



BHADRAK ENGINEERING SCHOOL & TECHNOLOGY (BEST),
ASURALI, BHADRAK

Electrical Installation & Estimating (Th- 01)

(As per the 2019-20 syllabus of the SCTE&VT,
Bhubaneswar, Odisha)



Sixth Semester

Electrical Engg.

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ELECTRICAL INSTALLATION AND ESTIMATING
CHAPTER-WISE DISTRIBUTION OF PERIODS & MARKS

Sl. No.	Chapter/ Unit No.	Topics	Periods as per Syllabus	Expected Marks
01	01	Indian electricity rules	06	10
02	02	Electrical installations	12	20
03	03	Internal wiring	12	20
04	04	Overhead installation	12	20
05	05	Overhead service lines	12	20
06	06	Estimating for distribution substations	06	20
TOTAL			60	110

CHAPTER NO.-01

INDIAN ELECTRICITY RULES

Learning Objectives:

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

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

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

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

Estimating:

- It is defined as an art of assessment of different items and their cost as per the plan which are required for executing a work before actually done.

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

- Following words have their specific meaning according to the Indian electricity rules

Ampere:

- It is the unit of current
- In other words it is the unvarying electric current which when passed through a solution of nitrate of silver in the water, it deposits silver at the rate of 0.01118 gm/s.

Volt:

- It is the unit of voltage or e.m.f
- It is also defined as an 1 volt of electric potential which when apply steadily to a conductor containing 1 ohm resistance will flow or cause to flow 1 amp of current.

Circuit:

- It is the defined as a closed path along which the electric current can flow.

Circuit breaker:

- It is defined as a device which is capable of making and breaking the circuit under all condition.

Switch:

- It is defined as a manually operate device for closing and opening of an electrical circuit.

Cut out:

- It is defined as an appliance which is capable of automatically interrupting the electrical energy through any conductor when the current rises above the pre-determined amount.

Conductor:

- It is defined as an material which conducts the electrical energy or currents when connected with an electrical system.

Live:

- It is defined as something which is electrically charged.

Dead:

- It is defined as something which is disconnected from any live system and it must have the potential equal to the earth potential.

Span:

- The horizontal distance between the two adjacent or consecutive supports is called as span.

Danger:

- It is defined as any injury to person or property or fire explosion of burning or any part of the body from electric shock or injury to life due to generation, transmission, distribution & utilization of electric power of energy.

Earthing system:

- It is defined as a system in which all the appliances are properly earth.

System:

- It is defined as an electrical arrangement in which all the conductor s or apparatus are connected electrically to a common source of supply.

Apparatus:

- It is defined as electrical equipment's which includes all accessories m/c fitting & appliance where conductor is used.

Bare:

- It is defined as something which is not covered with any insulating materials.

Conduit:

- It is defined as a tubular structure may be of rigid or flexible which is mechanically strong and fire proof through which cables are drawn

Cable:

- It is defined as a length of insulating single or more conductors which are aid up together.

Electrician:

- It is defined as a person over 21 years of age & is competent for all the I.E rules in which, he is assign to his work & who has been appointed by the agent or manager of the installation.

Voltage:

- It means the difference of electrical potential measured in volts between any part of the conductor & the earth as measured by a suitable voltmeter.

Low Voltage:

- According to I.E rules it is defined as a voltage which does not exceeds 250V under normal condition subjected to the percentage of variation allowed by the rules.

Medium Voltage:

- According to I.E rules, it is defined as a voltage ranging from 250V to 650V under normal conditions subjected to the percentage of the variation allowed by the rules.

High Voltage:

- According to I.E rules, it is defined as the voltage ranging from 650V to 33000V or 33KV under normal condition allowed by the rules.

Extra high voltage:

- According to I.E rules it is defined as the voltage which exceeds above 33kv under normal condition subjected to the percentage of variation allowed by the rule.
- The maximum voltage regulation allowed for low voltage and medium voltage is +/- 5% as per I.E rules.

- The maximum voltage regulation allowed for high voltage and extra high voltage is $\pm 12.5\%$ as per I.E rules.

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

Rule-29:

- Construction, installation, protection, operation & maintenance of electric supply lines & apparatus.
- 1. All electric supply lines and apparatus shall be sufficient in power and size and of sufficient mechanical strength for the work they may be required to do, and, so far as is practicable, shall be constructed, installed, protected, worked and maintained in accordance with standards of the Indian Standards Institution so as to prevent danger.

Rule-30:

- Service lines and apparatus on consumer's premises.
- 1. The supplier shall ensure that all electric supply lines, wires, fittings and apparatus belonging to him or under his control which are on a consumer's premises are in a safe condition and in all respects fit for supplying energy, and the supplier shall take due precautions to avoid danger arising on such premises from such supply lines, wires, fittings and apparatus.
- 2. Service line placed by the supplier on the premises of a consumer which are underground or which are accessible shall be so insulated and protected by the supplier as to be secured under all ordinary conditions against electrical, mechanical, chemical or other injury to the insulation.
- 3. The consumer shall also, as far as circumstances permit, take precautions for the safe custody of the equipment on his premises belonging to the supplier.
- 4. The consumer shall also ensure that the installation under his control is maintained in a safe condition.

Rule-31:

- Cut-out consumer's premises.
- 1. The supplier shall provide a suitable cut-out in each conductor of every line other than an earthed or earthed neutral conductor or the earthed external conductor of concentric cables within a consumer's premises in an accessible position. Such cut-out shall be contained with adequately enclosed fire-proof receptacle. Where more than one consumer is supplied through a common service line, each such consumer shall be provided with an independent cut-out at the point of junction to the common service.
- 2. The owner of every electric supply line, other than the earthed or neutral conductor of concentric cable, shall protect it by suitable cut-out.

Rule-32:

- Identification of earthed and earthed neutral conductor and position of switches and cut-outs therein.
- Where the conductors include an earthed conductor of a two-wire system or an earthed neutral conductor of a multi-wire system or a conductor which is to be connected there to, the following conditions shall be complied with.
- 1. An indication of a permanent nature shall be provided by the owner of the earthed or earthed neutral conductor, or the conductor which is to be connected thereto, to enable such conductor to be distinguished from any live conductor. Such indication shall be provided.
 - (a) Where the earthed or earthed neutral conductor is the property of the supplier, at or near the point of commencement of supply.

- (b) Where a conductor forming part of a consumer's system is to be connected to the supplier's earthed or earthed neutral conductor, at the point where such connection is to be made.
 - (c) In all other cases, at a point corresponding to the point of commencement of supply or at such other points as may be approved by an Inspector.
2. No cut-out, link or switch other than a linked switch arranged to operate simultaneously on the earthed or earthed neutral conductor and live conductors shall be inserted or remain inserted in any earthed or earthed neutral conductor in a two-wire system or in any earthed or earthed neutral conductor of multi-wire system or in any conductor connected there to with the following exceptions:
 - (a) A link for testing purposes, or
 - (b) A switch for used in controlling a generator or transformer.

Rule-33:

- Earthed terminal on consumer's premises.
1. The supplier shall provide & maintain on the consumer's premises use a suitable earthed terminal in an accessible position at or near the point of commencement of supply as defined under rule 58.
 2. The consumer shall take all reasonable precaution to prevent mechanical damage to the earthed terminal and its lead belonging to the supplier.
 3. The supplier may recover from the consumer the cost of installation of such earthed terminal on the basis laid down in sub-rule (2) of rule 82.

Rule-34:

- Accessibility of bare conductor-
- Where bare conductor s are used in a building the owner of such conductors shall Ensure that they are inaccessible.
- Take such other safety measure as are considered necessary by the inspector.

Rule-35:

- Caution notice.
- The owner of every medium, high and extra voltage installation shall affix permanently in a conspicuous position a caution notice in Hindi and the local language of the district and of a type approved by the Inspector on:
 - (a) every motor, generator, transformer and other electrical plant and equipment together with apparatus used for controlling or regulating the same :
 - (b) all supports of high and extra voltage overhead lines;
 - (c) luminous tube sign requiring high voltage supply X-ray and similar high-frequency installation;

Rule-36:

- Handling of electric supply lines, apparatus.
1. Before any conductor or apparatus is handled, adequate precautions shall be taken by Earthing or other suitable means, to discharge electrically such conductor or apparatus, and any adjacent conductor or apparatus if there is danger there from, and to prevent conductor or apparatus from being accidentally or inadvertently electrically charged when persons are working thereon; Provided that the sub-rule shall not apply to the cleaning of Commutator and slip-rings working at low or medium voltage.
 2. No person shall work on any live electric supply line or apparatus and no person shall assist such person on such work unless he is authorized in that behalf, and takes the safety measures approved by the inspector.
 3. Every telecommunication line on supports carrying a high or extra high voltage line shall for the purpose of working thereon, be deemed to be a high voltage line.

Rule-40:

- Street Boxes.
- 1. Street boxes shall not contain gas pipes, and precautions shall be taken to prevent, as far as reasonably possible, say influx of water or gas.
- 2. Where electric supply lines forming part of different systems pass through the same street box they shall be readily distinguishable from one another and all electric supply lines at high or extra-high voltage in street boxes shall be adequately supported so as to prevent risk of damage to or danger from adjacent electric supply lines.
- 3. All street boxes shall be regularly inspected for the purpose of detecting the presence of gas and if any influx or accumulation is discovered, the owner shall give immediate notice to any authority or company who have gas mains in the neighborhood of the street box and in cases where a street box is large enough to admit the entrance of a person after the electric supply lines apparatus therein have been placed in position, ample provision shall be made.
 - a. to ensure that any gas which may have accidentally obtained access to the box shall escape before a person is allowed to enter, and
 - b. for the prevention of danger from sparking.
- 4. The owners of street boxes or pillars containing circuits or apparatus shall ensure that their covers and doors are so provided that they can be opened only by means of a key or a special appliance.

Rule-41:

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

Rule-43:

- Provisions applicable to protective equipment.
- 1. Fire buckets filled with clean dry sand and ready for immediate use for extinguishing fires, in addition to fire extinguishers, suitable for dealing with electric fires, shall be conspicuously marked and kept in all generating stations, enclosed sub-stations and enclosed switch-stations in convenient situations.
- 2. First aid boxes or cup boards, conspicuously marked and equipped with such contents as the State Government may specify, shall be provided and maintained in every generating station, enclosed sub-station and enclosed switch station so as to be readily accessible during all working hours. All such boxes and cupboards shall, except in the case of attended substations and switch stations be kept in charge of responsible persons who are trained in first aid treatment and one of such persons shall be available during working hours.

Rule-44:

- Instructions for Restoration of Persons suffering from Electric Shock.
- 1. Instructions, in English, Hindi and the local languages of the district for the restoration of person suffering from electric shock, shall be affixed by the owner in a conspicuous place in every generating station, enclosed sub-station, enclosed switch station and in every factory as defined in clause (m) of section 2 of the Factory Act, 1948 (LXIII of 1946) in which electricity is used and in such other premises where electricity is used as the Inspector may by notice in writing serve on the owner, direct.
- 2. Copies of instruction shall be supplied on demand by an officer appointed by the Central or State Government in this behalf at a price to be fixed by the Central or the State Government.

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

Rule-45:

- Precautions to be Adopted by Consumers, Owners, Electrical Contractors, Electrical Workmen and Suppliers.
- (1) No electrical installation work, including additions, alterations, repairs and adjustment to existing installations, except such replacement of lamps, fans, fuses, switches, low voltage domestic appliances and fitting as in no way alters its capacity or character, shall be carried out upon the premises of or behalf of any consumer or owner for the supply to such consumer or owner, except by an electrical contractor licensed in this behalf by the State Government and under the direct supervision of a person holding a certificate of competency issued or recognized by the State Government.
- (2) No electrical installation work which has been carried out in contravention of sub-rule (1) shall be connected with the works of any supplier.
- (3) The provisions of sub-rule (1) shall come into force in respect of a state or part thereof on such date as the State Government may, by notification in the official Gazette appoint;

Rule-46:

- Periodical inspection and testing of consumer's installation.
- 1. (a) Where an installation is already connected to the supply system of the supplier every such installation shall be periodically inspected and tested at intervals not exceeding five years either by the Inspector or by the supplier as may be directed by State Government.
(b) Where the supplier is directed by the Central or the State Government as the case may be, inspect and test the installation, he shall report on the condition of the installation to the consumer concerned in a form approved by the Inspector and shall submit a copy of such report to the Inspector.
- 2. (a) The fees for such inspection and test shall be determined by the Central or State Government, as the case may be, in the case of such class of consumers and shall be payable by the consumers in advance.
(b) In the event of the failure of any consumer to pay the fees on or before the date specified in the fee-notice, supply to the installation of such consumer shall be liable to be disconnected under the direction of the Inspector. Such disconnection, however, shall not be made by the supplier, without giving to the consumer seven clear days' notice in writing of his intention to do so.
- 3. Notwithstanding the provisions of this rule, the consumer shall at all times be solely responsible for the maintenance of his installation in each conditions as to be free from danger.

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

Rule-47:

- Testing a consumer's installation.
- 1. Upon receipt of an application for a new or additional supply of energy and before connecting the supply or reconnecting the same after a period of six months, the supplier shall inspect and test the applicant's installation.

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

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

Rule-48:

- Precautions against leakage before connecting .
1. The supplier shall not connect with his works the installation or apparatus on the premises of any applicant for supply unless he is reasonably satisfied that the connection will not, at the time of making the connection, cause a leakage from the installation or the apparatus exceeding one five thousandth part of the maximum current supplied to the applicant's premises.
 2. If the supplier declines to make connection under the provisions of sub-rule (1) he shall serve upon the applicant a notice in writing, stating his reason for so declining.

Rule-49:

- Leakage on consumer's premises.
1. If the inspector or the supplier has reason to believe that there is leakage in the system of consumer which is likely to affect injuriously the use of energy by the supplier or by the other persons, or which is likely to cause danger he may give the consumer reasonable notice in writing that he desires to inspect and test the consumer's installation.
 2. If on such notice being given:
 - (a) the consumer does not give all reasonable facilities for inspection and testing of his installation, or,
 - (b) a leakage exceeding one five-thousandth part of the maximum current supplied to the consumer's installation is shown to exist. The supplier may, and if directed to do by the inspector, shall discontinue the supply of energy to the installation but only after giving to the consumer forty eight hour's notice in writing of disconnection of supply and shall not commence the supply until he or the Inspector is satisfied that the cause of the leakage has been removed.

Rule-50:

- Supply to consumers.
1. The supplier shall not commence or continue to give supply of energy to any consumer unless :
 - (a) A suitable linked switch or a circuit-breaker of requisite capacity to carry and break the current is placed as near as possible to, but after the point of commencement of supply as defined under rule 58 , so as to be readily accessible and capable of being easily operated to completely isolate the supply to the installation, such equipment being in addition to any equipment installed for controlling individual circuits or apparatus;
Provided that where the point of commencement of supply and consumer's apparatus are near each other, one linked switch or circuit-breaker near the point of commencement of supply shall be considered sufficient for the purpose of this rule;
 - (b) A suitable linked switch or a circuit breaker of requisite capacity to carry and break the full-load current is inserted on the secondary side of a transformer, in the case of high or extra high voltage installation. Provided, however, that the linked switch on the primary side of the transformer may be of such capacity as to carry the full-load current and to break only the magnetizing current of the transformer;

Provided further that the provision of this clause shall not apply to transformers installed in substations up to and including 100kVA belonging to the supplier.

(c) every distinct circuit is protected against excess energy by means of a suitable cut-out or a circuit breaker of adequate breaking capacity suitably located and so constructed as to prevent danger from overheating, arcing or scattering of hot metal of cut-out without danger;

(d) the supply of energy to each motor or other apparatus is controlled by a suitable linked switch or a circuit breaker of requisite capacity placed in such a position as to be adjacent to the motor or other apparatus readily accessible to and easily operated by the person in charge and so connected in circuit that by its means all supply of energy can be cut off from the motor or apparatus and from regulating switch, resistance or other device associated therewith:

(e) all insulating material is chosen with special regard to the circumstances of its proposed use, the mechanical strength being sufficient for its purpose and so far as is practicable, is of such a character or so protected as to maintain adequately its insulating properties under all working conditions in respect of temperature and moisture; and

(f) adequate precautions are taken to ensure that no live parts are so exposed as to cause danger.

