters remain the property of the supplier. The point at which the consumer's wiring is connected into the cutout is known as <u>point of commencement of supply</u> or <u>consumer's terminals</u>. From consumer terminals onwards the supply cables are entirely under the control of consumer and layout as per consumer selection. A typical house-wiring circuit is shown in fig ①

Systems of Distribution of Electrical Energy in a Building

Since as per recommendation of Indian Standards the Maximum number of points of lights, fans and 5A socket-outlets that can be connected in one circuit is 10 and the Maximum load that can be connected in such a circuit is 800 watts, in case more load or points are required to be connected to the supply, then it is to done by having more than one circuit.

1) Distribution Board System

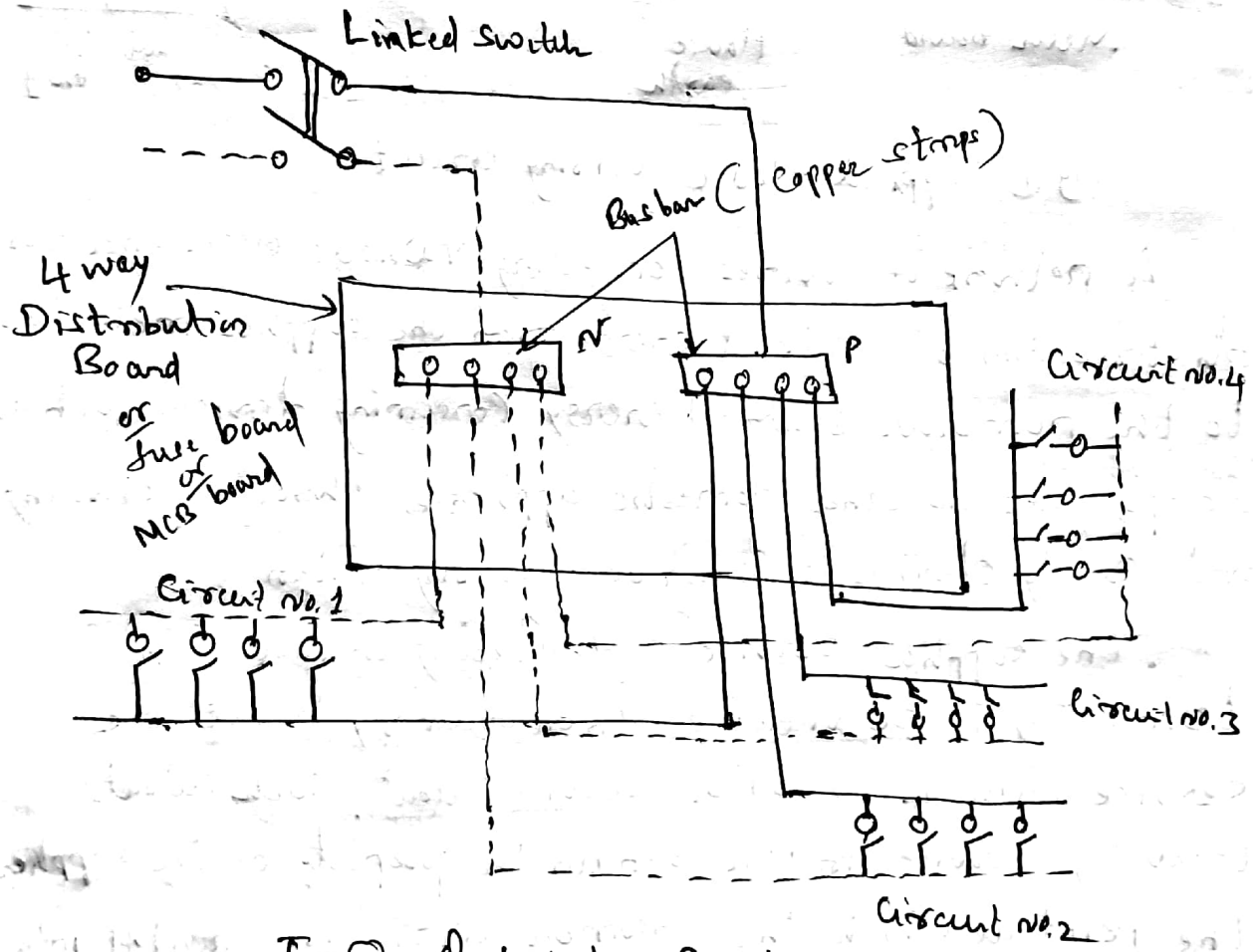


Fig ② Distribution Board system

In distribution board system, which is most commonly adopted for distribution of electrical energy in a building, the fuses of various circuits are grouped together on a distribution board, simply known as fuse board. Connections necessary for connecting two or more than two circuits, each consisting of ten or less no. of lamps is shown in fig ②

The two copper strips known as bus-bars, fixed in a distribution board of hard wood or metal case are connected to the supply mains through a linked switch so that the installation can be switched off as a whole from both poles of supply if required. A fuse is inserted in the +ve or phase pole of each circuit so that each circuit is connected up through its own particular fuse. The lamps constituting each circuit need not necessarily be in the same room or even on the same floor in case of a small building and simply allocated to each circuit in such a way that the router or runs for connecting them is most convenient and expenditure incurred is minimum. The distribution board shown in fig ② has 4 ways for four circuits but there is no limit to the number of ways or circuits provided the cable feeding the board is large enough to carry the total load current. In large buildings, however, if only one distribution board were used, some of the points would be at a considerable distance from it and in such cases it is advisable to employ sub-distribution boards either to save cable or to prevent too great voltage drop at the more distant points (lamps, fans or other appliances). In such cases main distribution board controls the circuits to each sub-distribution board from which the sub circuits are taken, as shown in fig ① The sub-distribution boards are installed near the load.

The no. of circuits and sub-circuits is decided as per number of points to be wired and load to be connected to the supply system. For determination of load of an installation the following ratings may be assumed unless the values are known or specified.

i) Fluorescent lamps - 50 watts
ii) Incandescent lamps, fans and Socket outlets - 60 watts
iii) Power Socket outlets = 1000 watts
iv) Exhaust fans / Air conditioner - as per Capacity of exhaust fans / air-conditioner

2) Tree System

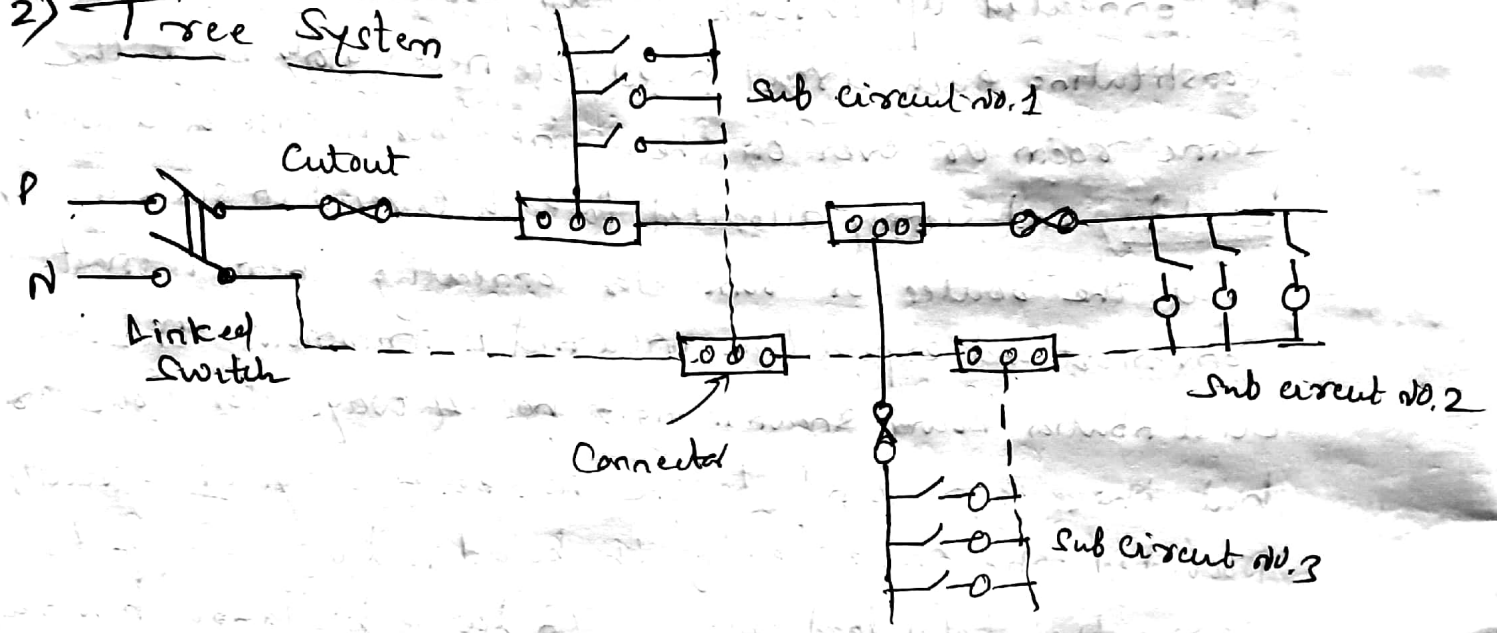


Fig ③ Tree System

Another system of distribution of electrical energy in a building is the 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. Nowadays it is no more adopted due to the following drawbacks

i) The voltage across all the lamps does not remain the same. The lamps in the last branch will have least voltage across them on account of voltage drop in leads
ii) A no. of joints are involved in every circuit
iii) Fuses are scattered
iv) In case of occurrence of fault all the joints have to be located and if some of these joints are concealed beneath floors or roof spaces a lot of distruction are faced. Sometimes a no. of such joints are required to be opened for testing purpose. So damage is caused to installation, conductors & building

Systems of Wiring

The types of internal wiring usually employed in our country are

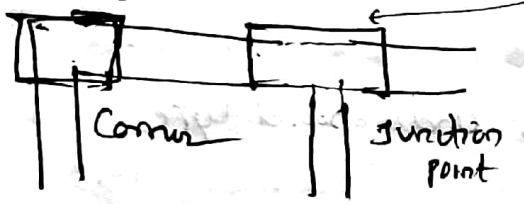
1) Cleat wiring
2) Casing & Capping wiring
3) CTS or TRS or PVC Sheathed wiring
4) Lead Sheathed or metal Sheathed wiring
5) Conduit Wiring
   a) Surface or open type
   b) Recessed or concealed or underground type

P.V.C Casing & Capping Wiring

This is one of the simple form of electric wiring system. As the name referred, the cables used in this type of wiring are either VIR or PVC or any other approved insulated cables and are placed in plastic casing and covered with cap. The cables are carried through casing enclosures. The casing consists of V-shaped grooves and is covered at the top by means of rectangular strip, known as capping of same width as that of casing. The casing hallow channel and cap are normally made of PVC plastic. The channels and caps are available in the market in standard length. The commonly available standard lengths are 1 metre, 10 feet and 6.5 feet etc.

In casing & capping wiring system, required lengths of casing channels are cut with capping cover then screw

these on the wall as per layout planning of wiring. Normally screws are placed after each 30cm in the channel, then PVC insulated wires of size $0.75mm^2$, $1mm^2$, $1.5mm^2$, $2.5mm^2$ or $4mm^2$ are placed in the channel as per wiring requirements and cover the channel by cap. The channels can be fit in both vertical and horizontal alignment. In corner and junctions, elbow joint & tee joints are done respectively.



The casing should be well fixed to its supporting structure i.e. walls or ceilings. Gaps should be avoided. If there is a need to extend a circuit by adding an additional receptacle or to add a switched-controlled ceiling light in a room where one doesn't exist, then also this surface channel wiring is used.

Advantages

1) Cheap in cost as compared to lead sheathed and conduit wiring system.
2) Easy to instal and rewire.
3) Easy to inspect by opening the capping.
4) Good appearance.

Dis-advantages:

1) Since it require better workmanship, the labour cost is higher
2) This type of wiring can be used only on surface and cannot be concealed in plaster.
3) Since there is a risk of fire, it cannot be used where there is a possibility of fire hazard.