2. Every consumer or other user of energy shall so maintain his installation as to conform at all times to the provisions of sub-rule (1) and shall use all reasonable means in his power to ensure that where energy is supplied by a supplier, no person other than the supplier shall interfere with the service lines and apparatus placed by the supplier on his premises.

Rule-51:

- Provisions Applicable to Medium, High or Extra High voltage installations.
- The following provisions shall be observed where energy at medium, high or extra-high voltage is supplied, converted, transformed or used:
 1. (a) All conductors (other than those of overhead lines) shall be completely enclosed in mechanically strong metal casing or metallic covering which is electrically and mechanically continuous and adequately protected against mechanical damage unless the said conductors are accessible only to an authorized person or are installed and protected to the satisfaction of the Inspector so as to prevent danger.
 - (b) All metal work enclosing, supporting or associated with the installation other than that designed to serve as a conductor shall, if considered necessary by the Inspector, be connected with earth.

Rule-54:

- Declared Voltage of Supply to Consumer.
- 1. Except with the written consent of the consumer or the previous sanction of the State Government a supplier shall not permit the voltage at the point of commencement of supply as defined under rule 58 to vary from the declared voltage by more than 5 percent in the case of low or medium voltage or by more than $12\frac{1}{2}$ percent in the case of high or extra-high voltage.

Rule-55:

- Declared Frequency of Supply to Consumer.
- 1. Except with the written consent of the consumer or with the previous sanction of the State Government a supplier shall not permit the frequency of an alternating current supply to vary from the declared frequency by more than 3 percent.

Rule-56:

- Sealing of Meters and Cut-outs.

1. A supplier may affix one or more seals to any cutout and to any meter, maximum demand indicator, or other apparatus placed upon a consumer's premises in accordance with section 26, and no person other than the supplier shall break any such seal.
2. The consumer shall use all reasonable means in his power to ensure that no such seal is broken otherwise than by the supplier.
3. The word "supplier" shall for the purpose of this rule include a State Government when any meter , maximum demand indicator is placed upon a consumers premises by such Government.

Rule-57:

- Meters, maximum demand indicators and other apparatus on consumer's premises.
 - (1) Any meter, or maximum demand indicator or other apparatus placed upon a consumer's premises in accordance with section 26 shall be of appropriate capacity and shall be deemed to be correct if its limits or error do not exceed 3 percent above or below absolute accuracy at all loads in excess of one-tenth of full load and upto full load.
 - (2) No meter shall register at no load.
 - (3) Every supplier shall provide and maintain in proper condition such suitable apparatus as may be prescribed or approved by the Inspector for the examination, testing and regulation of meters used or intended to be used in connection with the supply of energy.
- Provided that the supplier may with the approval of the Inspector and shall, if required by the Inspector enter into a joint arrangement with any other supplier for the aforesaid purpose.
 - (4) Every supplier shall examine, test and regulate all meters, maximum demand indicators and other apparatus for ascertaining the amount of energy supplied before their first installation at the consumer's premises and at such other intervals as may be directed by the State Government in this behalf.
 - (5) Every supplier shall maintain a register of metres, showing the date of the last test, the error recorded at the time of the test, the limit of accuracy after adjustment and final test, the date of installation, withdrawal, reinstallation etc. for the examination of the Inspector or his authorized representative.

Rule-58:

- Point of commencement of supply. The point of commencement of supply of energy to a consumer shall be deemed to be point at the outgoing terminals of the cut-outs inserted by the supplier in each conductor of every service line other than earthed or earthed neutral conductor or the earthed external conductor of concentric cable at the consumer's premises.

Rule-59:

- Precautions against failure of supply. Notice of Failure.
 - (1) The lay-out of the electric supply lines of the supplier for the supply of energy throughout his area of supply. shall under normal working conditions be sectionalized and so arranged, and provided with cut-outs or circuit breakers so located as to restrict within reasonable limits the extent of the portion of the system affected by any failure of supply.
 - (2) The supplier shall take all responsible precautions to avoid any accidental interruptions of supply and also to avoid danger to the public or to any employee or authorized person when engaged on any operation during and in connection with the installation, extension and replacement, repair and maintenance of any works.
 - (3) The supplier shall send to the Inspector notice of failure of supply of such kind as the Inspector may from time to time require to be notified to him and such notice shall be sent by the earliest practicable post after the failure occurs or after the failure becomes known to the supplier and shall be in such form and contain such particulars as Inspector may from time to time specify.

Rule-60:

- Test for the resistance of Insulation.

1. Where any electrical supply line for use at low or medium voltage has been disconnected from a system for the purpose of addition or alteration or repair, such electric supply line shall not be reconnected to the system until the supplier or owner has applied the test prescribed under rule 48 .
2. The provisions of sub rule (1) shall not apply to the overhead lines except overhead insulated cable unless the Inspector otherwise directs in any particular case.

Rule-61:

➤ Connection With Earth.

1. The following provisions shall apply to the connection with earth of systems at low voltage in case where the voltage normally exceeds 125 volts and of the systems at medium voltage:
 - (a) The neutral conductor of a three-phase four-wire system, shall be earthed by not less than two separate and distinct connections with the earth both at the generating station and at the sub-station.
 - (b) In the case of a system comprising electric supply lines having concentric cables, the external conductor of such cables shall be earthed by two separate and distinct connections with earth.
 - (c) The connection with earth may include a link by means of which the connection may-be temporarily interrupted for the purpose of testing or for locating a fault.
 - (d) (i) In a direct current three-wire system the middle conductor shall be earthed at the generating station only, and the current from the middle conductor to earth shall be continuously recorded by means of a recording ammeter and if at any time the current exceeds one thousandth part of the maximum supply current, immediate steps shall be taken to improve the insulation of the system.
 - (ii) Where the middle conductor is earthed by means of a circuit-breaker with a resistance connected in parallel the resistance shall not exceed 10ohms and on the opening of the circuit-breaker, immediate steps shall be taken to improve the insulation of the system, and the circuit-breaker shall be reclosed as soon as possible.
 - (iii) The resistance shall be used only as a protection for the ammeter in case of earths on the system and until such earths are removed, immediate steps shall be taken to locate and remove earth.
 - (e) In the case of an alternating current system there shall not be inserted in connection with earth any impedance (other than that required solely for the operation of the switchgear or instruments), cut outs or circuit breaker, or result on any test, made to ascertain whether the current (if any), passing through the connection with earth is normal, shall be duly recorded by the supplier.
 - (f) No person shall make connection with earth by the aid of, nor shall he keep it in contact with, any water main not belonging to him except with the consent of the owner thereof and to the Inspector.
 - (g) Alternating current systems which are connected with earth as aforesaid may be electrically interconnected.

Provided that each connection with the earth is bonded to the metal sheathing and metallic armouring (if any) of the electric supply lines concerned.
2. The frame of every generator, stationary motor, and so far as practicable, portable motor and metallic parts (not intended as conductors) of all transformers and any other apparatus used for regulating or controlling energy and all medium voltage energy consuming apparatus shall be earthed by the owner by two separate and distinct connections with the earth.
3. All metal casings or metallic coverings containing or protecting any electric supply-line or apparatus shall be connected with earth and shall be so joined and connected across all junction-

boxes and other openings as to make good mechanical and electrical connection throughout their whole length.

Provided that where the supply is at low voltage, this sub-rule shall not apply to isolated wall tubes or to brackets, electrodes, switches, fans, regulators covers or fittings (other than portable hand lamps and portable and transportable apparatus) unless provided with earth terminal.

This sub-rule shall come into force immediately in the case of new installations and in the case of existing installations the provisions of this sub-rule shall be complied with before the expiry of a period of two years from the commencement of those rules.

4. All earthing systems shall, before electric supply lines or apparatus are energised, be tested for electrical resistance to ensure efficient earthing.
5. All earthing systems belonging to the supplier shall, in addition, be tested for resistance on dry day during the dry season not less than once every two years.
6. A record of every earth test made and the result thereof shall be kept by the supplier for a period of not less than two years after the day of testing and shall be available to the Inspector when required.

Rule-62:

➤ System at Medium Voltage.

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

Rule-63:

➤ Approval by the Inspector.

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

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

2. The owner of any high or extra high voltage installation shall, before making application to the Inspector for approval of his installation or additions thereto, test every high or extra high voltage circuit or additions thereto, other than an overhead line, and satisfy himself that they withstand the applications of the testing voltage set out in sub rule (1) of rule 65 and shall duly record the results of such tests and forward them to the Inspector.
3. The owner of any high or extra-high voltage installation who makes any additions or alterations to his installation shall not connect to the supply his apparatus or electric supply lines, comprising the said alterations or additions have been approved in writing by the Inspector.

Rule-64:

➤ Use of Energy at high and Extra-high voltage.

1. The Inspector shall not authorise a supplier to connect a supply of energy at high or extra-high voltage to any consumer, unless:
 - (a) all conductors and apparatus intended for use at extra-high voltage and situated on the premises of the consumer are inaccessible except to an authorized person and all operations in connection with the said conductors and apparatus are carried out only by an authorised person;

- (b) the consumer has provided and agrees to maintain a separate building or a locked weatherproof and fire proof enclosure of agreed design and location, to which the supplier shall at all times have access, for the purpose of housing his high or extra-high voltage apparatus and metering equipment, or where the provisions of a separate building or enclosure is impracticable, the consumer has segregated the aforesaid apparatus of the supplier from any other part of his own apparatus.
- (c) all pole type sub-stations are constructed and maintained in accordance with rule 69.
- 2. The following provisions shall be observed where energy at high or extra-high voltage is supplied, converted, transformed or used.
 - (a) All conductors or live parts of any apparatus shall ordinarily be inaccessible:
 - (b) All windows, at high or extra-high voltage of motors or other apparatus within reach from any position in which a person may require to be, shall be suitably protected so as to prevent danger.
 - (c) Where transformer or transformers are used, suitable provision shall be made either by connecting with earth a point of the circuit and the lower voltage or otherwise, to guard against danger by reason of the said circuit becoming accidentally charged above its normal voltage by the leakage from or contact with circuit at the higher voltage.

Rule-65:

- Voltage Tests.
- 1. High and extra high voltage electric supply lines (other than overhead lines) and apparatus of the supplier shall not be connected to a system for the purpose of supply or use of energy unless the insulation of the said electric supply lines and apparatus has withstood, either:
 - (i) the tests prescribed in that behalf in the appropriate specifications of the Indian Standards Institution or in its absence the British Standards Institution; or
 - (ii) in cases where no such tests have been prescribed, the continuous application, between conductors and also between conductors and earth, during a period of one minute of the testing voltage given in sub-rule (2).
- 2. For the purposes of clause (ii) of sub-rule (1)
 - (a) if the normal working voltage does not exceed, 1,000 volts. The testing voltages shall be 2,000 volts;
 - (b) if the normal working voltage exceeds 1,000 volts but does not exceed, 11,000 volts, the testing voltage shall be double the normal working voltage;
 - (c) if the normal working voltage exceeds, 11,000 volts, the testing voltage shall be normal working voltage plus, 10,000 volts.

Rule-66:

- Metal sheathed electric supply lines: Precautions against excess leakage.
- 1. The following provisions shall apply to electric supply lines (other than overhead lines) of supplier for use at high or extra-high voltage :
 - (a) The conductors shall be enclosed in metal sheathing which shall be electrically continuous and connected with earth, and the conductivity of the metal sheathing shall be maintained and reasonable precautions taken where necessary to avoid corrosion of the sheathing.
 - (b) In the event of failure of insulation occurring between one conductor and the metal sheathing at any point along an electric supply line as aforesaid, the impedance of the relevant circuit shall be such that current resulting from such failure shall not be less than twice the value of the current for which a suitable cut-off of adequate rupturing capacity or other suitable overload protecting device has been set to operate or the current required to operate a suitable discriminative fault current relay: Provided that the operation of the aforesaid protective device

or of the discriminative fault current relay shall cause the automatic operation of a circuit-breaker of an adequate rupturing capacity.

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

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

Rule-67:

➤ Connection with earth.

1. The following provisions shall apply to the connection with earth of three phase system for use at high or extra-high voltages :-

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

(a) the neutral point shall be earthed by not less than two separate and distinct connections with earth each having its own electrode at the generating station and the sub-station and may be earthed at any other point provided that no interference of any description is caused by such earthing.

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

2. Single-phase high or extra-high voltage systems shall be earthed in a manner approved by the Inspector.
3. In the case of a system comprising electric supply lines having concentric cables, the external conductor shall be the one to be connected with earth.
4. Where a supplier proposes to connect with earth an existing system for use at high or extra-high voltage which has not hitherto been so connected with earth he shall give not less than fourteen days notice in writing together with particulars to the telegraph-authority of the proposed connection with earth.

Rule-68:

➤ General conditions as to transformation and control of energy.

1. Where energy at high or extra-high voltage is transformed, converted, regulated or otherwise controlled in sub-stations or switch-stations, (including outdoor sub-stations or outdoor switch-stations) or in street boxes constructed underground, the following provisions shall have effect:
 - (a) Sub-stations and switch-stations shall preferably be erected above ground, but where necessarily constructed underground, due provision for ventilation and drainage shall be made.
 - (b) Outdoor sub-stations except pole type sub-stations and outdoor switch-stations shall (unless the apparatus is completely enclosed in a metal covering connected with earth, the said apparatus also being connected with the system by armored cable) be efficiently protected by fencing not less than 2.44 metres (8ft) in height or other means so as to prevent access to the electric supply lines and apparatus therein by an unauthorized person.

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

Rule-70:

- Condensers.
- 1. Suitable provision shall be made for immediate and automatic discharge of every static condenser on disconnection of supply.

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

Rule-74

- Material and Strength.
- 1. All conductors of over-head lines other than those specified in sub-rule (1) of rule 86 shall have breaking strength of not less than 317,5 kg (700 lbs.).
- 2. Where the voltage is low and the span is of less than 15.24 m(50 ft) and is on the owner's or consumer premises, a conductor having an actual breaking strength of not less than 135 kg (300 lbs) may be used.

Rule-75-

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

Rule-76

- Maximum Stresses: Factor of Safety.
- 1. (a) The owner of every overhead line shall ensure that it has the following minimum factors of safety. The minimum factors of safety for supports based on crippling load shall be as follows :
 - (i) for metal supports
 - (iii) for hand molded concrete supports . 3.0 line is not less than one fourth of the strength required in the direction transverse to the line. line is not less than one fourth of the strength required in the direction transverse to the line.Provided that in the case of latticed steel or other compound structure the factors of safety shall not be Authority.
- (b) The minimum factor of safety for stay-wires, guard wires or bearer wires shall not be less than 2.5 or based on ultimate tensile strength of the wire.
- (c) The minimum factor of safety for conductors shall be 2 or based on their ultimate tensile strength. In addition the conductor tension at 90°F without load shall not exceed the following percentages of the ultimate strength of such conductor :

Rule-77-

- Clearances above ground of the lowest Conductor.
- No conductor of an overhead line including service lines erected across any street shall at any part there of be at a height less than:
 - for low or medium voltage lines 5.8 m(19ft)

- for high voltage lines..... 6 m (20 ft)
- No conductor of an overhead line including service lines erected along any street shall at any part there of be at a height less than:
 - for low, medium and high voltage lines 5.49 m(18ft)
 - for high voltage lines..... 5.8m (19 ft)
- No conductor of an overhead line including service lines, erected elsewhere than along or across any street shall be at a height less than:
 - for low medium, and high voltage lines upto and including 11,000 volts if bare 4.57m(15ft)
 - for low, medium and high voltage lines upto and including 11,000 volts if insulated 3.96 m (13 ft)
 - for high voltage lines above 11,000 volts -----5.18m(17ft)
- For extra-high voltage lines the clearance above 11,000 volts5.18 m (17ft)

Rule-78-

- Clearance between conductors and trolley wires. No conductor of an overhead line crossing a tramway or trolley bus route using trolley wires shall have less than the following clearances above any trolley wire.
 - (a) low and medium voltage lines..... 1.22 m(4ft)
- Provided that where an insulated conductor suspended from a bare wire crosses over a trolley wire the minimum clearance for such insulated conductor shall be 0.6 m(2ft)
 - (b) high voltage lines up to and including 11,000 volts1.83 m(6ft)
 - (c) high voltage lines above 11,000 volts2.44 m(8ft)
 - (d) extra-high voltage lines 3.05 m(10ft)

Rule-79:

- Clearances from buildings of low and medium voltage lines and service lines.
- (1) Where a low or medium voltage overhead line passes above or adjacent to or terminates on any building, the following minimum clearances from any accessible point, on the basis of maximum sag, shall be observed :
 - For any flat roof, open balcony, verandah roof and lean-to-roof :-
 - when the line passes above the building, a vertical clearance of 2.44" " m (8ft) from the highest point, and
 - when the line passes adjacent to the building, a horizontal clearance of 1.22" " m(4ft) from the nearest point, and
 - for pitched roof.
 - when the line passes above the building, a vertical clearance of 2.44" " m(8ft) immediately under the lines, and
 - When the line passes adjacent to the building, a horizontal clearance of 1.22" " m(4ft).
- (2) Any conductor so situated as to have a clearance less than that specified in sub-rule (i) shall be adequately insulated and shall be attached by means of metal clips at suitable intervals to a bare earthed bearer wire having breaking strength of not less than 317.5" " kg. (700lbs).
- (3) The horizontal clearance shall be measured when the line is at maximum deflection from the vertical due to wind pressure.