Fields of application: This type of wiring is suitable for low voltage domestic installations in dry places and where there is

Conduit Wiring

In this system of wiring steel tubes, known as Conduits, are installed on the surface of walls by means of saddles or pipe hooks or buried under plaster and VIR or PVC cables are drawn afterwards by means of a GI wire of size of about 18 SWG. In damp situations the conduits can be spaced from the walls by means of small wooden blocks fixed below the pipes at regular intervals. In order to facilitate drawing of wires number of inspection fittings are provided along its length. The conduits should be electrically and mechanically continuous and connected to earth at some suitable point. The conduit used for this purpose is of two types namely

i) light gauge (or Split type) conduit
ii) Heavy gauge (or Screwed type) conduit.

1) Surface or open conduit wiring
2) Concealed conduit wiring

Light gauge or split conduit with a seam along its length is used for cheap work. It is not watertight or even damp proof and is not permitted on medium voltage (i.e. on voltage higher than 250V). Here the pipe joint by means of couplings and it is useful in surface conduit wiring.

Screwed conduit (solid drawn or with welded seam) is used for all medium voltage (250V to 600V) circuits and in places where good mechanical protection and protection from moisture is desired. This is suitable for use in underground system. In general the finish of the conduit is black stove enamelled, smooth coat of enamel both on the inside & outside surface of the tube

Galvanised Conduit is also employed, especially in damp situations when the conduit is on the surface but under ordinary conditions buried in walls it offers advantage over good enamelled conduits.

Conduit size is stated in terms of its outer diameter. The smallest size is 12mm, the next size is 16mm and the next 19mm after which it raises in size in 6mm steps to 31mm and next std. sizes are 38mm & 50mm. The largest standard size is 63mm but this is not much in use. The number of cables of different wires that can be accommodated in various sizes of conduits are given in table. (Refer Page no. 32 of text book. Author J.B Gupta)

PVC conduit pipes are also available now and are being employed in place of steel conduits. PVC conduits are cheaper in cost and the labour time saved may be as much as 25%. Compared to the time taken in installing steel conduit. Such conduits are resistant to acid, alkalies, oil and moisture. They can be buried in lime or cement plaster without ill effects. The main drawback of PVC conduit is its movement due to variations in temperature. Also PVC conduit is not suitable for use in locations prone to fire hazards

Advantages:

1) It provides protection against mechanical damage
2) It provides complete protection against fire due to short ckts etc
3) The whole system is waterproof
4) Its life is long if the work is properly executed
5) It is shockproof also if earthing & bonding is properly done.

Disadvantages

1) It is very costly system of wiring
2) Its erection is not easy and requires time.
3) Experienced and highly skilled labour is required for carrying out the job.
4) Internal condensation of moisture may cause damage to the insulation unless the system outlets are properly drained and ventilated.

Fields of Application :

As this system of wiring provides protection against fire, mechanical damage and dampness so this is the only approved system of wiring for

i) Places where considerable dust or fluff is present such as in textile mills, sawmills, flour mills etc
ii) Damp situations
iii) In workshops for lighting and motor wirings.
iv) Places where there is possibility of fire hazards such as in oil mills, varnish factories etc
v) Places where important documents are kept such as record room.
vi) Residential and Public buildings where appearance is the prime thing.

The recessed type conduit wiring is preferred for residential & Public buildings.

PVC conduit wiring system (Particularly concealed) is cheaper in cost & takes less time but does not provide protection against fire. Insurance requirements stipulate metallic conduit wiring & PVC wiring only for offices.

Precautions to be observed:

1) In order to avoid condensation of water, the conduits must be well ventilated in order to allow circulation of free air.
2) Edges of the conduit should be filed before laying to remove burrs etc and so to save cable insulation from mechanical damage.
3) The oil used for threading the conduits must be wiped off in order to save cable insulation from chemical injury.
4) The threads should be coated with aluminium paint inorder to keep the conduit electrically continuous.
5) Inspection 'Te' inspection bends or Junction boxes should be used at all bends.
6) In wall conduit is drawn into the joints of brickwork so that the conduit is held firmly to the wall, the conduit should be at least 6mm in plaster
7) Speeral care should be taken then no moisture can enter Junction boxes & joints etc
8) The conduit must be placed in position before drawing the wires. Therefore the layout should be carefully done
9) Overcrowding of cables should be avoided in conduits
10) The conduit must be electrically continuous and properly earthed.
11) Contact of the conduits with the metal work should be avoided and conduits should be kept away from gas and water pipes.
12) Size of conduit used should be one throughout the run as far as possible even if the conduits are to carry less no. of cables that its capacity
13. Conduit pipes should be fixed by heavy gauge saddle, secured to suitable wood plugs.

Choice or Desirabilities of Wiring Systems

The choice of any wiring system for a particular installation should be based on technical & economic considerations, both in the context of the wiring system itself and the installation for which it is proposed. In general the following factors should be considered.

1) Safety: The first and foremost consideration is safety to the person using electricity against leakage or shock. For instance, in factory where lot of fumes are produced, Cleat or Casing-Capping wiring cannot be employed. Where there is possibility of fire hazard, conduit wiring must be used.

2) Durability: The type of wiring to be selected must be durable and it must be of proper specifications and also in accordance with assessed life and type of building. The wiring should be able to withstand wear & tear due to weather and it must be capable of carrying the maximum current without overheating.

3) Appearance: The wiring must provide a good look after its installation. From aesthetic point of view, Concealed Conduit wiring system provides good appearance but is costly. PVC wiring system also provides good appearance and is very popular nowadays.

4) Mechanical Protection: The wiring must be protected from mechanical damage during its use.

5) Permanency: The wiring must not deteriorate unduly by action of weather fumes, dampness etc.

6) Accessibility: In a selected wiring system there should be facilities for extension, renewal or alterations.

7) Initial cost: The initial cost of the wiring system to be selected is one of the main points to be considered. The wiring system selected should be safe as well as economical.

8) Maintenance Cost: The wiring system selected should have, as far as possible, low maintenance cost.

The other factors to be kept in view while making the choice of wiring system are load, voltage to be employed, type of building etc.

Fire hazards & insurance standards must be kept in mind in case of large factories etc.

Types of Cables used in Internal Wiring

The wires employed for internal wiring of buildings may be divided into different groups according to

i) Conductor used
ii) No. of cores used
iii) Voltage grading
iv) Type of insulation

According to the conductor material used in cables, these may be divided into two classes known as copper conductor cables & aluminium conductor cables.

According to the number of cores, the cables may be divided into classes known as single core cables, two core cables,

three core cables; two core with ECC (earth Continuity Conductor) cables etc.

According to voltage grading the cables may be divided into two classes i) 250/440 volt cables and ii) 650/1100 volt cables.

According to type of insulation the cables are of the following types

1) Vulcanized Indian Rubber (VIR) insulated cables
2) Tough rubber sheathed (TRS) or Cab type sheathed (CTS) cables
3) Lead sheathed cables
4) Polyvinyl chloride (PVC) cable
5) Weatherproof cables
6) Flexible cords & cables
7) XLPE cables cross-linked polyethylene (XLPE)

1) Vulcanized Indian Rubber (VIR) cables

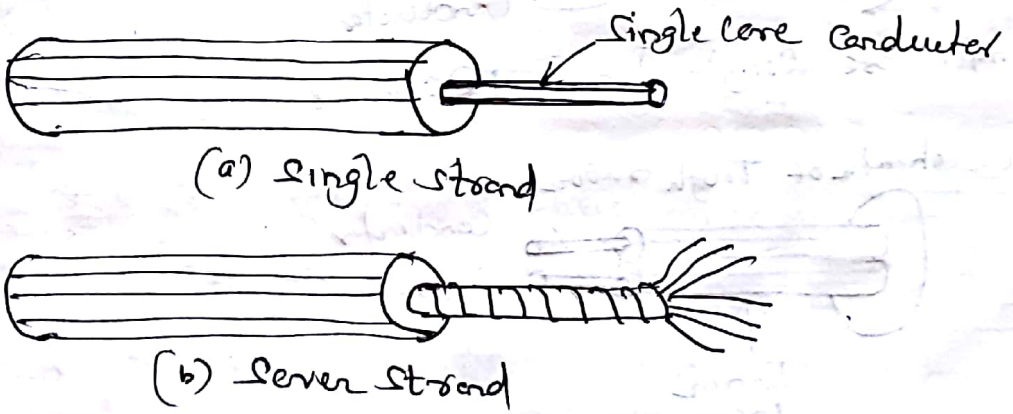


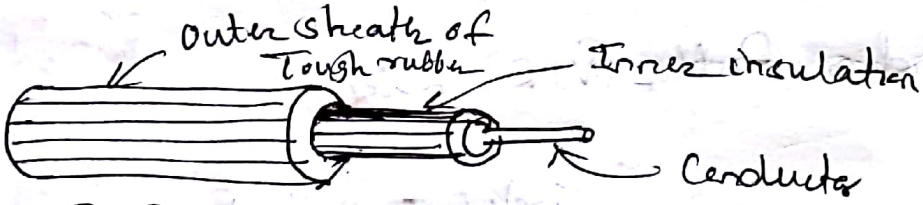
Fig ① Single core VIR cables

VIR Cables are available in 240/415 volt as well as in 650/1100 volt grades. VIR cable consists of either tinned copper conductor covered with a layer of vulcanized Indian rubber Insulation. Over the rubber insulation cotton tape sheathed covering is provided with moisture resistant compound bitumen wax or some other insulating material for making the cables moisture proof. The thickness of rubber insulation depends upon the voltage grade for which the cable is required.

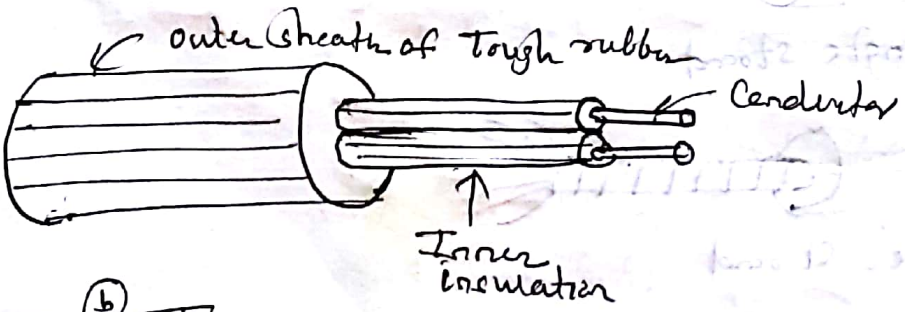
The copper conductor is tinned to provide protection against corrosion due to presence of traces of sulphur, zinc oxide and other mineral ingredients in the VIR

A single core single strand VIR wire may be employed but larger Cables have to be stranded. Single core single strand VIR wire and single core sever strand VIR cables are shown in figs ① a & ⑤ resp.

2) Tough Rubber sheathed (TRS) or Cab Type sheathed (CTS) cables.



ⓐ Single core single strand TRS Wire



ⓑ Twin core single strand TRS cable for Indoor service

Fig ②

These cables are available in 250/440 volt & 650/1100 volt grades and used in CTS (or TRS) wiring. TRS cable is nothing but a Vulcanized rubber insulated conductor with an outer protective covering of tough rubber which provides additional insulation and protection against wear & tear. These cables are waterproof, hence can be used in wet conditions. These cables are available as single core, circular twin core, circular three core, flat three core, twin or three core with an earth continuity conductor (ECC). The cores are insulated from each other and covered with common sheathing. Different types of TRS cables are shown in fig (2)

In wiring of 3 pin plugs separate earth wire may be used as it is cheaper in cost & easier in installation. These cables are cheaper in cost & lighter in weight than lead alloy sheathed cables.

3) Lead Sheathed Cables :

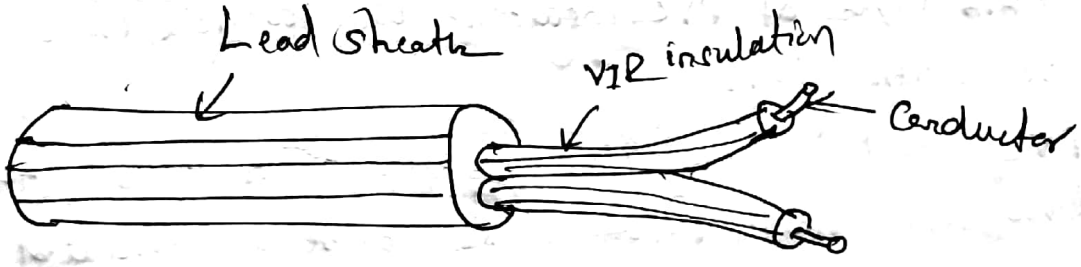


Fig (3) 2 core lead sheathed cable

These cables are available in 240/415 volt grade. The lead sheathed cable is a Vulcanized rubber insulated conductor covered with a continuous sheath of lead. The lead sheath provides very good protection against the absorption of moisture and sufficient

protection against mechanical injury and so can be used without casing or conduit system. It is available as single core, flat twin core, flat three core & flat twin or three core with an E.C.C. Two core lead sheathed cable is shown in fig (8)

4) Polyvinyl Chloride (PVC) Insulated Cables

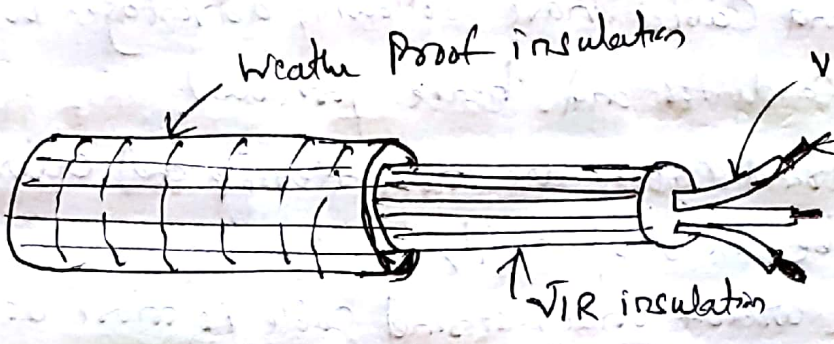
These cables are available in 250/440V & 650/1100V grades and are used in casing - capping, batten & conduit wiring system. In this type of cable conductor is insulated with PVC insulation. Since PVC is harder than rubber, PVC cable does not require cotton taping and braiding over it for mechanical and moisture protection.

PVC insulation is preferred over VIR insulation because of the following reasons.

i) PVC insulation has better insulating qualities
ii) PVC insulation provides better flexibility
iii) " " has no chemical effect on metal of the wire
iv) This layer of PVC insulation will provide the desired insulation level
v) PVC coated wire gives smaller diameter of cable and therefore more no. of wires can be accommodated in the conduit of a given size in comparison to VIR or CTS wires.

PVC cables are most widely used for internal wiring these days. Though the insulation resistance of PVC is lower than that of VIR but its effect is negligible for low & medium voltages, below 600V.

5) Weather Proof Cables



3-core weather Proof Cable

These cables are used for outdoor wiring and for power supply or industrial supply. These cables are either PVC insulated or Vulcanized rubber insulated conductors being suitably taped (only in case of vulcanized rubber insulated cable) braided and then compounded with weather resisting material. These cables are available in 240/415 volt & 650/1100 volt grades. These cables are not affected by heat or sun or rain. Although TRS cables can be used for outdoor purposes but due to their higher cost, weather proof cables are generally used for outdoor services.

6) Flexible Cords & Cables

The flexible cords consist of wires (silk/cotton) plastic covered. Plastic cover is popular as it is available in different pleasing colours. Flexible cords have tinned copper conductors. Flexibility and strength is obtained by using conductors having larger 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. The flexibility of such wires facilitates in handling the appliances and prevents the wires from leakage.

Multistrand Cables

Multistrand Cables have following advantages with respect to single solid conductor and hence preferred.

i) The multi-strand cables are more flexible and durable and therefore can be handled easily.

ii) The surface area of multi-strand cable is more as compared to the surface area of equivalent single solid conductor, so heat radiating capacity, being proportional to the surface area, is more.

iii) Skin effect is better as the conductors are tubular, specially in case of high frequency.

The number of strands in stranded cable must be 3, 7, 19, 37, 61, 91 and so on in order to obtain a circular contour. Thus a 7-strand cable has one central wire with 6 wires surrounding it.

The size of the cable can be given by a designation giving number of strands and gauge number of each strand. For example a cable having 3 strands each of gauge 20 SWG may be referred as 3/20. In the system of specifying the size of cables, numerator indicates the number of strands employed and denominator indicates the gauge number of each strand.

The size of cables, may also be given in terms of number of strands & diameter of each strand in mm. For example a cable having 19 strands, each strand of diameter 1.12 mm may be referred as 19/1.22 mm. The cable size is often denoted in terms of total cross-sectional area of the core instead of number and diameter of strands. As 19/1.12 mm cable has a cross-section of 19.35 mm^2 so this cable is often referred to as a 19.35 mm^2 cable.

Voltage Grading of Cables

This specifies the safe voltage which the insulation of the cable can withstand. The cables employed for domestic wiring are graded 650/1100V.

Main Switch and Distribution Boards

As per Indian Electricity Rule 50 a suitable linked switch (a switch operating simultaneously on phase or line and neutral wires) is to be provided immediately after the meter board. This rule also stipulates that a suitable cutout must be provided just after the linked switch to protect the circuit against excessive current. The linked main switch & fuse unit may be provided as one unit or as separate units.

Switch fuse is a combined unit and is known as an enclosed switch, being made of iron. It may be double pole for controlling single phase two-wire circuits or triple pole for controlling three-phase, 3-wire circuits or tripple pole with neutral link for controlling 3-phase 4-wire circuits. The respective switches are known as double pole iron clad (DPIC), tripple pole iron clad (TPIC) and tripple pole with neutral link iron clad (TPNIC) switches. Since no fuse is to be provided in neutral (IE Rule 32), in DPIC switch fuses where provision is made for fuses in both the wires one fuse carrier is furnished with fuse element and the other with a thick copper wire.

The specifications of IC switch fuse units are given below as samples:

1) For Two-wire DC circuits or Single phase AC circuits
   240V, 16A, DPIC switch fuse of any make approved by IS.
2) For three-wire DC circuits
   500V, 32A (63/100/150 or higher amperes). IS approved TPIC switch fuse
3) For Three-phase Balanced Load circuits
   415V, 32A (63/100/150 or higher amperes), IS approved TPIC switch fuse
4) For three-phase 4-wire circuits
   415V, 32A (63/100/150 or higher ampere) IS approved TPIC switch fuse with neutral link.

Distribution Boards: The distribution board is an assembly of parts, including one or more fuses or circuit breakers arranged for the distribution of electrical energy to various circuits or other distribution boards known as submain distribution boards. The boards are usually metal-cased in sheet steel or hardwood-cased in oak or teak. The door may be solid or glazed. The earthing terminal and locking arrangement are invariable provided. The number of ways depends upon the circuits or sub-circuits to be fed. Separate distribution fuse boxes should be provided for light and power circuits. E.g. 1) 2 way 16A, 240V, 2) 3 way 16A 240V 4way, 6way, 8way 10way, 12way 16A, 240V 3) 2 way, 3 way 4way 6way, 32A, 240 volts etc

Fuse/Distribution Boards – General requirements

Distribution boards have similar requirements as switch fuse units except that the metallic enclosure must have a locking arrangement. The specifications of fuse boards are –

1) For medium size residential building: 6way, 16A, 240V, ICOB of any make approved by IS 2) For motor installations: 6way 415V, 300A, Tripple pole with (or without) neutral link ICOB of any make approved by IS

Conduits

In general conduits can be classified as

1) Light gauge steel - Plain (Unscrewed) Conduit
2) Heavy gauge steel - Screwed Conduit
3) Flexible Conduit
4) PVC Conduit

1) Light Gauge steel conduit: This type of conduit is used on the surface usually in connection with special grip fittings. It is available with an external diameter of 12mm, 16mm, 19mm, 25mm, 31mm, 38mm & 50mm. The fittings are generally of the pressed steel lug grip type, which clamp the conduit on the tightening of the lug screws. The light gauge conduit is the cheapest and quickest of the conduit installations but should be used where the location is dry and there is likelihood of mechanical damage

2) Heavy gauge Screwed Steel conduit:

Though it is expensive but this type of conduit provides a permanent installation with a maximum of protection for the cables. The joints into fittings are by means of screw threads which provide mechanical strength and good electrical continuity. There are two types of heavy gauge conduit: Welded and Solid drawn. Both types can be obtained with enamelled surface (black or silver grey) or rust proofed by either galvanizing or sherardizing. These are available in approximate 3 metre lengths and are threaded at the two ends.

3) Flexible Steel conduit: This usually consists of light gauge galvanized steel grip spirally wound and interlocked to form a tube. It is made in sizes from 19mm to 50mm internal diameter and in two grades, one watertight & watertight

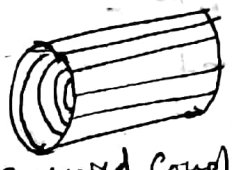
The flexible conduits are available in lengths upto 250 meters so no coupling is required and hence no threading. Since the conduits are flexible and are easily bent, no elbow is required. For connecting the flexible conduit to ordinary conduit, special brass adaptors are used. It is necessary to run an earthwire through the flexible conduit as the spiral formation doesn't provide effective continuity. One of the most common uses of flexible metal conduit is for protecting the final connections to motors.

4) PVC Conduit: This type of conduit has wide application in internal wiring because it is light in weight, shockproof self fixing, fire resistant, acid, alkali & corrosion resistant having high insulation values and dielectric strength. Such conduits can be used for surface recessed or concealed type wiring. Conduits may be joined by the screwed or plain type of couplers depending upon whether conduits are of screwed type or plain type. Such conduits are particularly useful in installations where the problem of corrosion is acute. Use of PVC conduits in ambient temperature, beyond 60°C is prohibited by IS.

Conduit Accessories & Fittings

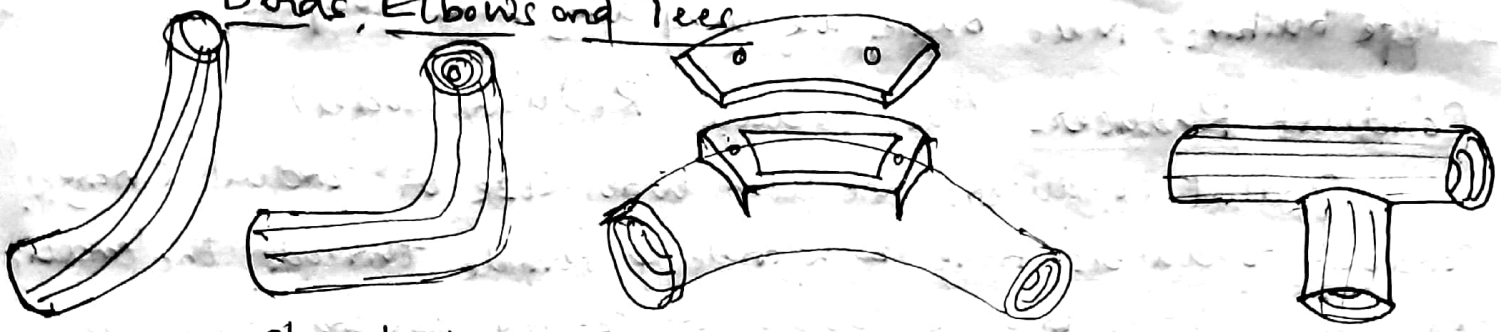
For conduit wiring system various accessories and fittings are required.

a) Conduit Couplers: Conduit is available in lengths from 3 metres to 5 metres and for straight runs of greater length couplers are used to join two lengths of conduits.



Screwed coupler/socket

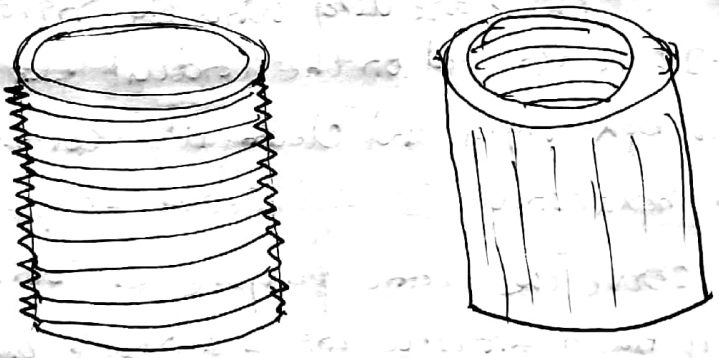
Bends, Elbows and Tees



Normal bend Sharp bend Inspection elbow (Detachable lid) Solid Tee

Bends are usually used for change in direction of conduit. These should never be sharp. The minimum radius of curvature allowable is $2\frac{1}{2}$ times the outside diameter of conduit. Elbows are of shorter radius, are only used where sudden right turn is required or on a surface work where neatness is required. Solid elbows and Tees should be used only at the end of the conduit run. The detachable lid provided in inspection type tees & elbows facilitate pulling of cables.