Rule-80:

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

- (a) for high voltage lines up to and including 33,000 volts 3.66" " m(12ft).
- (b) for extra-high voltage line 3.66" " m (12 ft) plus 0.3" " m(1ft) for every additional 33,000 volts or parts thereof.
- (2) The horizontal clearance between the nearest conductor and any part of such building shall, on the basis of maximum deflection due to wind pressure be not less than
- (a) for high voltage lines up to and including 11,000 volts22" " m(4ft)
- (b) for high voltage lines above 11,000 volts and up to and including 33,000 volts 1.83" " m(6ft).
- (c) for extra-high voltage lines 1.83" " m (6 ft) plus 0.3" " m(1ft) for every additional 33,000 volts, or part thereof.

Rule-81

- Conductors at different voltages on same supports. Where conductors forming parts of systems at different voltages are erected on the same supports the owner shall make adequate provision to guard against danger to lines men other from the lower voltage system being charged above its normal working voltage by leakage from or contact with the higher voltage system and the methods of construction and the clearance between the conductors of the two systems shall be subject to the prior approval of the Inspector.

Rule-86:

- Conditions to apply where telecommunication lines and power lines are carried on same supports.
- (1) Every overhead telecommunication. line erected on supports carrying a power line shall consist of conductors each having a breaking strength of not less than 272.2" " kg (600lbs.).
- (2) Every telephone used on a telecommunication line erected on supports carrying a power line shall be suitably guarded against lightning and shall be protected by cut-outs.
- (3) Where a telecommunication line is erected on supports carrying a high or extra-high voltage power line arrangement shall be made to safeguard any person using the telephone against injury resulting from contact, leakage or induction between such power and telecommunication lines.

Rule-87:

- Lines crossing or approaching each other.
 - (1) Where an overhead line crosses or is in proximity to any telecommunication line, the owner of the overhead line shall protect it in a manner laid down in the Code of Practice of the Power and Tele-communication Coordination Committee.
 - (2) When it is intended to erect a telecommunication line which will cross or be in proximity to an overhead line, the person proposing to erect such telecommunication line shall give notice in writing of his intention to the owner of the overhead line and the owner of the overhead line shall, with in twenty-one days of receiving such notice, provide the protection referred to in sub-rule (1).
 - (3) Where an overhead line crosses or is in proximity to an overhead line belonging to another person, the owner of the line which was last erected shall so protect it as to guard against the possibility of its coming into contact with the other overhead line.
 - (4) A person erecting or proposing to erect an overhead line may require the owner of the other overhead line to provide the protection referred to in sub-rule (3) within twenty one days of the receipt of the notice on that behalf.
 - (5) In all cases referred to in the preceding sub-rules, the expenses of making the guarding arrangement shall be borne by the person whose line was last erected.

- (6) Where two lines cross, the crossing shall be made as nearly at right angles as the nature of the case admits.
- (7) The guarding arrangement shall ordinarily be carried out by the owner of the supports on which it is made and he shall be responsible for its efficient maintenance.
- (8) All work required to be done by or under this rule shall be carried out to the satisfaction of the Inspector.

Rule-88-

➤ Guarding.

- (1) Where guarding is required under these rules, the provisions of sub rules (2) to (4) shall apply.
- (2) Every guard-wire shall be connected with earth at each point at which electrical continuity is broken.
- (3) Every guard-wire shall have an actual breaking strength of not less than 635 " " kg (1,400lbs) and if made of iron or steel, shall be galvanised.
- (4) Every guard-wire of cross-connected system of guard-wires, shall have sufficient current carrying capacity to ensure the rendering dead, without risk of fusing of the guard-wire or wires till the contact of any line wire has been removed.

Rule-89

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

Rule-90

➤ Earthing.

- (1) All metal supports of overhead lines and metallic fittings attached thereto, shall be permanently and efficiently earthed. For the purpose a continuous earth wire shall be provided and securely fastened to each pole and connected with earth ordinarily at four points in every 1.609 " " km (1 mile), the spacing between the points being as nearly equidistant as possible. Alternatively, each support and the metallic fitting attached thereto shall be efficiently earthed.
- (2) Each stay-wire shall be similarly earthed unless an insulator has been placed in it at a height not less than 3.048 meters (10 ft.) from the ground.
- Every over head line erected over any part street or other public place on any consumers premise.

Rule-91

➤ Safety and protective devices.

- (1) Every overhead line (not being suspended from a dead bearer wire and not being covered with insulating material and not being a trolley-wire) erected over any part of street or other public place or in any factory or mine or on any consumer's premises shall be protected with a device approved by the Inspector for rendering the line electrically harmless in case it breaks.
- (2) An Inspector may by notice in writing, require the owner of any such overhead line wherever it may be erected to protect it in the manner specified in sub-rule (1)
- (3) The owner of every high and extra-high voltage over-head line shall make adequate arrangements to the satisfaction of the Inspector to prevent unauthorized persons from ascending any of the supports of such overhead lines without the aid of a ladder or special appliances.

POSSIBLE SHORT TYPE QUESTIONS WITH ANSWER-

Q.1- Write the following terms as per Indian Electric Rules.

Low voltage, High voltage, Extra high voltage, Medium voltage, Ampere, Circuit Breaker.

Ans:

Low voltage:

According to I.E rules it is defined as a voltage which does not exceeds 250 v under normal condition .

High voltage:

According to I.E. rules it is defined as a voltage ranging from 650v to 33,000v or 33kv under normal conditions subjected to the percentage of variation allowed by the rules.

Extra high voltage:

According to I.E. rules it is defined as a voltage which exceeds above 33KV under normal conditions subjected to the percentage of variation allowed by the rules.

Medium voltage:

According to I.E. rules it is defined as an voltage which ranging from 250v to 650v under normal conditions subjected to the percentage of variation allowed by the rules..

Ampere:

It is the unit of current

In other word it is the un varying electric current which when passed through a solution of nitrate & silver in water, it is deposited the silver at the rate of 0.001118gm/sec

Circuit Breaker:

It is defined as a device which capable of making & breaking the ckt under all conditions.

Q.2 What is the maximum voltage regulation allowed for HV and EHV lines as per I.E rules? (S-13, S-24)

Ans: The maximum voltage regulation allowed for HV and EHV lines as per I.E rule is + or – 12.5%

Q.3- Define Low voltage and Medium voltage. (S-12,S-23)

Ans:

Low voltage:

According to I.E rules it is defined as a voltage which does not exceeds 250 v under normal conditions subjected to the percentage of variation allowed by the rules.

Medium voltage:

According to I.E. rules it is defined as an voltage which ranging from 250v to 650v under normal conditions subjected to the percentage of variation allowed by the rules.

CHAPTER NO.-04

OVER HEAD INSTALLATION

Learning objectives:

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

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

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

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

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

Distribution:

- Generally for distributing for electrical energy we have two types of system such as L.T distribution and H.T. distribution. It depends on the voltage to supply.
- It may be HT & LT distribution but the following accessories must be used in the overhead distribution system

Main components of overhead lines:

Line Supports:

- Usually electric pole or towers are called as supports.
- The main function is to supports the conductor so as to keep it of a suitable label above the ground.
- Generally for LT distribution we used 8m or 9m PCC (pre-stress cement concrete) or RCC (rein forced cement concrete) and also rail pole of 9m & 10m height.

- Similarly for HT distribution we used 9m PCC or RCC pole & reinforced of height 12 m.
- Depending on the voltage will supply & variation regions. We also used tower for HT distribution.

Factors Governing Height Of The Pole:

Followings are the important factor governing the height of the pole.

1. The minimum clearances of the lowest conductor from the ground.
2. The number of conductor to be carried out and minimum vertical clearances between the conductors
3. The length of pole to be buried in the ground (generally $1/6^{\text{th}}$ of total height of the pole) must be buried in the ground in normal soil.

Conductor materials:

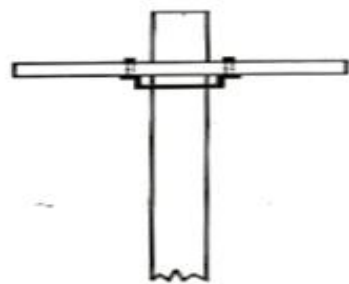
- The conductor is one of the important items of the overhead transmission line.
- The proper choice of material and size of the conductor is of considerable importance.
- The conductor material used for transmission and distribution of electric power should have the following properties :
 - i. High electrical conductivity.
 - ii. High tensile strength in order to withstand mechanical stresses.
 - iii. Low cost so that it can be used for long distances.
 - iv. Low specific gravity so that weight per unit volume is small.
- All conductors used for overhead lines are preferably stranded in order to increase the flexibility.
- In distribution line conductor plays a vital role to transmit or circulate the electric current. Hence conductor is a medium of electric supply system.
- Generally we use AAC (All Aluminum conductor) & ACSR (Aluminum conductor steel reinforced) as the overhead conductor in the distribution line.

Determination of size of conductor for overhead transmission line:

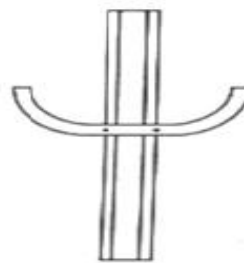
- The size of conductor (hard drawn bare copper or A A C or A C S R) is governed by the following factors :
 - (i) Line working voltage.
 - (ii) Length of transmission line.
 - (iii) Power to be carried.
 - and (iv) Power factor of the load and.
 - (v) Permissible voltage drop in line.
- The A C S R conductor of size not less than $6/1 \times 2.11$ mm should be used for service lines.

Cross Arms:

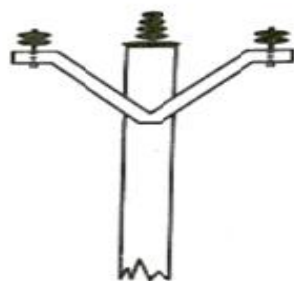
- Cross arm is a cross piece fitted to the pole top at the end portion by means of brackets known as pole brackets for supporting insulators in a suitable spacing.
- Generally in the distribution line we use MS Channel, Angle iron, U- shaped , V-shaped or zig-zag shape cross arms are used.



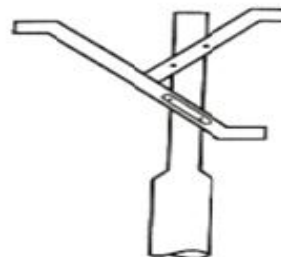
(a) MS Channel or Wooden Cross arm



(b) U-Shaped Cross arm



(c) V-Shaped Cross arm



(d) Zig-zag Cross arm

Pole brackets & clamps-

- Generally pole brackets are used to hold the cross arms with the poles. The brackets may be of the channels or angle iron and may be of pipe brackets.
- Clamps are made up off flat iron & are used for fixing as well as holding service line, stay wire, earth wire, shackle Insulators and cross arms etc.

Guys and Stays:

- Stay is basically used to provide support to the line poles where they are unbalanced irrection.
- Generally stay is done at an angle of 45 degree or not less than 30 degree.
- For HT line this stay angle may vary from 45 degree to 60 degree.
- Guy is a tensioned cable designed to add stability to a free-standing structure.
- They are used commonly for stay wire, ship masts, radio masts, wind turbines, utility poles, and tents.

Conductors configurations, Spacing and Clearances:

- Several conductor configurations are possible, but three configurations are the most common i.e Horizontal configuration, Vertical configuration and Triangular configuration.
- While stretching the conductor we must have to maintain a specific clearance among the conductors is called as conductor spacing and also between the ground called as ground clearance.
- A general formula is used to get the conductor spacing.

$$Spacing = \sqrt{S} \times \frac{V}{150}, \text{metres}$$

Where, S= Sag of the conductor

V = Line voltage, V

- Some typical spacing values are given below:

Supply Voltage in KV	0.4	11	33	66	132	220	400	765
Spacing in metres	0.2	1.2	2.0	2.5	3.5	6.0	11.5	14

- Similarly the ground clearance of the conductor in different locations are mentioned below.

Supplied voltage in KV	0.4	11	33	66	132	220	400
Across street (m)	5.8	5.8	6.1	6.1	6.1	7.0	8.4
Along street (m)	5.5	5.5	5.8	6.1	6.1	7.0	8.4
Other areas(m)	4.6	4.6	5.5	5.5	6.1	7.0	8.4

Span length:

- The horizontal distance between the two adjacent pole is called as span length.
- Depending on the supplied voltage of the distribution line as Well as transmission line we have following spans for the various types of supports.
 1. Wooden pole span is 40m to 50m.
 2. Steel tubular pole span is 50m to 80m.
 3. RCC and PCC pole span is 80m to 200m.
 4. Steel towers span is 200m to 400m.
- For river crossing long spans about 800m may be consider which is exceptional.

Overhead line insulators:

- The main function of the insulator in distribution line is to avoid the direct contact of the charged conductor with the earth.
- The commonly used material for the overhead line insulator is porcelain, toughed glass & ceramics.
- The important properties of Overhead line insulators are:
 1. High mechanical strength in order to withstand conductor load, wind load etc.
 2. High electrical resistance of insulator material in order to avoid leakage currents to earth.
 3. High relative permittivity of insulator material in order that dielectric strength is high.
 4. The insulator material should be non-porous, free from impurities and cracks otherwise the permittivity will be lowered.
 5. High ratio of puncture strength to flashover voltage.
 6. Ability to withstand large temperature variation.

Types of insulators

We have the following types of insulators.

1. Pin type insulator-
 - This type of insulators is generally used in 240V, 440V, 11KV & 33KV.
2. Disc type insulator.
 - It is two types depending upon its uses

i-suspension insulator

ii-strain insulator

I-Suspension Insulator-

- If the disc insulators are arranged in vertically then it is called as suspension insulator.

II-Strain Insulator-

- If the disc insulator is arranged in horizontally then it is called as strain insulator.
- Generally disc insulators are used 11KV onwards.

3. Shackle Insulator-

- This insulator is used only in LT line in 440V at the tapping pole, dead end pole and deviation pole.
- This insulator is also used in street light purpose.

4. Egg Insulator-

- The insulator which is used in stay wire L.T. line as well as H.T. line is called as egg insulator .
- Its appearance is similar to egg.

Lighting Arrester:

- It is a device which protects all the electrical equipment's from damage due to surge Voltage of lighting. Hence all the overhead conductors are also connected lighting arrester at the substations, grids etc. similarly all the modern protective devices must be connected with this lighting arrester.

Phage Plate:

- To identify the colour code of overhead conductors such as red (R), yellow (Y), & blue(B) such Phase plates are attached with the supports .

Danger Plate:

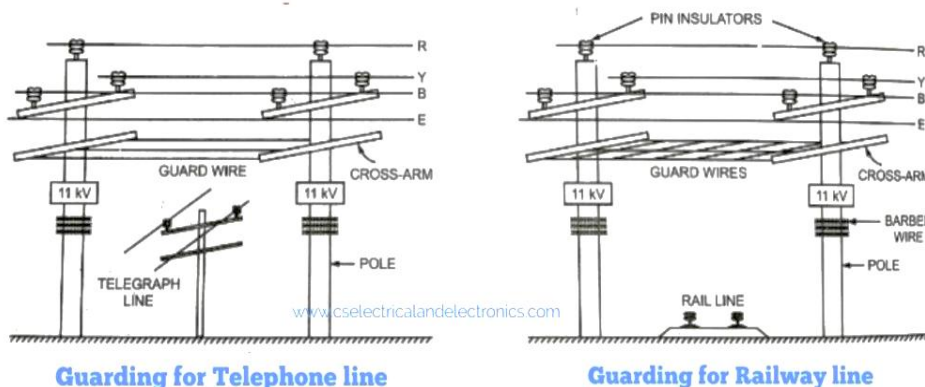
- Usually this plate is placed at a height of 2.4m from the ground on the support. This plate contains supplied voltage which is written in English, Hindi & in local language.
- This plate is used aware the human being.