Conduit Bushings



Male bush Female bush

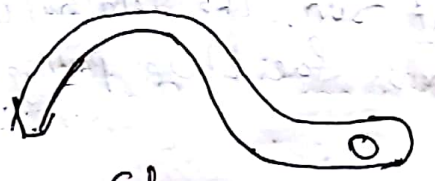
These are used when the rigid conduit enters the conduit box or a hole which is not threaded. These are used to prevent cable from being cut by the edges. These are of two types male & female. Male bushes are provided threads on their upper surface and female bushes are provided threads on their inner surface. Conduit can be directly screwed into the female

type bushes. Male bushes are used along with couplers.

Conduit Reducers (or Conduit Reducing Socket)

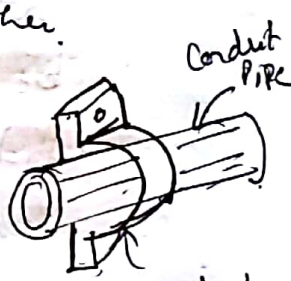
Conduit reducers are used when size of conduit changes. Conduit reducers have both male & female threads. The conduit reducer is fitted into the coupler or conduit box and into it the conduit of small size is screwed. A hexagonal end on the reducer provides a grip for the spanner.

Fixing of Conduit: Clips are used for fixing the conduit on rough brick walls & in concealed wiring. The saddles are used for fixing the conduit when clips cannot provide a firm enough hold or a single screw cannot be depended upon for fixing. Multiple saddles are used if two or more lengths of conduit run together.



Clip

Conduit Saddle



Locknuts or Checknuts: These are used when the rigid conduit enters a conduit box. It is screwed on the conduit for making connections of conduit to box rigid and electrically continuous. These are available in hexagonal or octagonal shapes.

Conduit Nipples: These serve the same purpose as conduit bushings. Similar to the bushing it has a smooth inner surface and are used for providing a coupling to the conduit box. These are rarely used due to their higher cost.

Conduit boxes: Conduit boxes are used in surface conduit wiring as well as concealed conduit wiring. These serve the following purposes: i) For providing connections to light, fan and other points. The conduit boxes serving this purpose are known as outlet boxes because conduit terminates at these boxes. These boxes may have entry either from side or from back or from both sides.

2) For pulling of cables into the conduits, the boxes serving this purpose are known as inspection boxes. These are provided after every 30 metre length of straight run. The inspection boxes on account of removable covers provides facility for drawing of cables.

3) For housing junction of cables, the conduit boxes serving this purpose are known as junction boxes.

Lighting Accessories and Fittings

1) Switches: A switch is used to in an electric circuit as a device for making or breaking the electric circuit in a convenient way. The switches may be classified in various ways. According to the type of base material they are classified as porcelain or bakelite switches. According to colour of base they are either white or black or brown coloured switches. According to operation required they are classified as one-way switches, two-way switches, two-way centre-off switches, double pole switches, Push button switches, table lamp switches, Bed switches, etc.

The switches are of two types, known as surface switches (or Tumbler switches) and flush switches (or Concealed switches)

a) Tumbler or surface switches are those which are fixed on mounting blocks directly fixed on the surface of the wall. Such switches project out of the surface of the wall and are in common use.

b) Flush switches are fixed flush with the wall and do not project out. These switches are used where high quality. These switches are used where high quality performance and appearance are required.

2) Ceiling Rose : The ceiling rose is used to connect the pendent lamp fans or fluorescent tubes to installation through flexible plastic or silk covered wire. It consists of two parts known as base & cover. The base may be of bakelite or porcelain and is fitted with two or more terminal plates separated from each other by a porcelain or bakelite bridge. The number of terminal plates fitted to ceiling rose base depends upon the number of ways of the ceiling rose i.e. two way ceiling rose is fitted with two-terminal plates and 3-way ceiling rose is fitted with three-terminal plates so on.

The specifications of a ceiling rose are: 6 amperes, 240 volts, two (or three or four) way of any make approved by I.S

3) Socket Outlets : The socket outlets are used to supply electrical connection wherever required for electrical appliances such as TVs, radios, table lamps, table fans, irons, stoves etc. Socket outlets are of two types : two pin type and three pin type. The 3-pin socket outlet has three hollow terminals in which three pin plug can easily be inserted. Two holes, being of same size, are meant for making connections to the flexible wire of the appliance and the third hole, which is bigger comparatively is meant for earth connection. Thus the three holes are for live, neutral and earth connections. The 3 pin socket outlets are also of two types i) 6A for table fan, table lamp, TV etc ii) 16A for power circuits as heater, geyser, iron etc.

The specifications of socket outlet for use for a table lamp or table fan are :

240V, 6A three pin socket outlet of any make approved by I.S.

Full specifications of switches Contd...

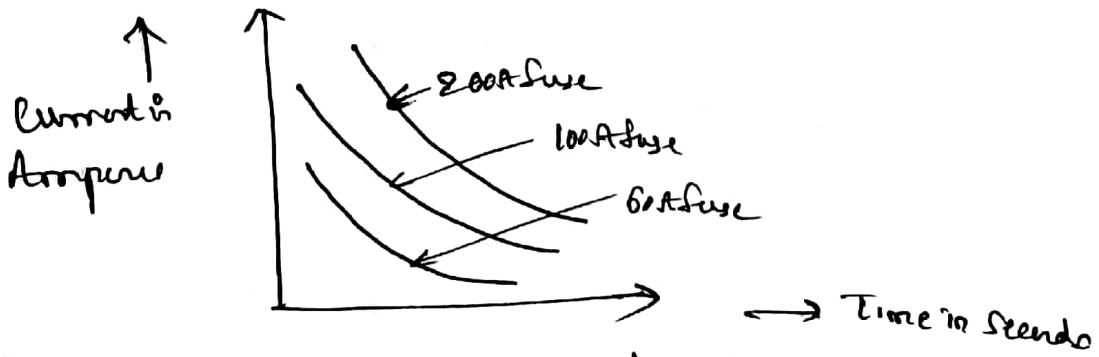
4) Plugs : Plugs are used to collect the supply from the socket outlets for electrical appliances such as table lamp, table fan, stove, iron, heater etc. Similar to socket outlets plugs are also of two types viz two pin & 3 pin type. Three pin type plug consists of three pins usually made from brass. To the two pins which are thin and of the same size, flexible wire are connected and then covered up. To the third pin, which is thicker comparatively, earth wire from the electrical appliance is connected.
The specifications of plug for use for a table lamp or a table fan are 2 no's, 5A, three pin plug of any make approved by I.S.

3) Lamp Holders : As the name indicates the function of lamp holder is to support the lamp and also to connect it electrically. These are designed for quick removal and replacement of the lamp. Lamp holders are of many types.
i) Batten holders ii) Pendent or Coved Grip holders
iii) Angle holders iv) Slanting holders v) Bracket holders
vi) Watertight Bracket holders vii) Miniature screw type lamp holders viii) Lamp-holder adopter.

Fuses:

Fuse is simplest and cheapest device used for interrupting an electrical circuit under short circuit, or excessive overload, current magnitudes. 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 dissipated into the surrounding air, and therefore, fuse element remains at a temperature below its melting point. However, when some fault, such as short circuit occurs or when 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. It thus protects a machine or apparatus or an installation from damage due to excessive current.

The time for blowing out of fuse depends upon the magnitude of the excessive current. Larger the current, the more rapidly the fuse will blow i.e. the fuse has inverse time-current characteristic as shown in figure ①. Such a characteristic is desirable for protective gear. A fuse consists of a fusible element in the form of a metal conductor, a case or cartridge to hold the fusible element. The part which actually melts and opens the circuit is known as the fuse element.



Time - Current characteristic of fuse

Fuse Element Materials

The materials commonly used for fuse element are tin, lead, silver, copper, zinc, aluminium and alloy of lead & tin.

Types of Fuses :

1) Supply Main fuse : This fuse is provided by the supplier and is fixed just after the service meter and sealed by supplier. The seal can be broken only by a authorized person of the supply authority in case of blowing out of fuse for the purpose of replacement. The rating of supply main fuse will be as per load current of the consumer.

2) Consumer Main fuse : This is another fuse of rating slightly less than that of supply main fuse provided by the supplier and placed after the consumer's main switch. The rating of consumer fuse is kept slightly lower than that of supply main fuse so that in case of exceeding of current than normal current (that may occur due to overload, short circuit or earth fault) consumer fuse, which can be replaced by him, may blow and supply main fuse may remain intact.

3) Sub-Circuit Fuses : The total wiring system is divided into the number of sub-circuits or branch circuits. A separate fuse is provided for each branch circuit and is known as sub-circuit or branch circuit fuse

4) Point fuses : In good quality indoor wiring of buildings every light and Plug point is provided with its individual fuse known as points fuse.

Determination of Size of fuse-wire

The factors responsible for determining the size of fuse wire in an installation are

i) Maximum current rating of the circuit and

ii) Current rating of the smallest cable in the circuit protected by the fuse.

For an ordinary lighting sub-circuit wired with 1/1.12 mm or 3/0.736 mm cable a fuse wire of 21 SWG, tin-lead alloy (having current rating of 5 amps) is used. In case use of 14/0.193 mm flexible cable is made for pendants portables on the sub-circuit, the fuse wire should be of rating 3 amps (23 SWG tin-lead alloy fuse wire).

For a power circuit (say of 2 kW) wired with 7/0.736 mm cable (having current carrying capacity of 15 amps) for 240 V supply, fuse wire used will be of current rating $\frac{2000}{240} = 8.33$ A Not of 15 A. i.e. 29 or 30 SWG not 25 SWG. [Refer Table 3.10 Page no. 71 of Text book]

In normal lighting circuits, the fuse of current rating 3 amps and minimum fusing current 5 amps is used as the cables used can carry 5 amps safely. In circuits where current is fluctuating, as in case of electric motors, the fuse wire should be of such size that it may carry momentary overloads without blowing.

If advantage is taken of the diversity factor in deciding the size of the cables and the cables of a small size are used then the size of the fuse must be decided according to the rating of the cable and not according to total load of the circuit.

On the other hand if cable of higher size is used in order to keep the voltage drop in the circuit with permissible limits then the size of the fuse must be decided as per circuit load and not according to rating of cable.

Fuse units

A fuse unit essentially consists of the metal fuse element or link, a set of contacts between which it is fixed and a body to support and isolate them.

The various types of fuse units, most commonly available are

1) Round type fuse unit
2) kit-kat type fuse unit or Rewirable Type fuse unit
3) Cartridge type fuse unit
4) HRC (high rupturing Capacity) fuse units and
5) Semiconductor fuse units

1) Round type fuse unit : This type of fuse unit consists of a porcelain or bakelite box and two separated wire terminals for holding the fuse wire between them. This type of fuse is not in common use on account of its following dis-advantages

a) One of the terminals remain always energised and therefore for replacement of fuse either the worker will have to touch the live mains or open the main switch

b) Appreciable arcing takes place at the instant of blowing off fuse and thus damage the terminals. After two or three arcing the fuse unit becomes unusable

2) Rewirable or kit-kat Type fuses

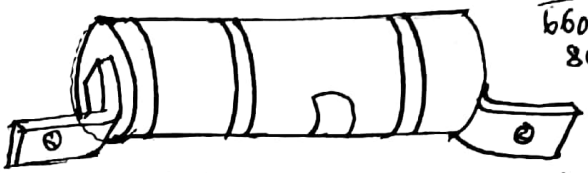
The most commonly used fuse in 'house wiring' and small current circuits is the semi-enclosed or rewirable fuse. It consists of a porcelain base carrying the fixed contacts to which the incoming and outgoing live or phase wires are connected and a porcelain fuse carrier holding the fuse element, consisting of one or more strands of fuse wire, stretched between its terminals. The fuse carrier is a separate part and can be taken out or inserted in the base without risk, even without opening the main switch.

The standard ratings are 6, 16, 32, 63 and 100A.