Anti –Climbing Wire:

- This wire is provided around the poles at a height of about 2.5 m from the ground for at least 1m.
- It is use not to climb any unauthorized person.

Bird Guards:

- These are the wooden pieces of size about 10cm x12.5cm x15cm, in case of metal poles are fitted under the insulators.
- Bird guards are used to avoid the short circuit or earth fault due to sitting of birds which may short circuit live conductors or any one line conductor with earth.



Jumpers

- Jumper the conductors which are used to continuity supply line from one point to another point by jumpering.
- Jumpers are generally used In DP structure & where disconnection of supply line is exiting.

Beads of jumpers:

- At certain places there are too many birds and due to their touching the jumpers and poles the failure of supply is most frequent. At such places to avoid bird age insulating beads are put all along the jumper.

Tee-offs:

- The tee-off from a line should be taken only from a pole and not in the middle of the span.
- While taking branch line from an existing line for supplying villages/farms etc, it is essential that the correct phasing, phase-to-phase clearance and phase-to-earth clearance are observed.
- Dissimilar materials should not be directly connected. Where metals such as copper and aluminium are to be joined a special connector with an interaction fiber washer should be used. Parallel groove clamps are used for connecting similar conductors at branch positions.

Guard Wire:

- It is provided for the safety of the life, installation and communication circuit .
- The guarding for 11KV lines provided at road crossing, canal crossing, railway crossing, crossing over LT lines or communication lines.

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

Problem-1

Electric supply to a factory is to be taken from an existing 11kv overhead 3-phase line for a distance of 1km from the exiting line. If this line is meaned for 300A load prepare a list of materials required for this purpose assume a road crossing in this distribution line.

Solution-

Calculation for no of poles:

Total length of line =1km =1000m

Assume that span length =50m

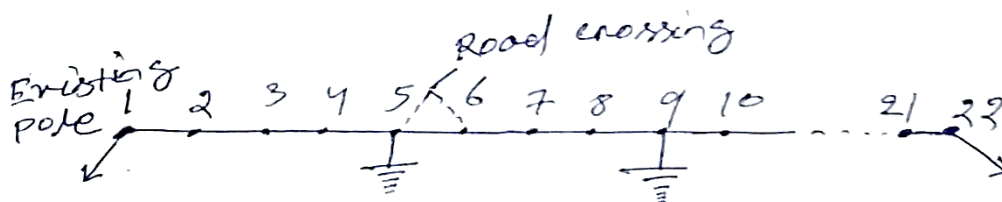
So no of span =Total length / Span length = 1000/50=20

So no of poles required =20+1=21 no

As road crossing are there in this line, so one more pole is required for this purpose.

Hence Total no of poles required =21+1=22 no

Single line diagram:



Calculation for no. of cross arms:-

According to single line diagram , let us select angle iron cross arm at the tapping pole as well as dead end pole & rest of the intermediate poles we select 'V' cross arm.

So no of angle iron cross arm required =2

So no of 'V' cross arm required =21

Calculation for no of insulators-

According to the above line diagram strain insulators are used at the tapping poles as well as dead end pole. 11 KV pin insulators are used in rest of the intermediate poles.

Hence no of Disc insulator required = 3+3=6

Total no of 11kv pin insulators =21 × 3 = 63

Calculation length of over head conductor

Net length of conductor required =3× (Total length of the line + 2% for sag) =3× (1000+20) =3060 m

Considering 12m extra for twisting & binding at the tapping pole as well as dead end pole.

So Gross length of conductor =3060+12=3072 m

Selection of overhead conductor-

From the conductor table for the current rating of 305A at 40⁰c ACSR, 6/1 × 4.50, cat type conductor should be selected.

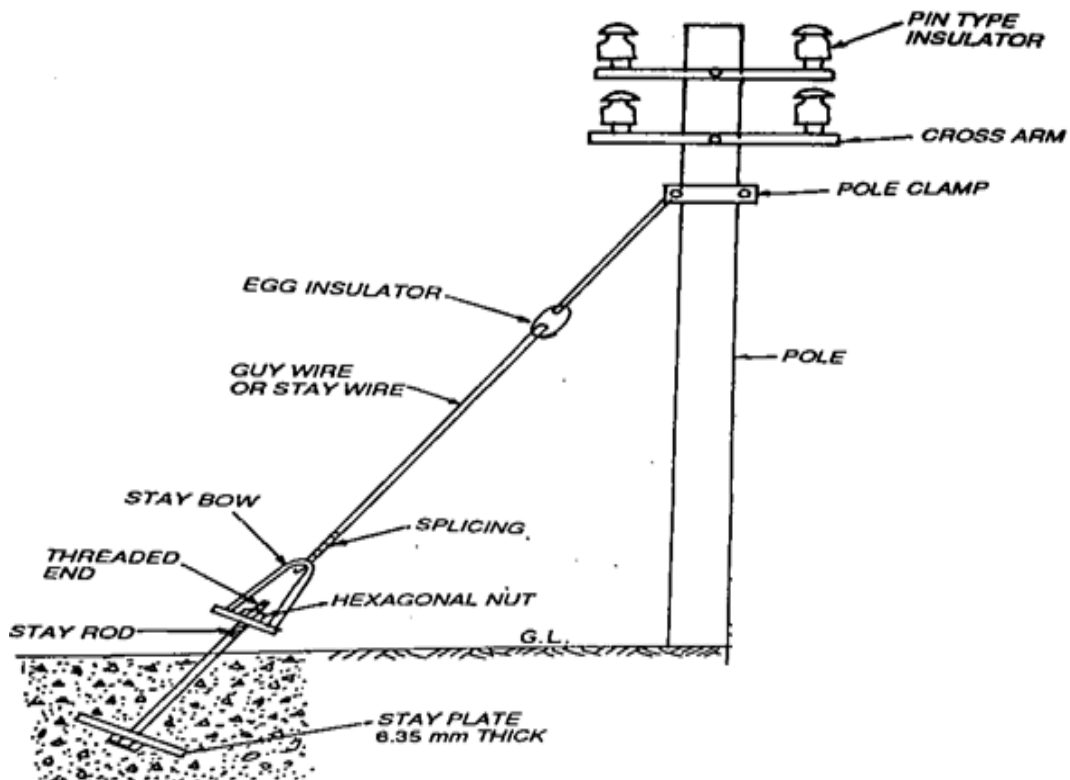
Material table-

SI No	DESCRIPTION	SPECIFICATION	QUANTITY
01	Supports	RCC, 9m	22 no's
02	Cross arms with it's fitting accessories	a)Angle iron cross arm	2 no's
		b) V- cross arm	21 no's
03	Insulators with its fitting accessories	a)Disc type, 11 kv	06 no's
		b) Pin type,11 kv	63 no's

04	Overhead conductor	ACSR , 6/1 × 4.50mm cat type	3072 m
05	Stay with its fitting accessories	For 11 kv line	02 set
06	Earthing with its fitting accessories	For 11 kv	04 set
07	Angle iron cross arm to support the guard wire	100mm×50mm×7.5 mm×2m long ,MS type	02 no's
08	Guard wire	14 SWG ,GI	50m
09	Binding wire at the rate 100gm per pin insulator	Aluminum type ,single core	6300=6.3kg
10	Anti-climbing wire at the rate 3m per pole	G.I type	66m
11	Danger plate	11kv	22 no's
12	Sundries to Complete the whole job		As per required

Problem-2

Prepare the list of materials required for a stay set & also draw neat sketch



Material table-

Sl no.	Description	Specification	Quantity
01	Anchor plate	(45×45×6.0) cm M.S type	01 no
02	Stay rod	M.S type 16mm diameter, 2.42m long	01 no
03	Stay bow	M.S type 12mm diameter	01 no
04	Stay wire	7/8 SWG ,G.I	7.5m
05	Stay insulator	Porcelain type	01 no
06	Stay clamp or pole clamp	--	01 no
07	Nut bolt	16mm diameter	02 no's
08	Stay thimble	M.S type	02 no's
09	Sundries to complete the whole job	-----	As per required

Problem-03

Prepare an estimate for high tension line for a distance of 5km using ACSR conductor to transmit 400kw load at 0.85 p.f. in 3-phase 11kv line, the span is 100m, and also draw the neat sketch.

Solution:

Calculation for no. of poles:-

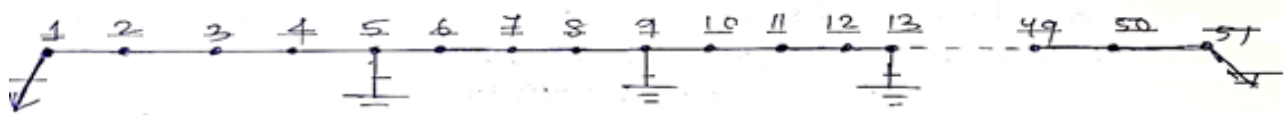
Total length of line=5km =5000m

Given that span length =100m

So no of span =Total length / Span length =5000/100 =50m

No of poles required =50+1=51

Single line diagram :



Calculation for no. of cross arms:

according to single line diagram let us select angle iron cross arm at the tapping pole as well as dead end pole and rest of the intermediate poles we select 'v' cross arm.

Hence,

Total no. of angle iron cross arm required =2 no.

Total no. of v cross arm required =49 no.

Calculation length for no of insulator :

According to the above line diagram strain insulator are used at the tapping pole as well as dead end pole . 11kv pin insulator are used in rest of the intermediate poles.

Hence,

No. of disc insulator required =3+3 =6

No. of 11kv pin insulator required $49 \times 3 = 147$ no.

Calculation length of overhead conductor:

Net length of conductor required = $3 \times [\text{Total length of the line} + 2\% \text{ of sag}]$
 $= 3 \times (5000 + 100) = 1530 \text{ m}$

Considering 20m extra for twisting and binding at the tapping pole as well as dead end pole.

Gross length of the conductor = $15300 + 20 = 15320 \text{ m}$

Selection of overhead conductor :

Here, given that

$P = 400 \text{ kw} = 400 \times 10^3 \text{ w}$

$\cos \phi = 0.85$

$V_L = 11 \text{ kv} = 11 \times 10^3 \text{ v}$

We know that,

$$P = \sqrt{3} V_L I_L \cos \phi$$

$$I_L = P / \sqrt{3} V_L \cos \phi$$

$$= 400 \times 10^3 / \sqrt{3} \times 11 \times 10^3 \times 0.85 = 24.69 \text{ A}$$

Full load current, $I_{FL} = 24.69 \text{ A}$

Short –cut current, $I_{SC} = 1.5 \times I_{FL}$

$$= 1.5 \times 24.69$$

$$= 37.035 \text{ A}$$

According to the S.C. current from the conductor table we should select 6/1×2.11 Squirrel type ACSR conductor.

Material table :-

Sl. no	Description	Specification	Quantity
01	Supports	RCC 9m	51 no's
02	Cross arm with its fitting accessories	a) angle iron cross arm b) V-cross arm	02 no's 49 no's
03	Insulator with its fitting accessories	a) disc type (11kv) b) pin type (1kv)	06 no's 147 no's
04	Overhead conductor	ACSR 6/1×2.11 squirrel type	15320m
05	Earthing with its fitting accessories	For 11kv	10 sets
06	Stay set with its fitting accessories	For 11kv line	02 set
07	Binding wire at the rate 100gm per pin insulator	Aluminium type single core	100×147 $= 14.7 \text{ kg}$
08	Anticlimbing wire at the rate 3m per pole	G.I type	$51 \times 3 = 153 \text{ m}$
09	Danger plate	11kv	51 nos
10	Sundries to complete the whole job	--	As per required

Problem-03

An overhead 11kv,50 Hz ,3-phase line is be tapped up for the existing 11kv line pole at about 90° angle. The purposed line has to be erected on 10m long RCC poles with ACSR conductor of size 6/1×2.11mm with average span of 100m line will have to pass through the city area about ½ km long make a list of materials required for 3.2 km long.

Solution :-

Calculation for no. of poles :-

Total length of line 3.2 km =3200m. given that span length =100m.

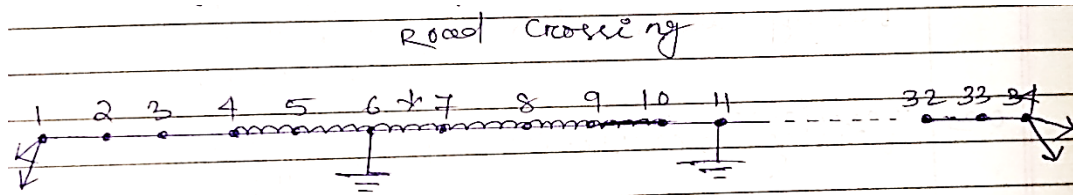
No. of span =3200/100 =32 no.

No. of pole required 32+1 =33 no.

Line will have to pass through the city area so road crossing are there in this line so I more pole required for this purpose.

Total pole required 33+1 =34 no.

Single line diagram :-



Calculation for no of insulators :-

According to line diagram 11kv strain insulator or disc insulator are used at the tapping pole as well as dead end pole and 11kv pin insulator are used in rest of intermediate pole.

No. of 11kv disc insulator required

3+3+30 =36 no.

No. of 11kv pin insulator required =96 no.

Calculation length of over head conductor :-

Net length of conductor required

= 3×[Total length of the line + 2% for sag]

=3×[3200+64] =9792 m.

Considering 50m extra for twisting and binding at the tapping pole as well as dead end pole.

Gross length of the conductor= 9792+50 =9842 m.

Material table :-

Sl. no	Description	specification	Quantity
01	Supports	10m-long RCC pole	34 nos
02	Cross arm with its fitting accessories	a)angle iron cross arm	8 nos
		b)V-CROSS ARM	32 nos

03	Insulator with its fitting accessories	a) Disc type(11kv) b) pin type (11kv)	36nos 96nos
04	Over head conductor	ACSR , 6/1×2.11 mm	9842 m
05	Earthing with its fitting accessories	For 11kv	5 sets
06	Stay set with its fitting accessories	For 11 kv line	4 sets
07	Guard wire	14 SWG G.I	500m
08	Binding wire at the rate log per pin insulator	Alluminium type single core	100×96=9.6 kg
09	Anti climbing wire at the rate 3m per pole	G.I type	3×34=102m
10	Danger plate	11kv	34 nos
11	Sundries to complete the whole job	----	As per required

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

Problem :

A 1km long overhead distribution line of 415 v,50 Hz is to be erected along a straight root from 100kvA ,11/0.4 KV pole mounting substation , the line is to be laid with 6/1×3.00mm ACSR conductor with 9m RCC pole . make a list of materials required and assume span length is 50m and also draw a rough sketch of this line.

Solution:-

Calculation for no. of poles :-

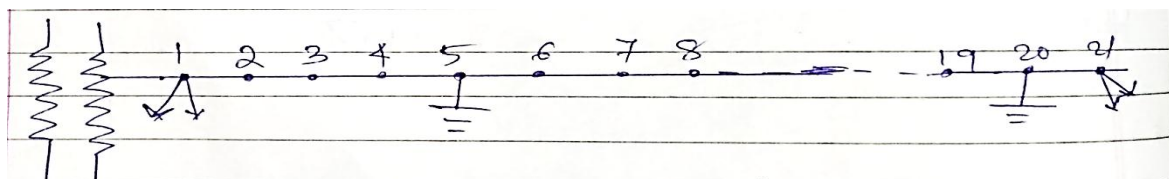
Total length of line 1km =1000m.

Given that span length=50m

No. of span =1000/50 =20 no.

No. of poles required =20+1 =21no.

Single line diagram :-



Calculation for no. of cross arms :-

According to the above single line diagram let us angle iron cross arm in each pole and one more cross arm required for tapping the line from the substation .

Hence, total no. of cross arm required 21+1=22

Calculation for no. of insulators :-

According to the single line diagram let us select shackle insulator at the tapping pole as well as dead end and rest of the intermediate poles we should select 440V pin type insulator.

Hence , no. of shackle insulators required =4+4=8 no.