Though such fuses have the advantages of easy removal or replacement without any danger of coming into contact with a live part and negligible replacement cost but they suffer from the following dis-advantages

a) Unreliable operation b) Lack of discrimination c) Small time lag d) Low rupturing capacity e) No current limiting feature f) Slow speed of operation (clearing time is more)

3) Cartridge Type fuse :



This is a totally enclosed type fuse unit. It consists of an insulating container of bulb or tube shape and sealed at its ends with metallic cap known as cartridge enclosing the fuse element and filled up with powder or granular material known as filler (sand, calcium carbonate, quartz etc). on overloads or short circuits, the fusible element is heated to a high temperature causing it to vaporize. The powder in the fuse cartridge cools and condenses the vapour and quenches the arc thereby interrupting the flow of current. Since it is totally enclosed it will not be possible to recharge and therefore the whole unit will have to be replaced once it blows out. It provides complete security against fire risk, as it is a totally enclosed unit. The filling powder provides good insulating path & helps to extinguish the arc at the time of blowing up of fuse. This type of fuse is available upto 660V and the current rating upto 800A.

4) High Rupturing Capacity (HRC) fuses :

With a very heavy generating capacities of modern power stations, extremely heavy currents would flow into the fault and the fuse clearing the fault would be required to withstand extremely high stresses in this process. HRC fuse rupturing capacity is as high as 500MVA upto 66kV and above.

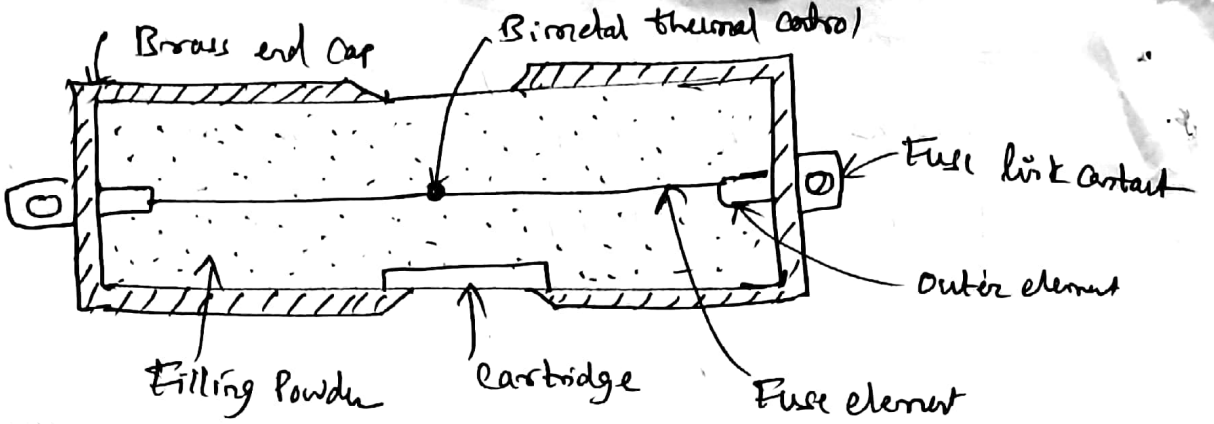


Fig. HRC Cartridge fuse

The HRC Cartridge fuse is most popular. Its consists of a heat resisting ceramic body having metal end caps to which are welded fusible silver (or bimetallic) current carrying elements. The complete space within the body surrounding the elements is filled with a powder which acts as an arc extinguishing agent.

5) Semiconductor Fuse: These are very fast acting fuses for protection of thyristor and other electronic circuits.

Earthing Conductor:

Earthing conductor is of high conductivity copper and is of either stranded, flat strips or circular or rectangular bar. Galvanised Solid iron or steel wire or rod or any other suitable approved material can be used. The cross-sectional area of copper earthing conductor is never smaller than half that of the largest current carrying conductor subject to an upper limit of 65 mm^2. Earthing conductors are so placed and connected that they may not get damaged or cut. They are fixed over their entire length by clamps, clips, saddles etc. which in no way damage the conduit. Aerial earthing conductor is supported on suitable insulators and is clearly identified. Joints in main earthing conductors are made by soldering, brazing or welding for conductors of size upto 7/1.6 mm, for larger main earthing conductors mechanical clamping is used.

Internal Wiring

General Rules of Wiring

For estimation of internal wiring it is necessary on the part of estimator that he be fully conversant with the general rules followed for internal wiring. The general rules, which are to be kept in mind in execution of internal wiring work are

1) Every installation is to be properly protected near the point of entry of supply cables by a two pole linked main switch and a fuse unit. In a two-wire installation if one pole is permanently earthed, no fuse, switch or circuit breaker is to be inserted in this pole. A 3 pole switch and fuse unit is to be used in 3-phase supply
2) The conductor used is to be such a size that it may carry load current safely
3) Every sub circuit is to be connected to a distribution fuse board.
4) Every line or phase is to be protected by a fuse of suitable rating.
5) A switch board is to be installed so that its bottom lies 1.25 metres above the floor.
6) a) All plugs and socket outlets are to be 3-pin type, the appropriate pin of socket being connected permanently to the earthing system
b) Adequate number of socket outlets are to be provided at suitable places in all rooms so as to avoid use of long lengths of flexible cords.
c) Only 3-pin 5A socket outlets are to be used in all light and fan sub-circuit and only 3-pin, 15A socket in power sub-circuits
d) In case an appliance requiring the use of a socket outlet of rating higher than 15A is to be used, it is connected through a double pole switch of appropriate rating. In no case a socket outlet of rating higher than 15A is to be installed.

e) No Socket outlet is to be provided in the bathrooms at a height less than 1.3 metre.

f) Depending upon the size of the kitchen, one or two 3 pin 15A Socket outlets are to be provided. Dining rooms, bedrooms, living rooms, if required, each is to be provided with at least one 3-pin, 15A Socket outlet

g) All incandescent lamps are to be hung at a height of 2.5 metres above the floor level and all ceiling fans at 2.75 metres from Fl. Level

h) a) Lights and fans may be wired on a common circuit. Each sub circuit is not to have more than a total of ten points of lights, fans and socket outlets. The total load on each sub-circuit is to be restricted to 800 watts. If a separate circuit is installed for fans only, the number of fans in that circuit is not to exceed ten (10).

b) The load on each power sub-circuit is to be normally restricted to 3000 watts. In no case more than two Socket outlets are to be in one power sub-circuit.

i) No fuse or switch is to be provided in earthed conductor

j) Every circuit or apparatus is to be provided with a separate means of isolation such as a switch

k) In any building light and fan wiring and power wiring are to be kept separate

l) In 3 ϕ, 4 wire installation the load is to be distributed equally on all the phases.

m) No additional load is to be connected to an existing installation unless, it can safely carry the additional load.

n) Lamp holders used in bathrooms are to be constructed in insulating materials and fitted with protective shield and proper size earth Continuity conductor not less than 7/0.915mm

o) The metal Sheaths or conduits for all wiring and metal Coverings of all consumer apparatus or appliances is to be properly earthed in order to avoid danger from electrical Shocks due to leakage or failure of insulation

16) Each sub-circuit is to be protected against excessive current by fuse or automatic circuit breaker

17) All light conductors are to be insulated or otherwise safeguarded to avoid danger.

18) After completion of work the installations are to be tested before energization.

Determination of Number of Points (Light, Fan, Socket outlets)

The number of light points are determined as per size of the room, illumination level required and the luminous efficiency of the lamps to be used.

Illumination level required as per ISI, in various parts of a building is given below.

Sl no.	Location	Illumination Level in Lux (Lm/m^2)
1	Entrances, hallways	100
2.	Living room	300
3.	Dining room	150
4.	Bedroom General	300
5.	Dressing tables	200
6.	Table games	300
7.	Games or Recreation room	100
8.	Kitchen	200
9.	Kitchen Sink	300
10.	Laundry	200
11.	Bathroom	100
12.	Bathroom mirror	300
13.	Sewing	700
14.	Workshop	200
15.	Stairs	100
16.	Garage study	70 300

The number of fan points is determined as per measurements (length, width & height) of the room and the size of the fans to be used. The air delivery for fans of different sizes at test voltage and at full speed is given in Table ①

Fan size in mm	Type	Air delivery in m^3/minute
900 mm	Capacitor ac	140
	dc	140
1200 mm	Capacitor ac	215
	dc	215
1400 mm	Capacitor ac	270
	dc	270
1500 mm	Capacitor ac	300
	dc	300

As regards the determination of number of socket outlets, recommended schedule of socket outlets is given below.

Location	No. of 5A Socket Outlets	No. of 15A Socket outlets
Bedroom	2 to 3	1
Living room	2 to 3	2
Kitchen	1	2
Dining room	2	1
Garage	1	1
For refrigerator	-	1
For air conditioner	-	1
Verandh	1 per $10m^2$	1
Bathroom	1	1

Determination of Total load

For determination of load of an installation the following ratings may be assumed unless the values are known or specified

i) Flourescent lamps (Choke type) 50W (40W + 10W)
ii) Incandescent lamps, fans & socket outlets - 60 Watts
iii) Power Socket outlets - 1000 watts
iv) Exhaust fans - as per capacity of exhaust fans.

* Determination of number of sub-circuits

The number of sub-circuits are decided as per number of points to be wired and total load to be connected to the supply systems.

In one light and fan sub-circuit the maximum load that can be connected is 800 watts and the maximum number of points which can be wired is 10

In one power sub-circuit the maximum load that can be normally connected is 3000 watts and the number of socket outlets which can be provided is 2.

* Determination of Ratings of Main switch & Distribution board

The current rating of the main switch is decided as per total current of the circuit to be controlled by it.

The number of ways & current rating of the distribution board is decided as per number of sub-circuits to be connected to it & current of the sub-circuit having highest current rating.

* Determination of Size of Conductor

There are three points which must be taken into account while determining the size of conductor for internal wiring for a given circuit. i) minimum size of cable (mainly for mechanical reasons) ii) Current carrying capacity iii) Voltage drop.

i) Minimum Size of the cable :

The conductor used in domestic wiring, according to the regulation in our country, must not be of size less than 1/1.02 mm (0.82 mm²) in copper or 1/1.40 mm (1.5 mm²) in aluminium wire. For flexible cords & fitting wires, a smaller size is permissible viz. 14/0.193 mm

ii) Current Carrying Capacity :

The wire or cable should be of size sufficient to carry the maximum circuit current continuously without overheating. [Refer Table 8.3 Page no. 159 of Text book Author J. B Gupta]

iii) Voltage drop : Maximum voltage drop from supply terminals to any point on the installation is not to exceed the prescribed limit viz 2% of the supply voltage plus one volt for light load wiring and 5% of declared supply voltage for power load wiring. Voltage drop on AC cables is greater than dc due to inductance & capacitance but difference is very small (negligible for small loads) and need only be taken into account for heavy loads & long run.

Approximate Current Density for determination of size of cable

The size of the conductor depends upon the current, it is required to carry. A ready guide which is convenient to remember for determination of size of cable is given below

Current density of	For X-section of conductor of
5 A/mm²	less than 5 mm²
4 A/mm²	5 mm² to 10 mm²
2.5 A/mm²	10 mm² to 20 mm²
2.0 A/mm²	20 mm² to 40 mm²

(1) Determine the size of the conductor for a two-core cable required to carry the maximum current of 60 ampere. It is given that length of cable is 60 metres and declared supply voltage is 240 volts

Soln: Total ampere-metres in the circuit

= Maximum current of the circuit × length of circuit cable (lead and return)

= 60 × 120

= 7200 ampere-metres.

Permissible voltage drop = $\frac{2}{100} \times 240 + 1 = 5.8V$

Ampere-metres per volt of permissible drop

= $\frac{\text{Total ampere-meters in the circuit}}{\text{Permissible voltage drop}} = \frac{7200}{5.8} = 1240$

From table 2.3 the copper conductor cable having voltage drop of figure next to the figure of ampere-metres per volt drop determined above, is 19/1.32 mm having current carrying capacity of 74 amperes and giving 1 volt drop per 1475 ampere-metres. Since the current carrying capacity of the copper conductor cable of size 19/1.32 mm selected is 74A, more than circuit maximum current of 60 amperes and voltage drop caused by this cable will be equal to $\frac{7200}{1475} = 4.88$ volts, less than permissible voltage drop of 5.8 volts, hence selected.

(2) Determine the size of cable required to carry the maximum current of 50 amperes. It is given that length of cable is 500 metres and allowable voltage drop is 5% of declared supply voltage. Declared voltage is (i) 400 volts dc & ii) 400 volts ac

Soln Maximum Current to be Carried $I_{max} = 50A$

Length of cable $l = 500$ metres

Total ampere-metres in the circuit $= 500 \times 50$

$= 25000$ ampere-metres

Declared voltage $V = 400$ volts

The permissible voltage drop $v = 400 \times \frac{5}{100} = 20$ volts

Ampere-metres per volt of permissible volt drop

$$= \frac{\text{Total ampere metres in the circuit}}{\text{Permissible voltage drop}} = \frac{25000}{20} = 1250$$

i) When supply voltage is dc, copper conductor cable of 19/1.32 mm (from Table 8.3) of current carrying capacity of 59 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

$$= \frac{25000}{1475} = 17.0 \text{ volts, less than permissible voltage drop of } 20 \text{ volts}$$

ii) When supply voltage is ac copper conductor cable of 19/1.32 mm (from Table 8.3) of current carrying capacity of 59 amperes and causing 1 Volt drop per 1327 (0.9×1475) ampere-metres (taking into account inductance & capacitance of the cable) will be most suitable.

Voltage drop with the cable of size 19/1.32 mm

$$= \frac{25000}{1327} = 18.0 \text{ volts less than the permissible voltage drop.}$$

Types of Lighting Schemes

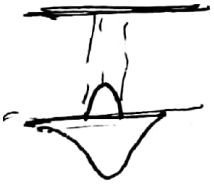
The distribution of the light emitted by lamps is usually controlled to some extent by means of reflectors or lenses. The lighting schemes may be classified as

i) Direct lighting: which is used in industrial and outdoor lighting where more than 90% of total light flux is made to fall on working plane with the help of deep reflectors.

ii) Semi-direct lighting where 60% to 90% of total light flux is made to fall down wards directly with the help of semi-direct reflectors and the remaining to illuminate ceiling & wall

iii) Semi-Indirect lighting, where 60 to 90% of total flux is thrown upwards to ceiling for reflection and the rest reaches working plane which is used for indoor decoration purpose

iv) Indirect lighting where more than 90% light thrown upwards to the ceiling for diffuse reflection by using inverted or bowl reflectors. In such a system the ceiling acts as the light source and the glare is reduced to minimum the resulting illumination is softer and more diffused the shadows are less and appearance of the room is much improved over that which results from direct lighting. It is used for decoration purposes in cinemas, theatres and hotels etc and in workshops where large pillars and other obstructions would cause troublesome shadows if direct lighting is employed.



v) General lighting: In this scheme lamps made of diffusing glasses are used which give nearly equal illumination in all directions.

Methods of lighting Calculations

The lighting outlets may be calculated by three methods

1. Watts per square metre method
2. Lumen or Light Flux method
3. Point to point or Inverse-square law method

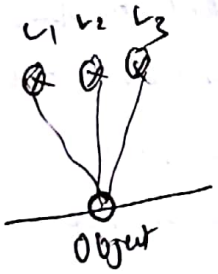
1) Watts per square metre method:

This method is used for rough calculation and it is "rule of thumb" method. It consists in making an allowance for watts per square metre of area to be illuminated according to the illumination desired on the assumption of an average figure of overall efficiency of the system.

2) Lumen or Light flux method:

This method is used where uniform illumination over the working plane is required.

3) Point to Point or Inverse-square law method



This method is applicable where the illumination at a point due to one or more sources of light is required, the candle power of the sources in the particular direction under consideration being known

Module-3 **Service Line or Service Main or Service Connection**

The overhead line or cable connecting the supplier's distributing line to the consumer premises is called service main or service line or service connection. The service connection terminates at the point, where the supply conductors enter the meter.

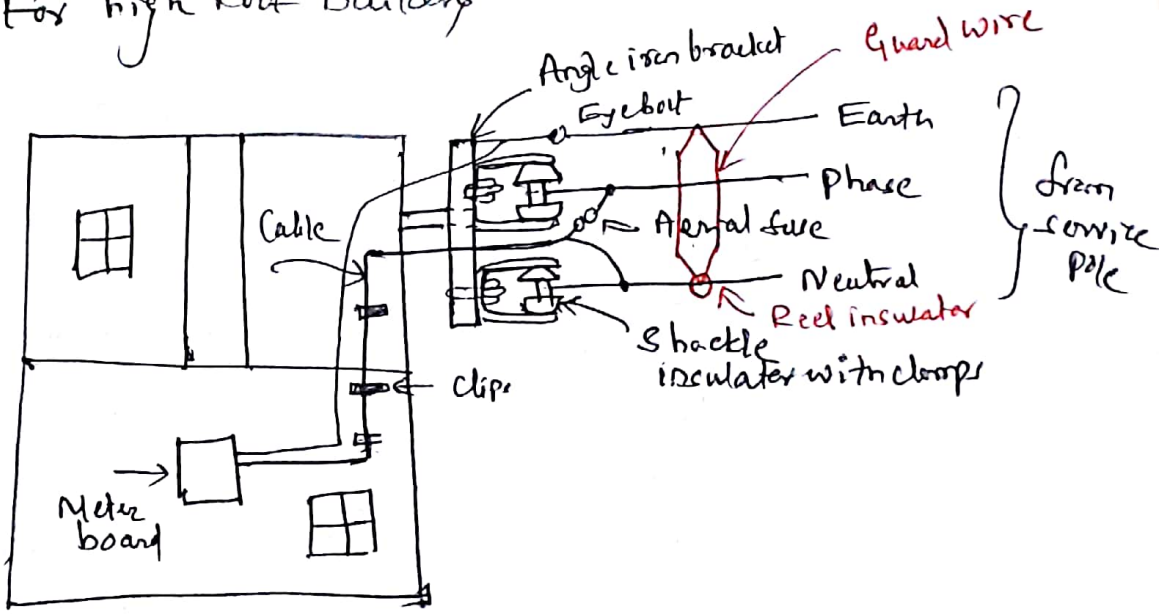
Methods of Installation of Service Lines

Service lines are of two types

1) Overhead service lines
2) Underground service lines

The various methods used for installation of overhead service lines are

1. (i) For high Roof Building



In such cases a service bracket (mild steel angle iron piece) is embedded into a wall at a suitable height. The pin type or shackle type insulators are fixed to the wall bracket. The number of insulators to be fitted depends upon the number of incoming wires (Two in case of general service connection and four in case of power service connection). As a rule the vertical distance between the insulators should be 35cm and the lateral distance 30cm.

The phase and neutral wires are taken from existing service pole and connected to the insulators fitted on the service bracket. The earth wire is connected to angle iron with the help of eye bolt. A weather proof or PVC cable known as service cable is connected to the conductors (overhead service line) - solidly or by means of connectors and may be carried either on wooden batten or inside a GI pipe or conduit of suitable size upto the service board. The GI pipe, if used is bent at the upper end with opening face downward in order to prevent the entry of rain water into the pipe.

ii) For low Roof or Single storeyed Building

If a building is of very low height, service bracket cannot be directly fixed to the wall if fixed the power conductors may not have distance from ground as per IE Rule. In such cases use of roof pole or GI pipe connection is made.

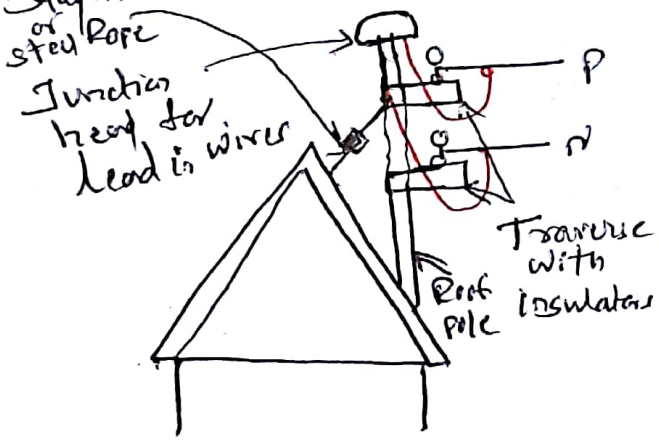


Fig ② Roof pole Connection

In case of roof pole connection as shown in fig 2 roof pole consists of a strong steel tube (60mm, 80mm or 90mm in diameter) provided with lateral arms on which the insulators are mounted. The height of roof pole should not exceed 3 metres, otherwise the tensile stresses involved will become too high. To keep tensile stress low, the roof pole is braced by a steel rope. If possible, the roof pole should be fastened to main truss of the roof construction.

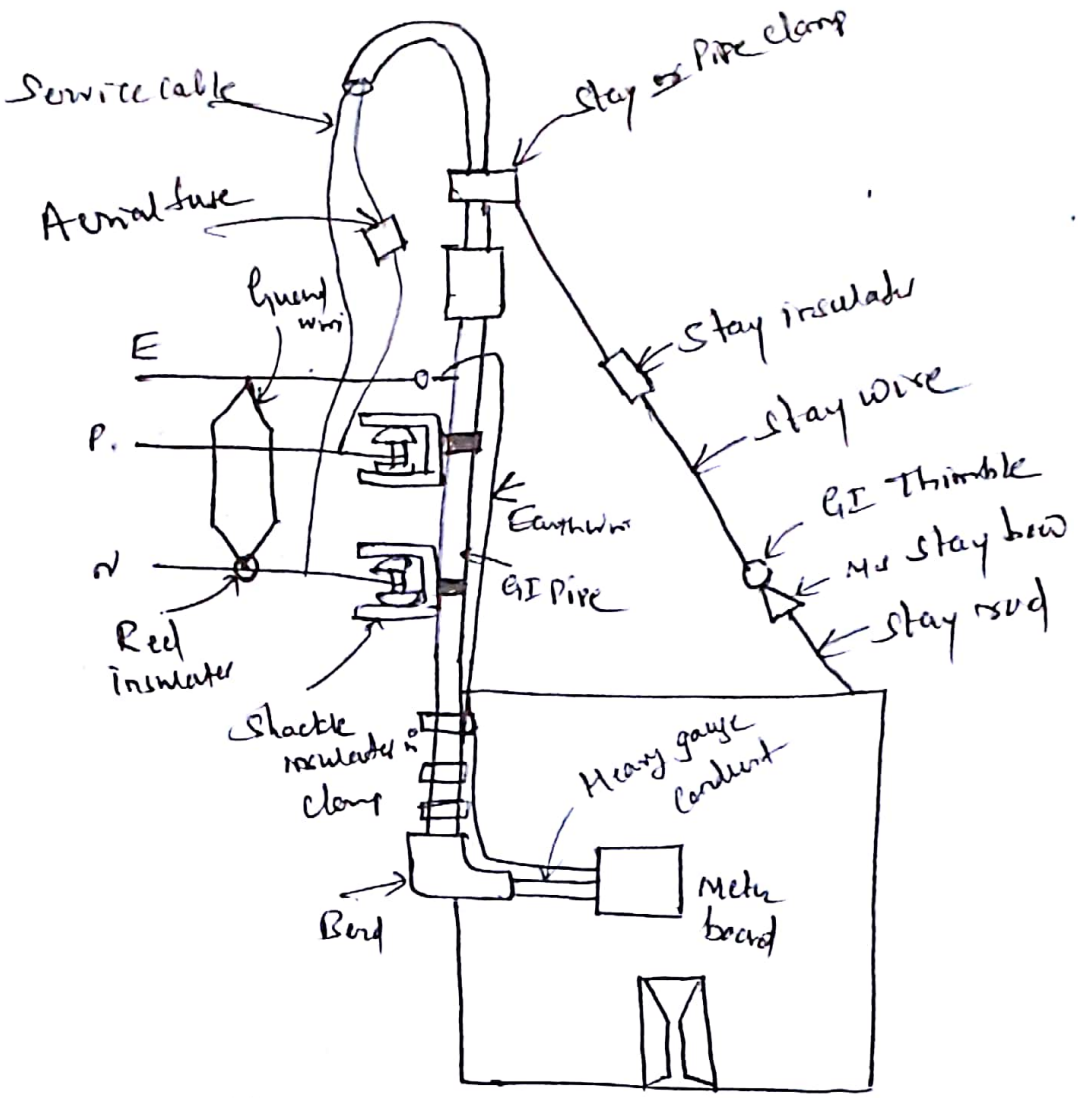


Fig ① G.I Pipe Service Connection

In case of GI pipe connection, GI pipe is raised above the roof to a suitable height. The GI pipe is suitably clamped to the wall at its lower end and is bent back and provided with a stay at its upper end. The service cable is carried to service board through GI pipe and heavy gauge conduit.