Total no. of pin insulator required = 20 ×4 =80 no.

Calculation for length of overhead conductor :-

Net, length of the conductor

=4×[Total length of the line +2% for sag]

=4[1000+20] =4080m.

Considering 20m. extra for twisting and cutting and binding at the tapping pole as well as dead end pole,

Hence , Gross length of the conductor =4080+20 =4100m.

Material table :-

Si no	Description	specification	Quantity
01	Supports	RCC, 9m	21 nos
02	Cross arm with its fitting accessories	Angle iron cross arm	22 nos
03	Insulator with its fitting accessories	Shackle insulator Pin type insulator	08 nos 08 nos
04	Over head conductor	ACSR, 6.1×3.00mm long	4100m
05	Stay with its fitting accessories	For 440 v lines	4 sets
06	Earthing with its fitting accessories	For 440 v	4 sets
07	Binding wire at the rate 100gm per pin insulator	Alluminium single core	8 kg
08	Anti climbing wire at the rate 3m /pole	G.I type	3×21=63 m
09	Danger plate	440v	21 nos
10	L.T cable	PVC insulated aluminium core	3 m
11	Sundries to complete whole job	-----	As per required

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

Problem:

An over head distribution line of 415 V , 3-phase, 50Hz is to be erected along a straight root. The length of the line 300m. and the end supports are terminal structures, the span is 50m make an sketch of the terminal showing the disposition of the conductor . the conductor on the line are as follows.

(i) phase wire :-hard drawn bare copper wire no. of 4 SWG.

(ii) neutral & street light hard drawn bare copper conductor number for 8 SWG.

Prepare the list of material required for this purpose.

Solution :

Calculation number of supports :-

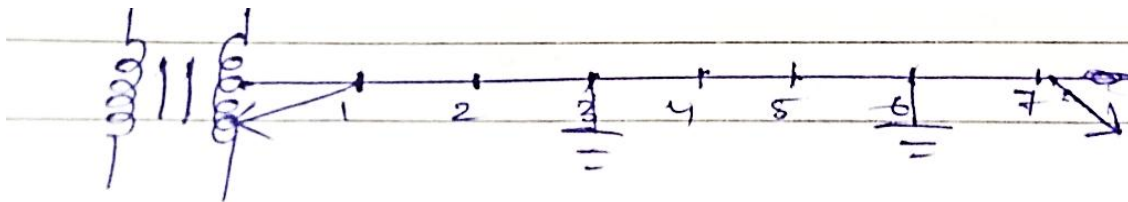
The total length of the line =300m

Here span length =50m

Number of span =300/50=6 no.

Number of pole required =7 no.

Single line diagram :



Calculation for no. of cross arm :

According to single line diagram we should select angle iron cross arm in each pole and one more cross arm required for tapping the line from the substation .

Hence, Total number of cross arm required =7+1 =8 no.

Calculation for no. of insulator :

According to the questions three shackle insulators are required for 3-phase other two shackle insulators required for street light and neutral for one pole.

Hence Total no. of insulator required= 8×5= 40 no.

Calculation for length of phase wire :

Net length of the phase wire =3×(declared length +2% for sag)

$$=3\times(300+6)$$

$$=918 \text{ m}$$

Considering 15m extra for twisting & cutting

Gross length = 918+15= 933 m.

Calculation for length of neutral & street wire

Net Length =2 × [Declared length +2% for sag]

$$=2\times[300 +6]=612 \text{ m.}$$

Considering 10m extra for twisting & cutting

Gross length = 612+10= 622 m.

Material table :

SI no	Description	Specification	Quantity
01	Supports	RCC,9m	7 nos
02	Cross arms with its fitting accessories	Angle iron cross arm	8 nos
03	Insulator with fitting accessories	Shackle insulator	40 nos
04	Overhead conductor(phase wire)	ACSR 6.1×2.00 mm	933 m
05	Overhead conductor(neutral & street wire)	ACSR 6.1×3.00 mm	612 m
06	Stay set with its fitting accessories	440 v line	4 sets
07	Earthing with its fitting accessories	440v line	4 sets
08	Binding wire at the rate 100gm /shackle insulator	Aluminium type single core	100×40=4000gm =4kg
09	Anti climbing wire at the rate 3m/pole	G.I type	3×7=21 nos
10	Danger plate	440v	7 nos
11	L.T cable	PVC insulated 4 core aluminium type	3 m
12	Sundries to complete the whole job	-----	As per required

POSSIBLE SHORT TYPE QUESTIONS WITH ANSWER

Q-1)Write the various types of cross arm which are used in LT as well as HT. distribution ?

Ans :- The various types of cross arm using LT & HT distribution are angle iron cross arm & v-cross arm .

Q2)What is the formula used for spacing of the conductor ?

Ans:- The formula use for spacing of the conductor is

$$Spacing = \sqrt{S} \times \frac{V}{150}, metres$$

Where, S=Sag of the conductor

V= Line voltage ,v

Q3What is the specification of stay wire?

Ans :- The specification of stay wire is 7/8 SWG G.I. type .

Q4) Write the various type of insulators which are used in L.T. as well as H.T. distribution.

Ans :- The various type of insulators which are used in L.T. as well as H.T. distribution are disc insulator, pin , shackle & egg insulators .

Q5) What is vertical clearance of the conductor along the street and across the streets for supplying 33kv voltage? [S-15,16]

Ans:- the vertical clearance of the conductor along the street is 5.5m and across the street is 5.8m for supply 33kv voltage .

Q6) What is vertical clearance of the conductor for supplying 11kv & 132kv transmission line ?

[S-13,17,24]

Ans:- The vertical clearance of the conductor for supplying 11kv & 132kv transmission line 5.8m & 6.1m respectively for transmission line .

Q7) What are the factors used to determine size of conductor for overhead line? [S-14, W-18]

Ans- Factors used to determine size of conductor for overhead line

- i) Line voltage
- ii) Span length
- iii) Sag
- iv) Minimum ground clearance

Q8) How many disc insulators required in H.T. line for supply voltage 33kv in each phase?

Ans :- 3no. Disc insulator required in H.T. line for supply voltage 33kv in each phase.

(Q9) What is lighting arrester & where it used ? (S-24)

Ans :- It is the devices which protects all the electrical equipment for damage due to surge voltage of lightning .

All the over head conductor are also connected lighting arrester at the substation and grid etc.

POSSIBLE LONG TYPE QUESTIONS

Q.1 Estimate the material required for the construction of 1 km of 11kv OH line .the line is tapped from the exiting 11kv OH line. Assume that the line is passing over the main road ,trolley way line, & rout way line.
[S-18,W-18]

Q.2 Discuss about the types of insulator used in transmission line. [S-16]

Q.3 Draw the neat sketch of a stay set & also prepare the list of material required. [S-12,15,16,24]

Q.4 Estimate the materials required for 3-phase ,4 wires O.H distribution line of 2km length connected load is 60 kw, at 400 v distributed along the route of the line .draw a neat sketch of one span of the line showing various components.

CHAPTER NO.-06

ESTIMATE FOR DISTRIBUTION SUBSTATION

Learning objectives:

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

6.1.1 Pole mounted substation.

6.1.2 Plinth Mounted substation

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

Introduction:

- In general practice substations are of different types depending on their nature of duties, service, operating voltage and its design.
- Depending on the design substations can be classified into two types.
 - (i) Indoor substation
 - (ii) Outdoor substation
- Again outdoor substation can be divided into two categories.
 - (i) Pole mounting substation which is flexible up to 125KVA or sometimes 250 KVA.
 - (ii) Plinth mounting substation which is flexible more than 250 KVA T/F.

6.1.1 Pole mounted substation

- Pole Mounted Substation is an outdoor step-down distribution substation that is placed on an overhead pole.
- It is the cheapest, smallest and simplest substation.
- This type of substation does not have any building works.
- The transformer is mounted on an H-Type pole or Four Pole Structure.
- The electrical power supply comes in our house mostly from this pole mounted substation.

Pole Mounted Substation Capacity:

Voltage Rating:

- The voltage rating of the pole mounted substation is 11KV/400V. It provides line voltage 400V for three phase system and 230V for single phase system.

Current Capacity:

- The current capacity of the pole mounted substation is varying with the load requirements. The current balancing system is arranged, so the transformer can give the maximum efficiency.

Power Capacity:

- The power capacity of the pole mounted substation is up to 250 KVA.

Transformer Connection:

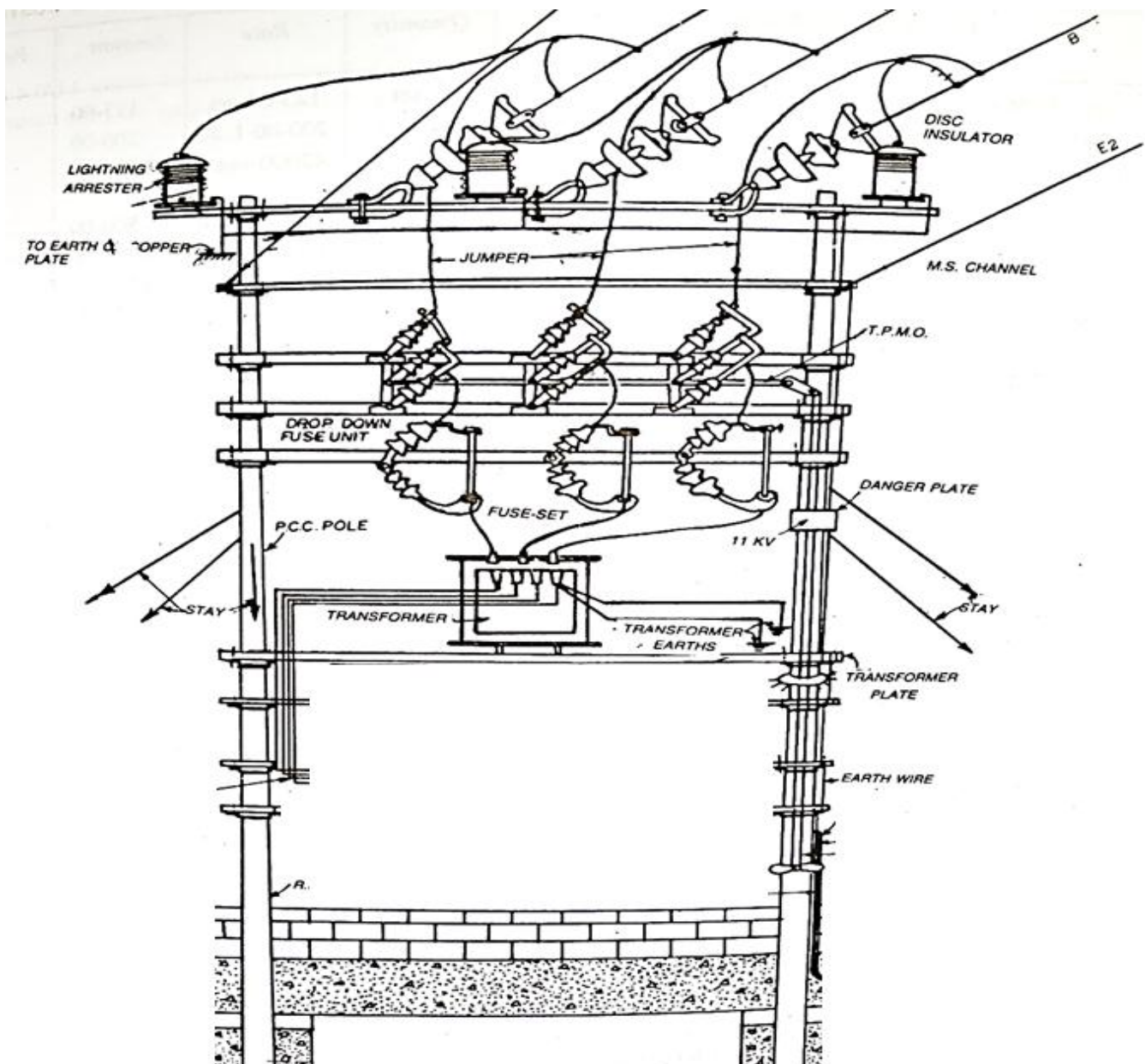
- The transformer in pole mounted substation is generally delta-star connected.

Pole Mounted Substation Use

- Pole mounted substation is used for the low voltage power distribution.
- It generally supplies the electrical power supply to the domestic consumers.
- It steps down the voltage from three phase three wire 11KV into three phase four wire 400V and single phase 230V power supply.
- The main advantage of this substation is it provides output in both three phase and single phase. So it can be used to provide power supply to both the single phase and three phase consumer.

Problem :-1

Draw the neat sketch of a 63 KVA, 50Hz 11/0.4 KV substation and prepare the list of materials required for this purpose.



Material table-

Sl no	Description	Specification	Quantity
A - For H.T arrangement			
01	Supports	RCC, 10m	2 nos.
02	Cross arms with its fitting accessories	M.S type , 100mm×50 mm×7.5 mm×2m	2nos.
03	Insulators with its fitting accessories	Disc insulator	3 nos.
04	Stay with its fitting accessories	For H.T.	2 sets
05	Lighting arrester with its fitting accessories	For 11kv	3 nos.
06	Earthing With its fitting accessories	For 11kv, pipe Earthing	1 sets
B- For A.B switch arrangement			
07	Cross arms with its fitting accessories	100mm×50mm×7.5 mm×2m	2 nos.
08	Angle iron cross arms to fixed the pin insulators with its fitting accessories	M.S. type 100mm×50mm×7.5mm×0.75m	3 nos.
09	Insulators with its fitting accessories	For 11kv , pin type	06 nos.
10	AB switch operated air breaker switch with 6m long G.I pipe along with its handle locking arrangement	For 11kv	1 set
C- For Drop – out arrangement			
11	Cross arm with its fitting accessories	M.S. type ,100mm×50mm×7.5 mm× 2 m.	02 no
12	Angle iron cross arm to support the insulators with its fitting accessories	M.S. type , 100mm×50mm ×7.5mm×0.75m	03nos.
13	Insulators with its fitting accessories	Pin type, 11kv	6 no.
14	Arcing or rod to be installed on the pin type insulator to supports the explosion type fuse wire	For 11kv	6 nos.
15	Explosion type fuse wire	For 11kv	1.5m
D-For Transformer installation			
16	Cross arms with its fitting accessories	M.S , 100mm×50mm×7.5mm×2m	02 nos.
17	Angle iron cross arm to be used for base plate	M.S. type , 100mm×50mm×7.5mm×0.75m	02 nos.
18	M.S. channel cross arm to support the T/F	M.S. type 100mm×50 mm×7.5mm×0.75m	02 nos.
19	Transformer	63 KVA, 11/0.4kv	01 no.
20	Earthing with its bitting accessories	Pipe earthing	2 sets.
21	L.T cable	4 core aluminium type pvc insulation	3m

22	L.T. cable box	TPICN, 1100grade with rewirable 3-unit	01 no.
23	Energy meter	3-phase digital type	01 no.
24	Anti-climbing wire	G.I type	6m.
25	Danger plate	11kv	02 nos
26	Jumper conductor from HT arrangement upto transformer installation	ACSR conductor	25 m
27	Binding wire at the rate 100 gm/pin insulator	Aluminium type single core	1.2 kg
28	Sundries to complete the whole job	-----	As per required

6.1.2 Plinth Mounted substation:

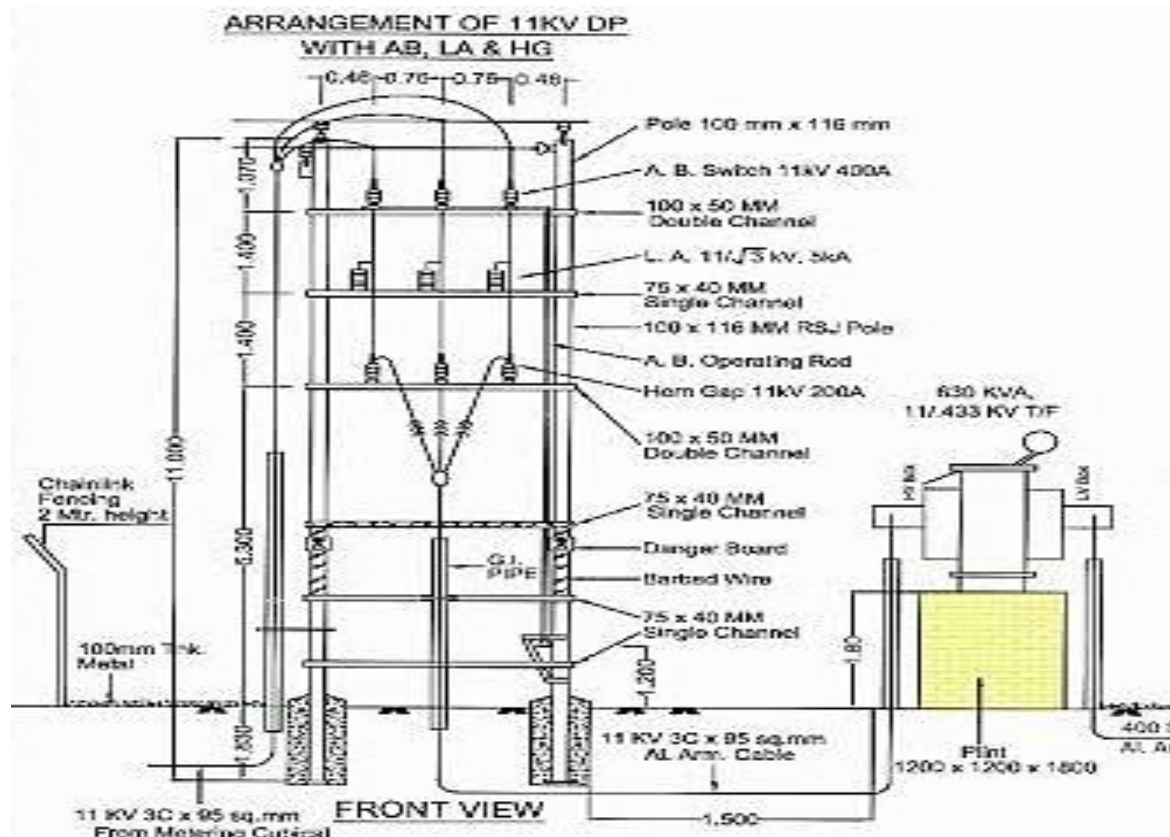
In this arrangement a foundation is prepared and the transformer is installed on that foundation. This is used for very heavy transformers. Fencing is provided around the transformer to protect it from animals and unauthorised access.