(iii) Weather proof Cable method: In this method an 8 SWG GI wire is stretched from the service pole to eye screw bolt fixed into a wall at a suitable height. The weather proof or PVC cable is then brought to the building by clipping it to the GI wire stretched between service pole and building and

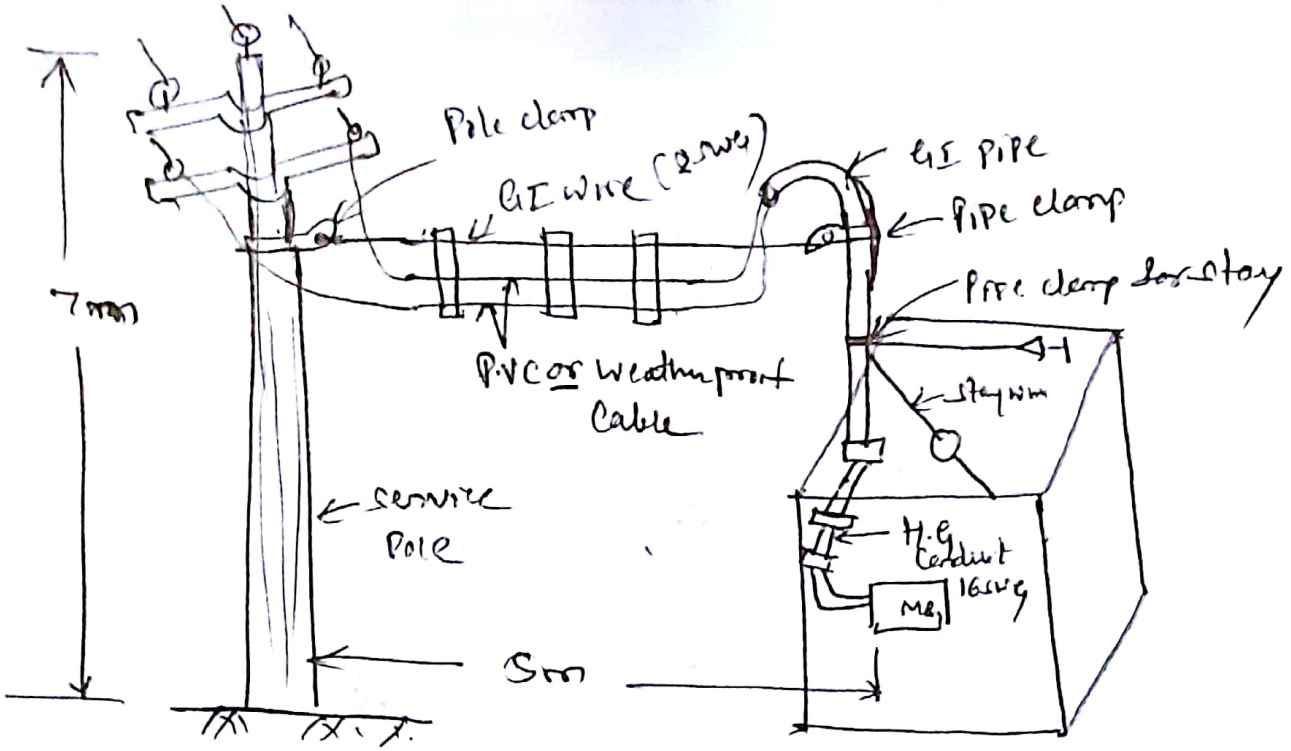


Fig ④ PVC / Weatherproof cable service Connection

then carried to service board as usual i.e on wooden batten or in a GI pipe or in a HG Conduit.

iv) Use of Junction or Joint box

For taking service connection from one house to another house use of Junction or Joint box is made. In this system the connections from existing pole are taken to the Junction box where the joints to cables for bifurcating the connections are made as shown in fig ①

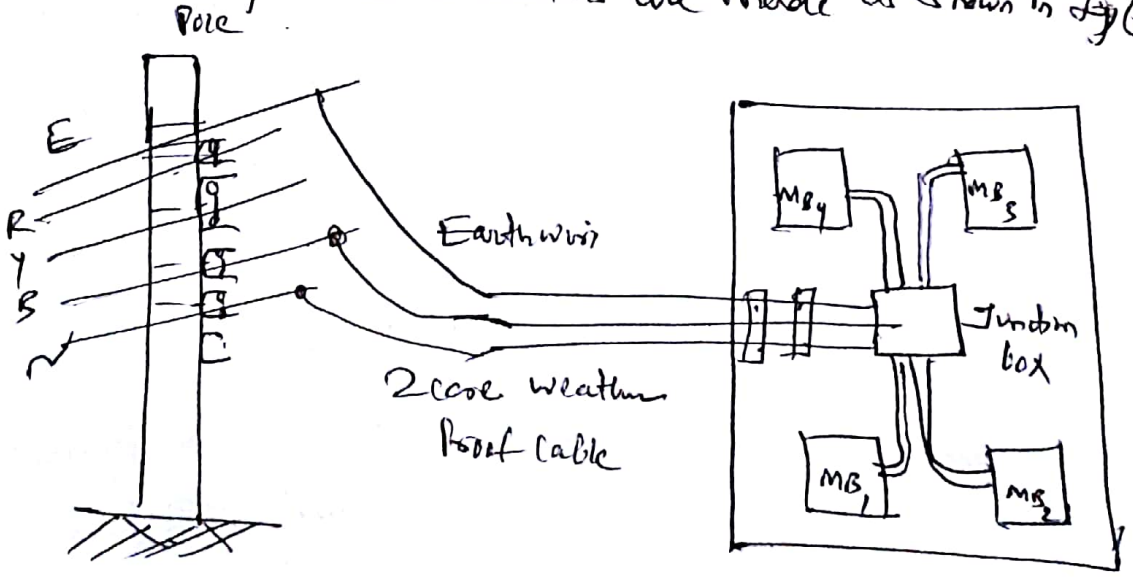


Fig ⑤ Joint box or Junction for service Connection

2. Underground Cable Service Connection

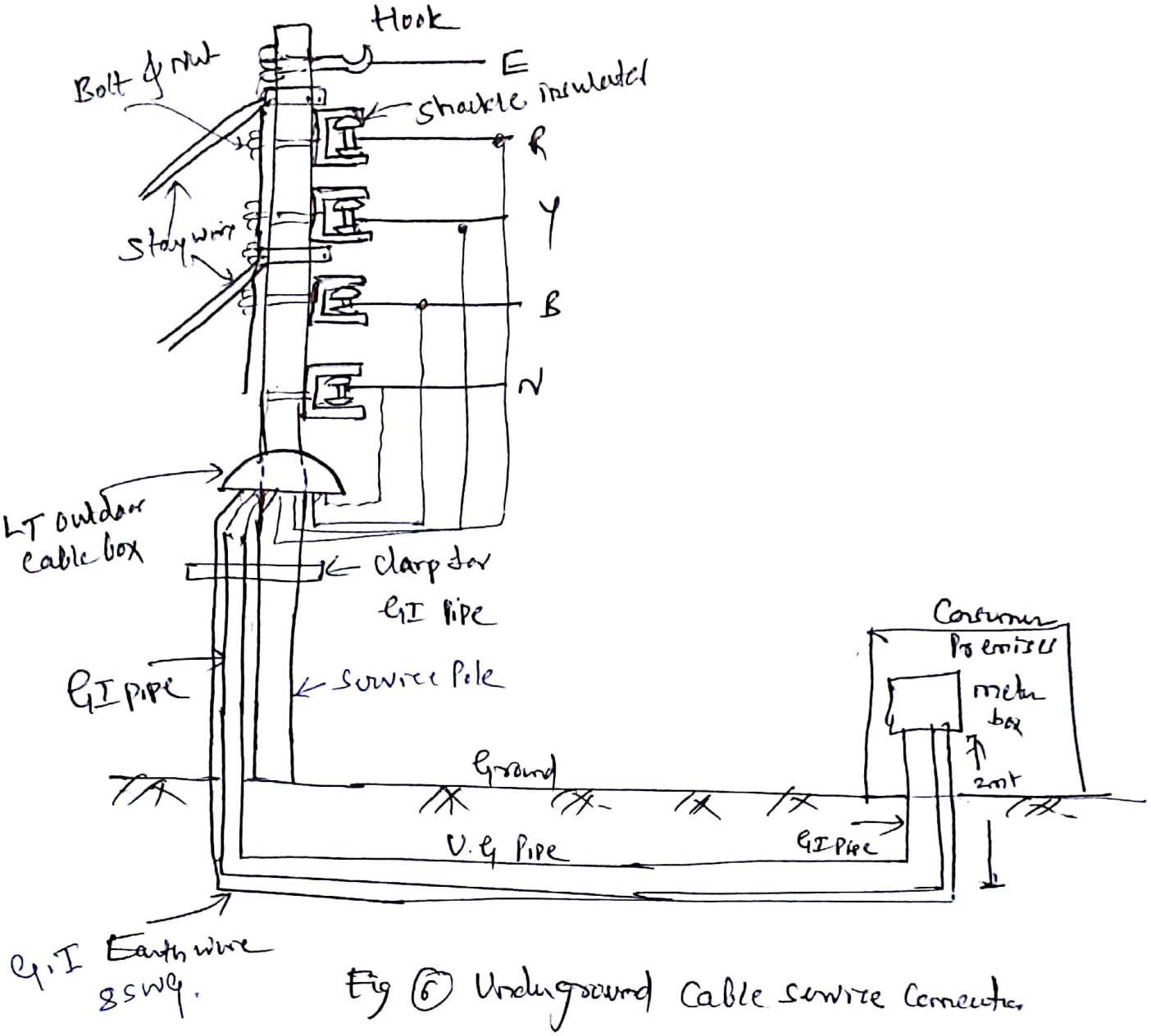


Fig ⑥ Underground Cable Service Connection

Use of underground cable is usually made for service connection when the power to be supplied to the consumer is large (say above 25 kW). For installation of underground cable service connection a cable box of suitable size fitted to the service pole by means of MS channel of size 65mm x 250mm and bolt & nuts. The cable is carried from the cable box fitted on pole to another cable box fitted on service board; first along the pole to the ground, then in the trench and lastly vertically along the wall to the second cable box. The trench starts from the pole and

terminates vertically below the service board. Use of GI pipe of suitable size is made upto 2 metres from the ground for enclosing the cable in order to save it from mechanical damage at both places i.e. along the Pole and below the service board. The cable is held to the pole by means of clamps.

Installation of Service Connection

Estimate

Ex 1) Prepare a list of material and estimate the cost for providing service connection to a single storey building at 240V single phase 50 Hz having a light and fan load of 5KW. The supply is to be given from an overhead line 20m away from the building.

Sol:- Connected load P = 5KW or 5000 W

Taking diversity factor of 1.66

Total load requirement = $\frac{5000}{1.66}$ = 3000 W

Keeping in view the future additional demand (say 100%) let the future load be twice of present load

i.e. 2 × 3000 W = 6000 W.

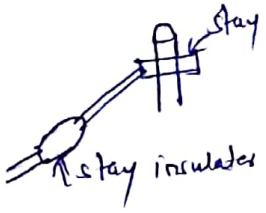
Load current in amperes = $\frac{\text{Load in watts}}{\text{Rated voltage}} = \frac{6000}{240} = 25\text{A}$.

Hence twin core 1/3.55 mm* (or 10 mm²) aluminium Conductor Weatherproof Cable having a current carrying capacity of 34 A may be employed.

The required material and cost for giving service connection is detailed below. (P.T.O)

* Refer Table 8.3 of Text book Page no. 159.