The foundations serves two basic purposes :

- It provide the base to the transformer and
- It absorbs the vibrations, if any, in the transformer during the operation.

Problem :-2

Prepare the list of materials required for plinth mounting substation of 11/0.4kv,50hz, 3-phase,250 KVA T/F .



Material table-

Sl. No	Description	Specification	Quantity
A-For H.T arrangement:			
01	Supports at the substation	Rail pole, 12m	2 no
02	Angle iron cross arm at the tapping pole	100mm× 50mm ×7.5mm ×1m	1 no
03	Disc type insulator at the tapping pole with its fitting accessories	Disc type for 11kv	6 no
04	Angle iron cross arm with its fitting accessories at the substation	M.S type ,100mm× 50mm ×7.5mm×0.75m	3 no
05	Lighting arrestor with fitting accessories	For 11kv	3 no
06	Earthing with its fitting accessories	For 11kv	3 sets
07	Stay with its fitting accessories	For H.T line	3sets
08	Over head conductor	ACSR 6/1×4.50	159 m
B-For AB switch arrangement:			
09	Cross arm with its fitting accessories	M.S type 100mm× 50mm ×7.5mm× 2m	2 no
10	Angle iron cross arm to support the pin insulator	M.S type 100mm× 50mm ×7.5mm× 0.75m	3 no
11	Insulators with its fitting accessories	Pin type 11 kv	6 no
12	GOAB switch with 6m long G.I pipe along with handle locking arrangement	For 11 /0.4 kv substation	1 set
C- For Drop out arrangement:			
13	Cross arm with its fitting accessories	M.S type 100mm× 50mm ×7.5mm× 2m	2 no
14	Angle iron cross are with its fitting accessories	M.S type 100mm× 50mm ×7.5mm× 0.75m	3 no
15	Insulators with its fitting accessories	Pin type 11 kv	6 no
16	Arcing rod to be fitting top of the insulator	for11 kv	6 no
17	Explosion type fuse wire	For 11 kv	1m
D- For Transformer installation:			
18	Angle iron cross arm at the base plate of the T/F which its fixed in the plinth	M.S type 100mm× 50mm ×7.5mm× 0.75m	2 no
19	Transformer	250 KVA, 11/0.4 KV	1 no

20	L.T cable	4 core aluminium type PVC insulated	5 m
21	Energy meter	Digital type 3-phase	1 no
22	L.T cable box	TPICN with rewirable type fuse unit	1 no
23	Earthing with its fitting accessories	Pipe earthing	2 sets
24	Jumper conductor	ACSR 6/11×4.50 mm	30 m
25	Danger plate	For 11 kv	3 no
26	Anti climbing wire	G.I type	6m
27	Plinth	Cement concrete	1:4:8
28	Sundries to complete the whole job	-----	As per required

POSSIBLE SHORT TYPE QUESTIONS WITH ANSWERS

(1)What is the maximum rating of the transformer which is installed in pole mounting substation?

Ans:- Generally in pole mounting substation up to 250 KVA transformer is installed.

(2) What is GOAB switch and where it is used?

Ans:- GOAB stands for gang operated air breaker switch and it is used to make and break the existing line manually.

It is used in distribution substation and intermediate line of the H.T. distribution.

(3) What is TPMO switch where and why it is used? [S-12, 16, 19, W-18,S-23,24]

Ans:- TPMO stands for triple pole manually operated switch and it is used in distribution substation as well as mid way of the H.T. line.

-It is used to make and break the existing line manually.

(4) What is TPIC switch? [S-12,16,19]

Ans :- TPIC means triple pole iron clad main switch. Generally it is used in D. C. distribution.

(5) What is TPICN switch and where it is used?(S-24)

Ans :- TPICN stands for triple pole iron clad with neutral link. It is used in 3-phase distribution main switch.

(6) What is AB switch and why it is used ?

Ans:- AB stands for air breaker switch it is used in distribution substation as well as in the mid-way of the H.T. lines

It is used to make and break the existing.

POSSIBLE LONG TYPE QUESTIONS

Q.1) Estimate the quantity of materials required for erection of a 100 KVA 11/0.4kv pole mounted substation & also draw the sketch. [S-13, 15, 16, 17, 19]

Q.2) Estimate the quantity of materials required for erection of a 250 KVA 11/0.4kv plinth mounted substation & also draw the sketch. [S-19,24]

CHAPTER NO.-05

OVER HEAD SERVICE LINES

Learning Objectives:

- 5. 1 Components of service lines, service line (cables and conductors), bearer wire, lacing rod. Ariel fuse, service support, energy box and meters etc.*
- 5. 2 Prepare and estimate for providing single phase supply of load of 5 KW (light, fan, socket) to a single stored residential building.*
- 5. 3 Prepare and estimate for providing single phase supply load of 3KW to each floor of a double stored building having separate energy meter.*
- 5. 4 Prepare one estimate of materials required for service connection to a factory building with load within 15 KW using insulated wire.*
- 5. 5 Prepare one estimate of materials required for service connection to a factory building with load within 15 KW using bare conductor and insulated wire combined.*

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

service cables:

- A cable is supplying electricity to a building, either by an overhead wire or in an underground conduit.
- Electric Service Cables that is specially designed for electrical Service. These are weather proof cables which can withstand the extreme mechanical & electrical conditions.

Bearer Wire

- Bearer wire, otherwise known as stone setting strip, is plain gold or silver wire measuring at two different thickness. These two thicknesses provide a step for the stone you're setting, supporting it and fixing it in place, while the thinner edge of the bezel can be used to hold the stone firmly in position.
- The bearer wire dimensions are Approx. 4.5mm with a 2mm strip bonded onto one half to form a step. A stone can be mounted onto the step and the thinner half of the strip pushed over to form a setting.

Lacing Rod

- Ties, lacing, and straps are used to secure wire groups or bundles to provide ease of maintenance, inspection, and installation.

- They may not be used in high vibration areas where failure of the strap would permit wiring to move against parts that could damage the insulation and foul mechanical linkages or other moving mechanical parts.

Ariel fuse

It is used in every field of constructions. Either a house or pole or any commercial buildings required this fuses. It act as a Circuits protectors which control the flow of Electricity. It's a stabilizers for the electricity consumption of a buildings.

Service Support

Gi wire support the service cable is called service support
Specification- G.I type, 14SWG

Energy Box And Meters

The service connection meet at the point where the supply conductors enter the energy meter.

It is the responsibility of the electricity department to install, maintain and for these we have to pay to the electric supply by conductors and energize the energy meter.

The board on which the cut-out, neutral link and meter are fitted is called meter board or service board. The meter is sealed by the electricity department.

Transmission line:

The power from the generating station is transmitted to substation by means of the transmission line.

Service line:

The overhead line or cable connection taken from the nearest pole of the service line to the consumer's premises or their building is called service line or consumers' service connection.

The over head line or cable or under ground cable connected between supplied line and consumer premises is called as service line or connection.

Generally service connection are of two types

- (1)single phase service connection
- (2)3-phase service connection

Depending on the field situation the service connections are of two types

- (1)over head service connection
- (2)under ground service connection

Important points to be remember: -

- If the service pole is situated more than 45m. from the consumers premises then overhead line may be used pole brackets.
- If consumers premises is more than 50m. from the service pole then one intermediate pole may be used
- If the consumers load does not exceed 1kw then 10SWG hard drawn copper conductors may be used.
- If the consumers load does not exceeds to 2.5 kw then 8SWG copper conductor or 13.9 mm² aluminum conductor may be used .

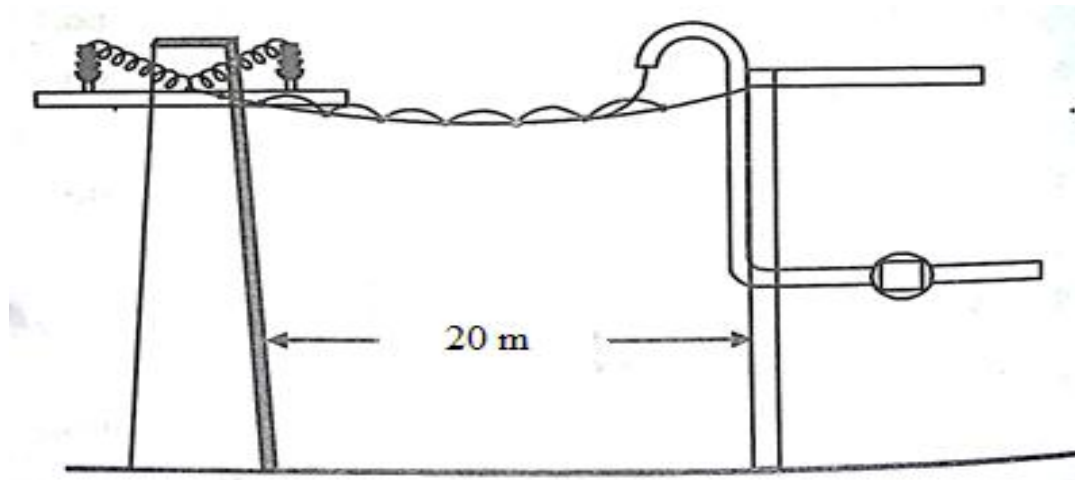
5. 2 Prepare and estimate for providing single phase supply of load of 5 KW (light, fan, socket) to a single stored residential building:

Problem:

Prepare a list of materials required for providing a service connection to a single staired building at 240 v 1-phase ,50hz a light & fan load of 5kw. The supply is to be given from an overhead line 20 m away from the building

Solution:

The neat sketch of service connection is dawn below.

**Calculation for short circuit current:**

Given that

$$P=5\text{kw}=5000\text{W}$$

$$V=240\text{V}$$

$$F=50\text{ Hz}$$

We know that

$$P=VI \cos\phi$$

$$I=P/V \cos\phi = 5000/(240 \times 1) = 20.83 = 21\text{A}$$

$$\text{So Full load current} = 21\text{A}$$

$$\text{So Short circuit current} = 1.5 \times \text{Full load current}$$

$$= 1.5 \times 21$$

$$= 31.5\text{ A}$$

Selection of cable:

Through our S.C current is 31.5 A but from the conductor table it is observe that for a current rating of 34A a PVC insulated twin core aluminum conductor of 10mm^2 , 240 V , Whether proof is to be selected.

Calculation for length 'of cable

Net length = Declared length +2% for sag +1m coil at the pole+1.5 m from coil to the overhead conductor + 1m coil at the service pipe +3 m along the pipe +0.3 m for wall thickness +0.5 m for meter clearance

$$\text{Net length} = 20 + 0.4 + 1 + 1.5 + 1 + 3 + 0.3 + 0.5$$

$$= 27.7\text{m}$$

Considering 10% extra for twisting cutting,

$$\text{Gross length} = 27.7 + 2.7 = 30.4\text{m}$$

Calculation for length of G.I wire

Net length = Declared length +2% for sag +1m at the pole +0.5 at the service pipe
=2.0+0.4+1+0.5=22m

Calculation for length of aluminum clip

Let 'us assume the length of G.I alluminium clip =10cm

Spacing of clip =20 cm

So length of the conductor =20m

$$=20 \times 100$$

$$=2000 \text{ cm}$$

So no of clip required =2000/20=100 nos

So length 'of clip wire = 100× 10=1000 cm'=10m

Material table:

Sl. no	Description	Specification	Quantity
01	Support wire	G.I type, 14SWG	22m
02	Cable	Pvc insulated twin core alluminium conductor 10mm ² weather proof	30.4 m
03	Support wire clips	Alluminium type, 38 mm	10 m
04	Service pipe	G.I type ,50mm dia ,2m height	01 no
05	Clamps to supports the service pipe along with it's fitting accessories	G.I type with appropriate diameter	03 nos
06	Energy meter	240 v, 1- ϕ digital type	01 no
07	Board to fix the energy meter with it's fitting accessories	45cm×60 cm ,iron clad with bakelight cover	01no
08	Sundries to complete the whole job	----	As per required

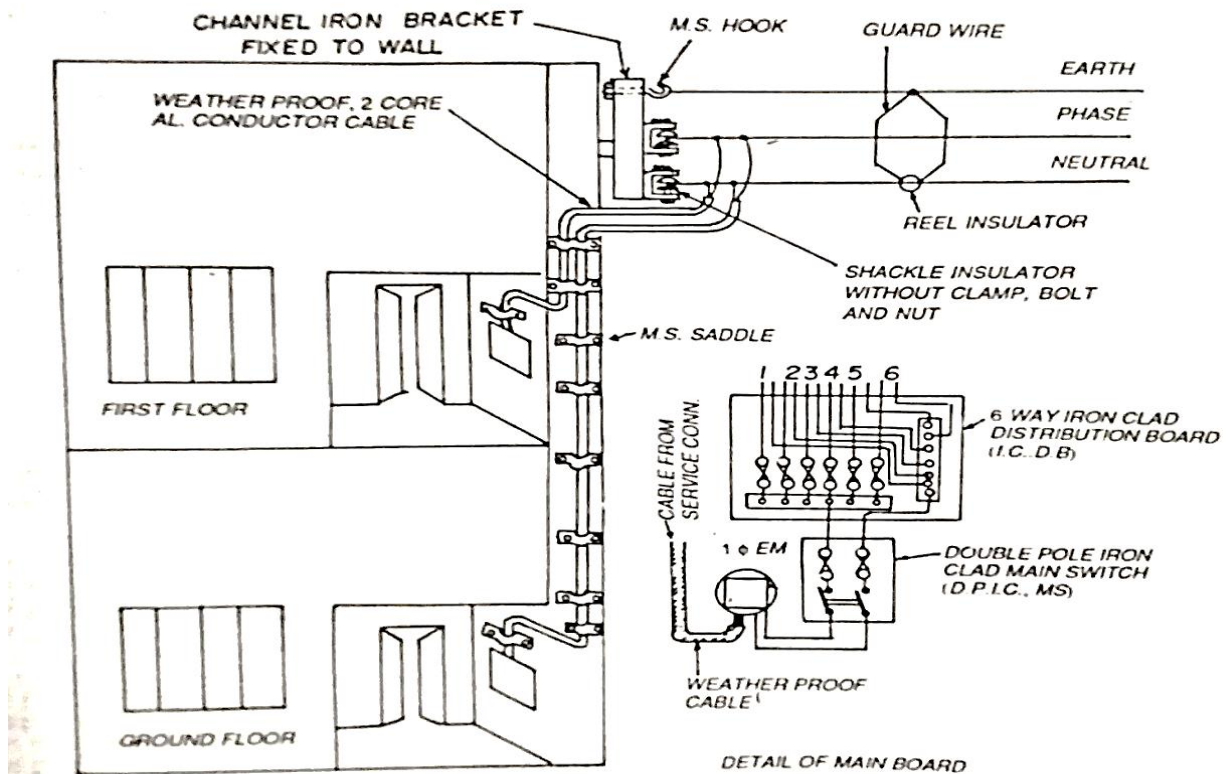
5. 3 Prepare and estimate for providing single phase supply load of 3KW to each floor of a double stored building having separate energy meter:

Problem

Estimate the quantity of materials required to providing connection to a double stored 'building with a load of 3 kw at 240 V , 50 Hz , separate meter are to be provided for the two floors .The distance between pole & building is 12 m & between the service bracket ' & service board of 1st floor is 3 m & between the service bracket ' & service board of ground floor is 6.5 m .

Solution:

The neat sketch of service connection is down below.



Calculation for short circuit current

Given that,

$$P=3\text{kw}=3000\text{w}$$

$$V=240\text{v}$$

$$f=50\text{ hz}$$

we that

$$P= V I \cos\phi$$

so $I= P/(V \cos\phi)$

$$=3000/(240 \times 1)$$

$$= 12.5 \text{ A (full load)}$$

$$\text{Short circuit current} = 1.5 \times \text{full load current}$$

$$= 1.5 \times 12.5$$

$$= 18.75 \text{ A}$$

Selection of cable:

Though our short circuit current is 18.75 A but from the conductor table, it is observed that for a current rating of 27 A PVC insulated twin core aluminum conductor of 6mm^2 240 v weather 'proof' is to be selected.

Calculation for length of cable:

For 1st floor

Net length = Declared length + 1m coil at the 'pole' + 1.5 from coil to the overhead conductor + 0.3 for wall thickness + 0.5 m meter clearance

$$= 3 + 1 + 1.5 + 0.3 + 0.5 = 6.3 \text{ m}$$

For ground floor

Net length =Declared length +1m coil at the 'pole +1.5 from coil to the overhead conductor +0.3 for wall
Thickness+ 0.5 m meter clearance
=6.5+1+1.5+0.3+0.5
=9.8 m =10m
Total length =6.5+10= 16.5m

Calculation for length of overhead conductor :

Net length = 2(Declared length + excess of height from the pole top+2% for sag)
=2× (12+6.5+0.24)
=37.48m

Considering 10% extra for twisting & cutting
So Gross length= 37.48+3.748= 41.228 m

Calculation for no of G.I clamps:

Assuming the installation G.I clamps at an interval of 1m along the angle iron & wall surface.
Hence no of clamps required =11

Material table:

Sl. no	Description	Specification	Quantity
01	Angle iron as the bracket with it's fitting accessories	M.S type, 50mm×50mm× 6mm× 10m long	1no
02	Cross arm with it's fitting accessories	M.S type, 50mm×50mm× 6mm× 0.75m long	01 no
03	Insulators with its fitting accessories	Pin type,' 440	02 nos.
04	Over head conductor	AAC	41.228 m
05	Cable	PVC insulated twin core aluminium conductor, 6mm ² weather proof	16.5m
06	Clamps to hold the cable on the wall with its fitting accessories	G.I. type	11nos.
07	Energy meter	240v,1-φ, digital type	02 nos.
08	Board to fix the energy meter with its fitting accessories	45cm 60cm ,IC type with backelite	02 nos.
09	Flexible conduit	Appropriate dimension	01 m.
10	Sundries to complete the whole job	-----	As per required

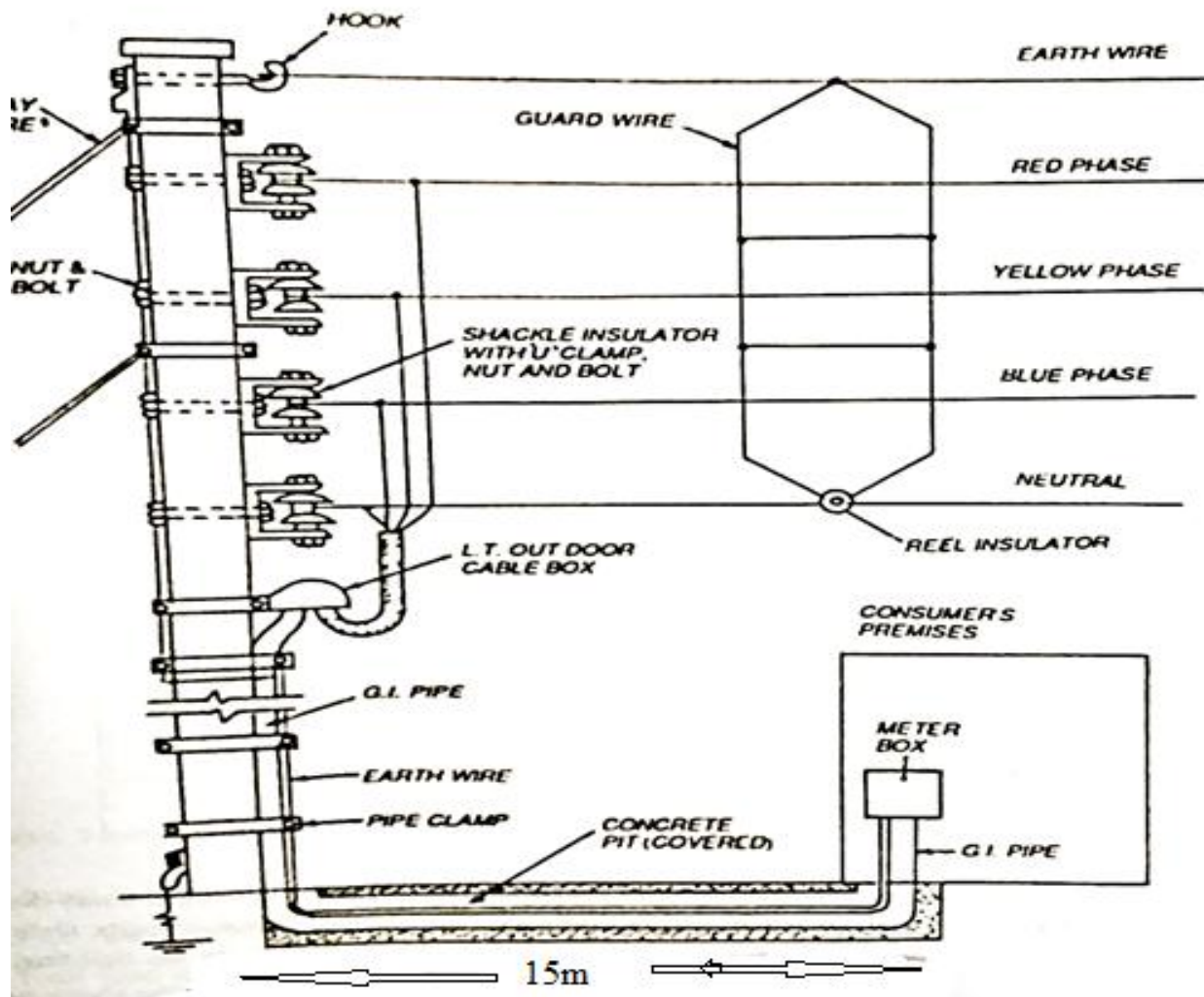
5. 4 Prepare one estimate of materials required for service connection to a factory building with load within 15 KW using insulated wire:

Problem:

A farmer required to connect a three phase 15kw, 415 v, 50hz motor to a 3- ϕ 4 wire, 415 V/ 240V, 50Hz overhead line. The distance of the service line from the firmer structure having 15m. The motor has an efficiency of 85% and power factor of 0.8 estimate the quantity of materials required for this purpose.

Solution:

The neat sketch of service connection is down below.



Calculation of short circuit current-

Output power of the motor (p_{out}) = 15kw = 15000w

Given efficiency = 85% = 0.85

Efficiency = output power / input power

So, Input power = output power / efficiency

$$= 15000 / 0.8 = 17647.05 \text{ w} = 17.64 \text{ kw}$$

But, input power= $\sqrt{3}$ VICos ϕ

So, I = Input power / ($\sqrt{3}$ VCos ϕ)

$$I = 17647.05 / (\sqrt{3} \times 415 \times 0.8)$$

$$= 30.69 \text{ A} = 30.7 \text{ A}$$

So Short circuit Current = 2 \times full load current

$$= 2 \times 30.7 = 61.37 \text{ A}$$

Selection cable:

From the conductor table it is observe that for a current rating of 158A, 50mm² paper insulated , 1100v grade 4 core aluminum underground cable is to be selected.

Calculation for length of cable

Net length= 2m from the over head conductor +5.5m along the core up to ground +0.2m trench depth

+15m along the trench +0.2 trench depth +2m meter clearance.

$$= [2 + 5.5 + 0.2 + 15 + 0.2 + 2]$$

$$= 24.9 \text{ m} = 25 \text{ m}$$

Considering 10% extra for twisting & cutting

$$\text{Gross length} = 25 + 2.5 = 27.5 \text{ m}$$

Calculation for no of G.I clamps

Assuming the distance between two clamps to be 1m, as per diagram we need 6 nos of clamps.

Material table-

Sl. no	Description	Specification	Quantity
01	Cable	4 core aluminum type ,1100 v grade ,50mm ² paper insulated	27.5 m
02	Clamps to hold the cables with its fitting accessories	G.I type appropriate dimension	6 nos.
03	L.T. cable box	TPICN, with rewirable type fuse unit	01 no.
04	Energy meter	3- ϕ , digital type	01 no.
05	Board to fix the energy meter	45cm \times 60cm iron clade with bakelite cover	01 no.
06	Earthing thimble	G.I. type	02 nos.
07	Sundries to complete the whole job	-----	As per required

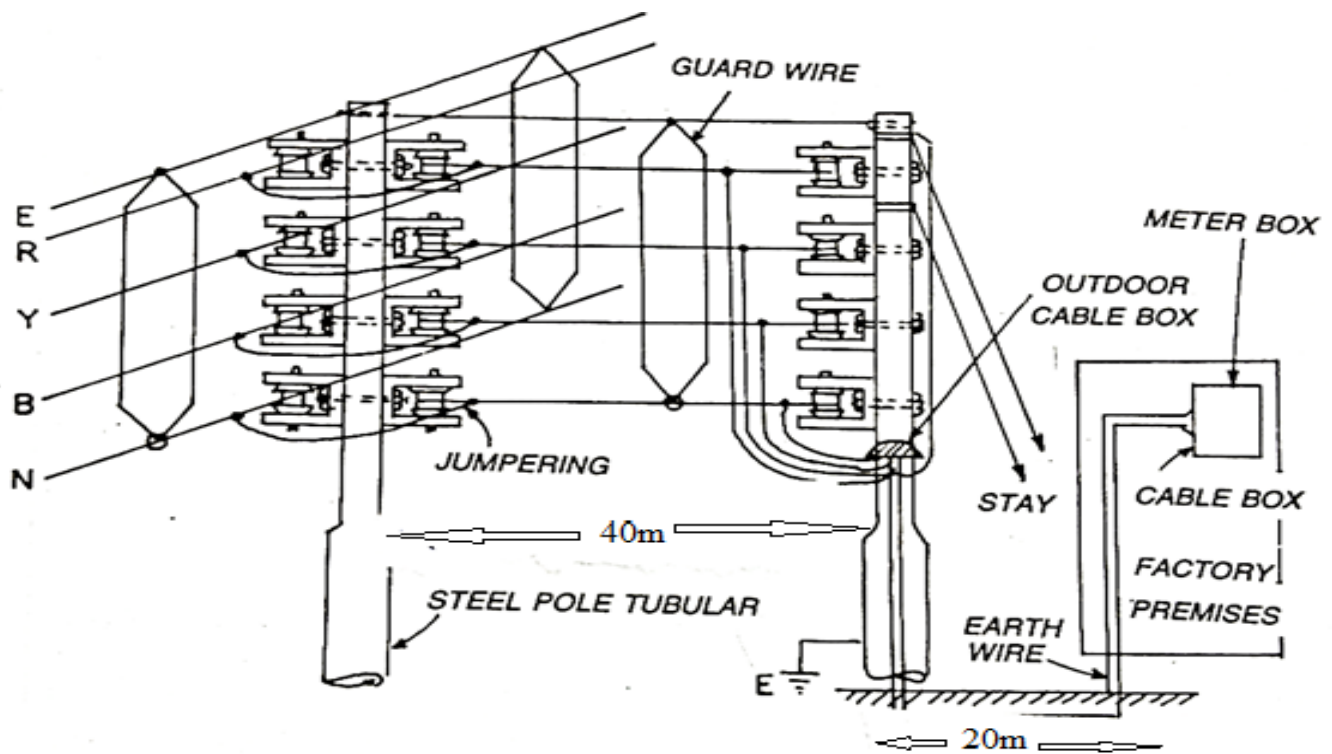
5.5 Prepare one estimate of materials required for service connection to a factory building with load within 15 KW using bare conductor and insulated wire combined:

Problem

A factory man required to connect a three phase 15 kw, 415 v, 50hz motor to a 3- ϕ 4 wire, 415 v/ 240v, 50hz over head line. The distance of the service line from the firm structure having 60m. the motor has an efficiency of 85% and power factor of 0.8 estimate the quantity of materials required for this purpose.

Solution:

The neat sketch of service connection is down below.



According to I.E rule, 'if consumer premises is more than 50 m from the service pole then one intermediate pole is used.

So according to question

Service pole to intermediate pole distance is 40 m which used in bare conductor according to overhead line process.

Intermediate pole to meter box distance is 15 m which used in underground insulated wire according to service line process.

Calculation for over head line accessories:

No of pole =1

No of Cross arms = 1+1=2

No of shackle insulator = 4+4=8

Calculation for length of over head conductor:

Net length of conductor = 4 (Total length of line +2% of sag)
 $=4(40+0.2) = 4 \times (40.2) = 80.8 = 81\text{m}$

Calculation of Short circuit Current:

Output power of the motor (p_{out}) = 15kw = 15000w

Given efficiency = 85% = 0.85

Efficiency = Output power / input power

So, Input power = Output power / efficiency

$$=15000/0.85 = 17647.05 \text{ w} = 17.64 \text{ kw}$$

But, input power = $\sqrt{3} VI \cos\phi$

So, $I = \text{Input power} / \sqrt{3} V \cos\phi$

$$I = 17647.05 / (\sqrt{3} \times 415 \times 0.8) = 30.69 \text{ A} = 30.7 \text{ A}$$

So Short circuit Current = 2 × full load current

$$= 2 \times 30.7 = 61.37 \text{ A}$$

Selection cable:

From the conductor table it is observe that for a current rating of 158A, 50mm² paper insulated, 1100v grade 4 core aluminum underground cables is to be selected.

Calculation for length of cable

Net Length = 2m from the overhead conductor + 5.5m along the core up to ground + 0.2m trench depth
+ 20m along the trench + 0.2 trench depth + 2m meter clearance
 $= [2 + 5.5 + 0.2 + 20 + 0.2 + 2] = 29.9\text{m} \approx 30\text{m}$

Considering 10% extra for twisting & cutting

Gross length = 30 + 3 = 33 m

Calculation for no of G.I clamps

Assuming the distance between two clamps to be 1m, as per diagram we need 6 no of clamps.

Material table:

Sl. No	Description	Specification	Quantity
<u>over head line materials</u>			
01	Supports	RCC, 9m	01 no
02	Cross arm with its fitting accessories	Angle iron cross arm	2 no
03	Insulator with its fitting accessories	Shackle insulator	8 no
04	Over head conductor	ACSR, 6.1×3.00mm long	81m
05	Earthing with its fitting accessories	For 440 v lines	1 set
06	Stay set with its fitting accessories	For 440 v	1set

07	Binding wire at the rate 100gm per pin insulator	Alluminium single core	As per required
08	Anticlimbing wire at the rate 3m per pole	G.I type	3 m
09	Danger plate	440v	1 no
<u>Under ground Service line materials</u>			
10	Cable	4 core alluminium type ,1100 v grade ,50mm ² paper insulated	33 m
11	clamps to hold the cables with its fitting accessories	G.I type appropriate dimension	6 nos.
12	L.T. cable box	TIPCN, with rewirable type fuse unit	01 no.
13	Energy meter	3- ϕ , digital type	01 no.
14	Board to fix the energy meter	45cm×60cm iron clade with backelite cover	01 no.
15	Earthing thimble	G.I. type	02 nos.
16	Sundries to complete the whole job	-----	As per required

POSSIBLE SHORT TYPE QUESTIONS WITH ANSWER

Q.1 Why the core of service cable is mostly selected as aluminium?