Sl No.	Description of Material with complete specifications.	Qty Required Qty	Unit	Rate ₹ P/Pm	Amount ₹ P	Remarks
1	$10mm^2$, 650V twin core aluminium Conducted weather proof cable	40	m	37 00/m	1500.00	2 nos brass 2 nos brass thimbles 1 no alloy GI Pipe and conduit upto service board & 5% wastage
2.	8 SWG GI Wire	40 m (4) kg		270 00/kg	1080.00	
3.	GI pipe 50mm diameter	4	m	180 00/m	720.00	
4	H.G Conduit 10 SWG 25mm diameter	4	m	27 00/m	108.00	
5.	Pole clamp	1	No.	27 00/each	27.00	one for fixing thimbles to the pole
6.	Pipe clamps	2	no.	27 00/each	54.00	one for fixing thimbles to GI Pipe & one for stay
7.	GI thimbles	3	No	15 00/each	45.00	
		↳ 2 for connecting GI wire to Pole and GI Pipe and one for stay				
8.	Wooden bushes for GI pipe	1	no	8 00/each	8.00	
9.	Conduit reducers 50mm X 25mm	1	no	15 00/each	15.00	
10	Conduit bend for for 25mm Conduit	1	no.	10 00/each	10.00	
11	Lock nut for 25mm Conduit	1	no.	8.00/each	8.00	At service Board
12.	Conduit bushing for 25mm Conduit	1	no	3 00/each	3.00	
13.	Wooden plugs	25	no.	80.00/100	20.00	
14.	Conduit Saddles					
	i) 50 mm	4	no.	5.00/each	20.00	
	ii) 25 mm	8	no.	3.00/each	24.00	
15.	IC main board of size 25cm X 30cm	1	no.	373.00/each	375.00	
16	Kitkat type 32A	1	no.	55.00/each	55.00	
17	Neutral link	1	no.	8.00/each	8.00	
18.	Aerial fuse 32A Capacity	1	no.	55.00/each	55.00	
19.	Stay wire 7/10 SWG	10 m (1) kg.		120.00/kg	120.00	
20.	Stay bow	1	no.	75.00/each	75.00	
21	Stay rod with bolts & stay buckle	1	no.	75.00/each	75.00	
22.	Stay insulator	1	no.	100.00/each	100.00	
23	Cement	1	bag	250.00/bag	250.00	
24	Sand	5	bags	20.00/bag	100.00	



	3 kg	80.00 / kg	240.00
		Total	5095.00
Storage and transportation charges		5%	254.75
Labour Charges		10%	509.50
Contingencies		1%	50.95
Electrical inspection fee			400.00
Single phase 25A, 240V, 50Hz E.M			1600.00
		Grand Total ₹	7910.20

EX 2) A farmer requires to connect a 3φ 37kW, 415V, 50Hz motor to a 3φ 4-wire 415/240V, 50Hz overhead line. The distance of the service line from the farmer structure having motor is 15m. The motor has an efficiency of 85% and a power factor of 0.8 Estimate the quantity and cost of material required.

Sol) Motor full load Current $I_f = \frac{\text{Motor o/p in kW} \times 1000}{\sqrt{3} \times V_L \times \eta \times \cos\phi}$

$= \frac{37 \times 1000}{\sqrt{3} \times 415 \times 0.85 \times 0.8} = 75.7\ A$

Starting Current $I_{st} = 1.5 \times I_f = 1.5 \times 75.7 = 113.6\ A$

Refer Table 3.7 Page no 46 of Text book

The Service Connection will be given by $3\frac{1}{2}$ core, 35mm², 1100V, aluminium conductor armoured cable which can carry 128A current

Total length of cable required = Length along the pole up to ground + Length along the trench + Vertical run upto cable box + for wastage & Connections

$= 6 + 15 + 2 + 3 = 26m$

The quantity and cost of material required is estimated below

(P.T.O)

S/No.	Description of material with Complete specifications	Qty Required	Unit	Rate ₹ P Per	Amount ₹ P	Remarks
1 *	$35mm^2$ 3½ core, 1100V, Al conductor Armoured Cable	26	m	270.00 m	7020.00	
2.	Laying of Cable underground at 1m depth covered with sand in trench and clamped properly on pole over ground	26	m	30.00 m	780.00	
3.	LT Cable box suitable for cable at item no. 1 outdoor type with bracket	1	NO.	525.00 each	525.00	For service Pole
4	Erection of Cable box Complete in all respects	1	NO.	60.00 each	60.00	
5.	GI pipe for cable at item no. 1	4	m	180.00 m	720.00	
6.	Pole Clamps for above Cable & GI pipe	6	NOS	75.00 each	450.00	
7.	200A 415V, ICTPN switch fuse unit With HRC fuses	1	NO.	9000.00 each	9000.00	Housed in indoor structure
8.	IC cut-outs fitted with fuse wires Complete in all respects for outdoor use	1	set	480.00 each	480.00	
9. **	P.VC Cable ~~19/0.84mm~~ single core aluminium conductor 1100V grade	10	m	210.00 m	2100.00	Connection from LT Cable box to DP/TPN switch fuse unit
10.	IC service board 45cm x 30cm	1	NO.	375.00 each	375.00	
11	Earthing set	2	NO.	3200.00 each	6400.00	
12.	GI Wire 8 SWG.	20 m (2) (kg)		270.00 kg	540.00	
13.	Bolts & nuts (Lump-sum)				350.00	
14.	Petty items like binders, sand bands etc				1400.00	Lump-sum provision
				Total ₹	30,200.00	
				Storage & Transportation charges 5%	1510.00	
				Labour charges already included	—	
				Contingencies (10% / 1%)	3020.00	
				Electrical Inspection fee (1%)	302.00	
				Energy meter 100A, 415V, 3φ 4 wire	7000.00	
				Energy meter 10A, 240V, 1φ	1400.00	
				Grand Total	₹ 40,732.00 say ₹ 41,000.00	

* Refer table 3.7 Page no 46

** Refer Table 3.2 Page no. 43 of Text book

Module-3

Electrical Installation for Power Circuits

Power circuits may be of 2 types

1) Power circuits for heaters, coolers, refrigerators, air conditioner etc
2) Power circuits for motors, generators, Machine tools, other ventilation equipment special purpose large loads.

Wiring for heaters, coolers, refrigerators, air-conditioners etc. are done similar to lighting ckt where subcircuit are restricated 10 outlet points or load of 800 watts but in power circuits sub circuits are restricated to 2 outlet points or 3000 watts of load. (IS 4648-1968)

Wiring for motor ckts: PVC cables of suitable size Conductor depending upon the rating of motor, run in rigid metallic conduit or laid underground.

Important Considerations regarding motor installation

Wiring

1. All equipment used in power wiring shall be of iron clad Construction and wiring shall be of the armoured Cable or Conduit type (IE Rule 51)
2. Wood work shall not be used for mounting of switchgear
3. Looping of Conductors and use of the joints shall not be done
4. The length of flexible conduit used for connections b/w the terminal boxes of motors and starter, switches and motors shall not exceed 1.25 metres
5. Every motor regardless of its size shall be provided with a switch fuse placed near it.
6. In addition to switch fuse all motor shall be provided with suitable means for starting and stopping (starter) placed at convenient places. The starter are used to limit the starting current to a desirable value.

Type of starter	Rating of AC Motor
Direct-on-line (DOL)	upto 0.75 kW
Star-delta starter	above 0.75 kW and below 11 kW
Auto-TFR starter	above 11 kW

* Rotor resistance starter in case of slip-ring induction motors

7. The conduct should preferably be laid in covered trenches to facilitate operator movement (safe)
8. Laying of cables must be in separate conduits for seperate motors

9. The minimum cross section of conductor that can be used for power wiring is 2.5 mm² for aluminium conductor cables & 1.25 mm² for copper conductor cables.

10. The current rating of cables for supply to motor may be based on the normal full load current of the motor but fuse rating should be based on ~~normal full-load~~ starting current. In no case should the rating of the fuse be greater than twice the rating of the cable. So the following points must be observed

a) For motors of capacity above 12 kW having starting current lower than twice normal full-load the current rating of the cables is to be based on normal-full load current of motors and current rating of fuses on motor starting current.

$I_{st} < 2I_{FL}$

b) For motors of capacity below 12 kW, which have a very large starting current fuse should be of current rating to carry starting current safely and cable of current rating not lower than half the current rating of fuse.

11. The conduit used in power wiring shall be electrically continuous throughout and connected to the frame of the motor. The frame of the motor shall be earthed by the owner by two separate and distinct connections of earth

12. The wire used to earthing conductor shall be of copper or galvanised iron. The x-sectional area of copper earthing wire should be not smaller than half of the largest current carrying conductor used in wiring. The x-sectional area of G.I wire, if used as an earthing conductor, should be such that its conductivity is not less than that of copper conductor.

Determination of Input Current to motors

In case of dc motors the calculations of current required by the motor is quite simple. For example current required by a 500 Volt, 10 hp (metric) dc motor at 80% efficiency is $\frac{10 \times 735.5}{500 \times 0.8} = 18.4A$.

In case of 1ϕ A.C motors, while calculating the input current required the power factor at which the motor operates is also to be taken into account. The power factor is a fraction usually b/w 0.75 & 0.9 depending on the type and size of motor. The input current to 1ϕ A.C motor is determined from the following relation

$$\text{Input Current} = \frac{\text{Rated bhp} \times 735.5}{\eta_m \times V \times \cos\phi}$$

Where η_m is the motor efficiency at full load,
V is the supply voltage &
$\cos\phi$ is the P.f of the motor at full load.

Input Current:
$\frac{2 \times 735.5}{0.8 \times 240 \times 0.7}$
i.e. 10.95A

For determination of input current to 3ϕ A.C motors use of following expression is made

$$\text{Input line current } I_L = \frac{\text{Rated bhp} \times 735.5}{\sqrt{3} \times \eta_m \times V_L \times \cos\phi}$$

↑ Line voltage

For example the input line current to a 3ϕ, 415V, (10hp (metric) motor at 80% efficiency & 0.85 P.f comes out to be equal to

$$\frac{10 \times 735.5}{\sqrt{3} \times 0.8 \times 415 \times 0.85} \quad \text{i.e. } 15.05A$$

13. Since supplier provides and maintains only a suitable earthed terminal at or near the point of Commencement of supply at the Consumer premises, the Consumer is required to provide his own earthing system with an independent electrode.

14. While deciding the current rating of a main switch controlling a group of motors, starting current of one motor (highest rating) plus full load current of remaining motors shall be considered.

Determination of Input Power

Motors are rated (In SI system motors are rated in kW) in brake horse power (bhp). the motor input will be greater than motor output due to motor internal losses such as iron loss, copper loss and frictional loss etc. For determination of input to motor for wiring calculations, these losses need not be determined separately but input is determined by making use of simple term, the efficiency of the motor which represents the ratio of output to input. The efficiency of motors varies from 50% to 65% below 1 hp ; from 70% to 75% for motors of ratings 1 and 2hp, 75% to 80% for motor of ratings b/w 2.5 and 5hp and rises gradually up to 90% for large sized motors. However, modern motors - special purpose motors at a higher cost are designed for higher efficiencies.

Thus Mathematically the input to the motor in watts is given as. Input in watts = $\frac{\text{Output in watts}}{\text{Motor efficiency}} = \frac{\text{Rated bhp} \times 735.5}{\eta_m}$

Since 1 hp (metric) = 735.5 watts

Determination of Rating of Cables

When a motor is started it draws current larger than full load current. Since this excessive current is only for a short period, and in the case of larger motor it is limited by various devices the starting current need not be taken into account for determination of size of wire or cable and the size of wire or cable is determined as per full load current of the motor.

Determination of Rating of fuses

The fuse wire employed for protection of motor should be of such a size that it may carry the starting current safely but in no case the rating of fuse should be greater than twice the rating of cables. In case of motor having starting current lower than twice their normal full load current, the current rating of cables should be based on normal full-load current and current rating of fuse should be based upon motor starting current as usual. But in case of motors having starting current higher than twice of their normal full load current, the rating of fuse should be based upon the motor starting current and the cable should be of current rating not lower than half of the current rating of fuse.

$I_{st} < 2I_{FL}$
(Cable rating
fuse rating

$I_{st} > 2I_{FL}$
(Fuse rating
Cable rating
$\geq \frac{1}{2}$ fuse rating

Determination of size of Conduit, Distribution Board, Main switch and starter.

The number of cables of different sizes that can be accommodated in various sizes of conduits are given in table. Knowing the size of cable and number of cables to be carried, the size of conduit is determined from table.

The number of ways, voltage rating and current rating of distribution board is decided from the number of circuits to be fed from it, voltage rating of the circuit and starting current of the sub-circuit having highest current rating respectively.

The current rating of the main switch is decided keeping in view the fact that it should be capable of handling starting current of one motor (of highest rating) plus full load current of remaining motors to be controlled from it.

For starting of squirrel cage I.M. of capacity upto 0.75 KW, b/w 0.75 KW & 11 KW and above 11 KW direct on line (D.O.L) starter, star-delta starter and auto transformer starter respectively are used.

For starting of slip-ring I.M. of high rating rotor resistance starter is used.