Ans- the core of the service cable is selected as aluminium because the over head conductor at the service is also aluminium. Hence to avoid interruption of energy supply due to dis-similarity of material contact.

Q.2 Write the size of G.I. wire used as a support wire in service line.

Ans- generally 14 SWG G.I. wire used as a support wire in service line.

Q.3 At what condition over head bare conductor is used for providing service connection.

Ans- the over head bare conductor is used for providing the service connection only when the distance between the distribution pole and consumer premises exceeds 45m.

Q.4 Why G.I. is used for carrying cable for service connection is bent back at the upper end with opening facing downward.

Ans- the G.I. pipe is used for carrying cable for service connection has been made bent to prevent entering of rain water into the pipe.

Q.5 What are the various types of service connection?

Ans- Depending on the field situation service connections are of two types.

1. Overhead service connection
2. Underground service connection

Depending on the voltage it is two types

1. Single phase service connection
2. 3- ϕ service connection

Q.6 State the minimum clearance between the ceiling & the lower position of the service wire while passing over a residential building. [S-12,24]

Ans-The minimum clearance between the ceiling & the lower position of the service wire while passing over a residential building 8m.

POSSIBLE LONG TYPE QUESTION

Q-1 Prepare a list of materials required for providing a service connection to a single staired building at 240 v 1-phase load of 2kw. The supply is to be given from an overhead line 20 m away from the building. draw the sketch. [S-12,15,S-23]

Q.2 Prepare a list of materials required for providing a service connection to a single staired building at 240 v 1-phase ,50hz a light & fan load of 6kw. The supply is to be given from an overhead line 15 m away from the building [S-16,19,24]

Q.3 Estimate the quantity of materials required to providing connection to a double stored 'building with a load of 4 kw at 240 v , 50 Hz , separate meter are to be provided for the two floors . The distance between pole & building is 12 m & between the service bracket ' & service board is 10 m.[S-17]

CHAPTER NO-02

ELECTRICAL INSTALLATION

Learning objectives:

- 2.1 *Electrical installations, domestics, industrial, Wiring System, Internal distribution of Electrical Energy. Methods of wiring, systems of wiring, wire and cable, conductor materials used in cables, insulating materials mechanical protection. Types of cables used in internal wiring, multi-stranded cables, voltage grinding of cables, general specifications of cables.*
- 2.2 *ACCESSORIES: Main switch and distribution boards, conduits, conduit accessories and fittings, lighting accessories and fittings, fuses, important definitions, determination of size of fuse – wire, fuse units. Earthing conductor, earthing, IS specifications regarding earthing of electrical installations, points to be earthed. Determination of size of earth wire and earth plate for domestic and industrial installations. Material required for GI pipe earthing.*
- 2.3 *LIGHTING SCHEME: Aspects of good lighting services. Types of lighting schemes, design of lighting schemes, factory lighting, public lighting installations, street lighting, general rules for wiring, determination of number of points (light, fan, socket, outlets), determination of total load, determination of Number of subcircuits.*

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

Electrical installations

An electrical installation is a combination of electrical equipment installed from a common electrical supply to fulfil a particular purpose.

Electrical installations in domestics:

An electrical installation is a combination of electrical equipment in domestic purpose installed from a common electrical supply to fulfil a particular purpose. This required 1-phase supply.

Electrical installations in industrial:

An electrical installation is a combination of electrical equipment in industrial purpose installed from a common electrical supply to fulfil a particular purpose.

This required 1-phase & 3-phase supply

Wiring system: -

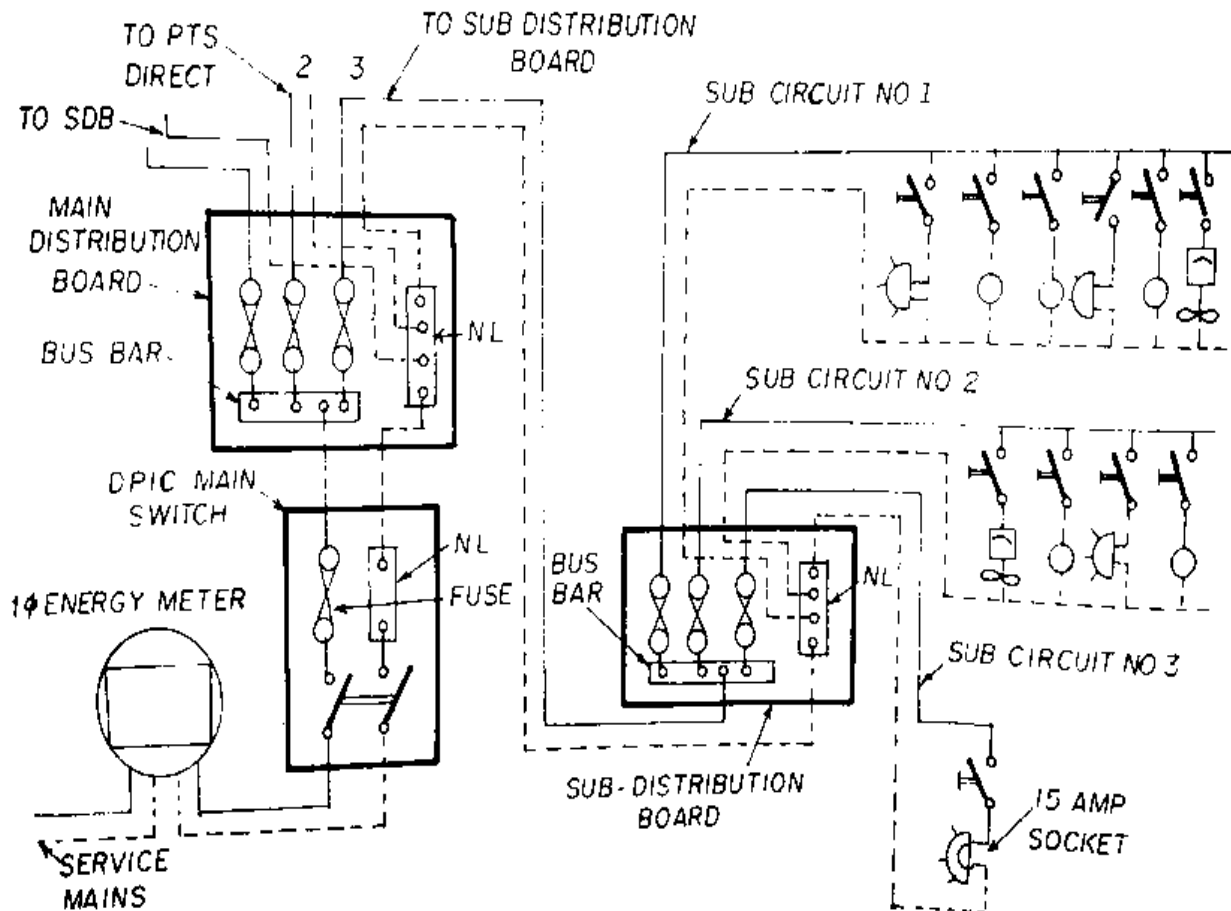
It is defined as a network of wires connecting with various electrical load from supplier meter boards through the safety and controlling device.

Internal distribution of Electrical Energy

In our country basically following two types of systems are adopted for distributing electrical energy.

- i. Distribution board system
- ii. Tree system

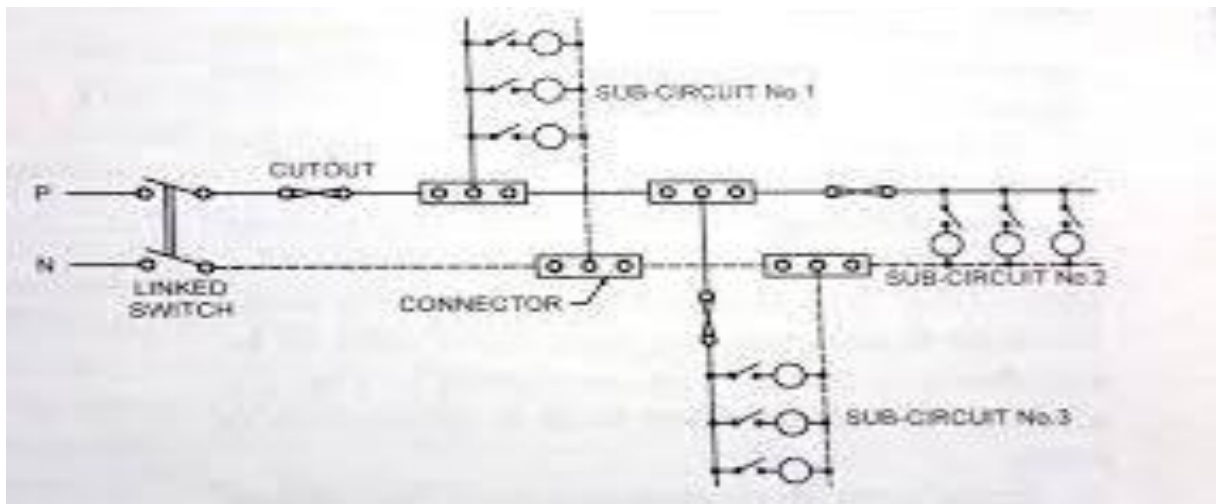
(i) Distribution board system: -



- This is one of the widely used energy distribution system in our country, this system has an iron clad, in each circuit one cut-out must have to be installed on the iron clad or board so this board sometimes called as fuse board or distribution board.
- For every circuit phase and neutral wire must be taken from the respective bus bar which is also fitted on the distribution board. In this system each circuit must contain 10 points or 800 watt.

Tree system: -

- This system of wiring is not used frequently due to the following reasons
 - The extreme end load or last end load cannot get the declared voltage due to resistive drop.
 - Fuses are connected which causes more expensive.
 - In this system fuses are connected in the phase wire; neutral link connectors are also connected in neutral and phase wire respectively for each circuit phase and neutral are taken from the connector and neutral links as shown in above figure.

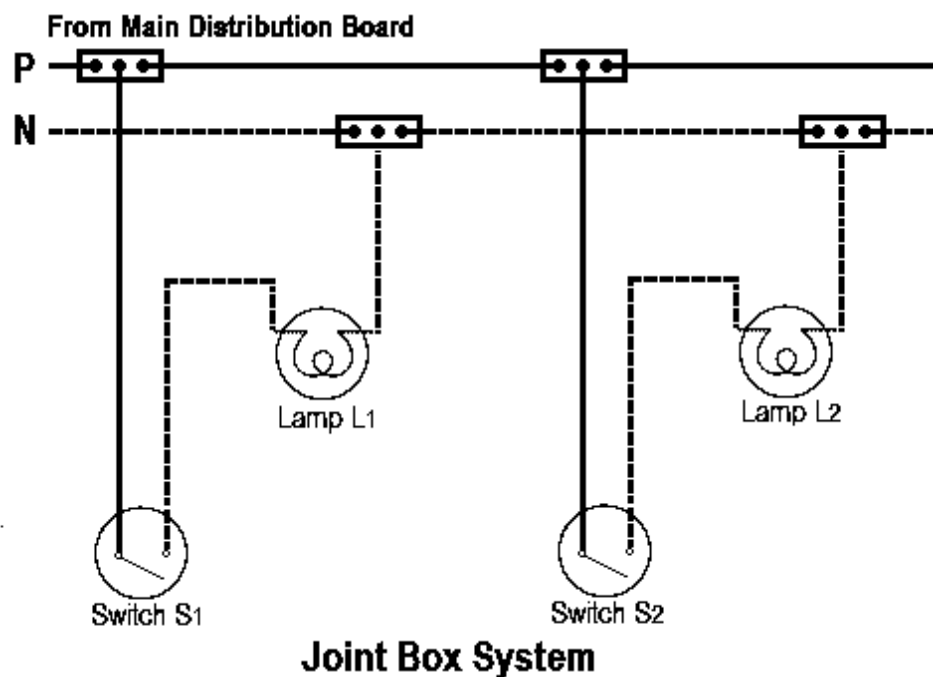


Methods of wiring: -

Generally, we have two types of methods for wiring that are

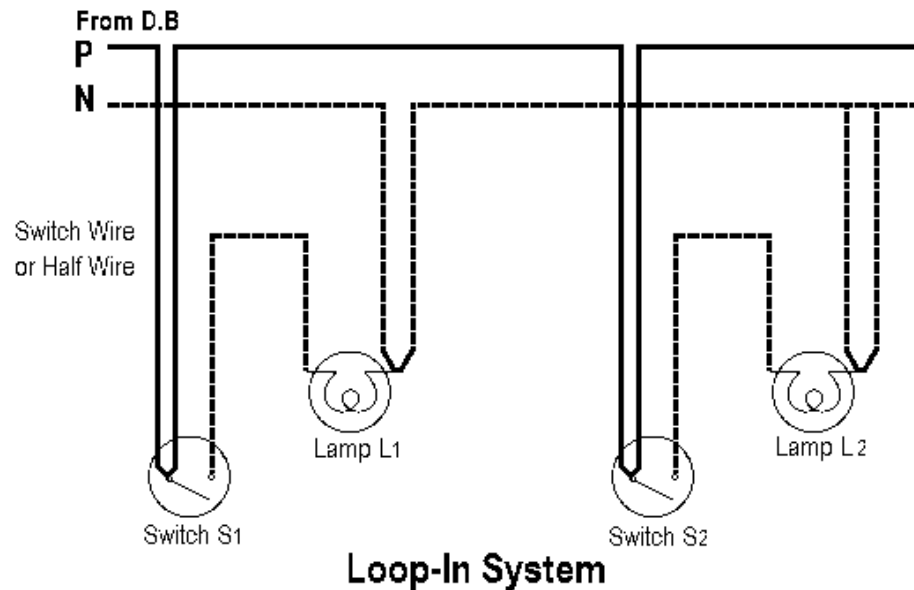
- (i) joint box
- (ii) loop in system

Joint box system: -



- In this system phase and neutral wires are connected with the joint boxes as shown in the above figure. For each electrical load, a phase wire is taken from the joint box through the switch, and a neutral wire goes from the joint box directly to the load. By this way, for each number of electrical loads, joint boxes are used, and accordingly switches are used.
- This method is a costlier method. Hence this method is not adopted nowadays.

Loop – in system: -



- In this system phase wire is to be controlled by the switches and the same phase to be connected to a particular load as shown in the above figure, the neutral is directly connected to each load but not through the switches. This system of wiring is widely using now a days.

Systems of wiring: -

In the wiring system may be domestic or industrial following wiring systems are adopted

1. Cleat wiring
2. Wooden casing & capping wiring
3. CTS or TRS or LEAD sheathed wiring
4. Conduit wiring

(1) Cleat wiring:-

At first in this wiring demarcation is given on the wall surface, using hand drill holes are made long the demarcation at 3cm to 60cm apart then wooden gutties (plugs) of size 38mm×38mm of 6.5c.m. long are placed in the drilled holes. Then the base cleats are to be fixed on the gutties then VTR cables are taken through the base cleats and immediately after it the top cleats are screwed over the base cleat. Now the cables are permanently placed in the cleats.

Application:-

This wiring system is basically used in un damped places and also where a temporary wiring is needed.

(2) Wooden casing & capping wiring: -

In this wiring demarcation is given on the wall surface at a height of 3m from other ground. Using drilling holes are made along the demarcation line with 15cm apart. The wooden gutties (plugs) are inserted in the drilled holes the wooden casing is fixed on the gutties by means of screw. The length of such casing is about 2.5m to 3m. After its PVC or VIR cables are drawn through the casing then the top cover named as capping is now fixed by the help of screws.

Application: -

This wiring system is basically used in low voltage (1-phase, 240v) domestic wirings. Normally in dry places where there is no risk of fire.

(3) CTS or TRS or lead sheathed wiring: -

In this wiring demarcation is given on the wall surface and height 3m from ground using hand drill holes are created along the demarcation line of distance 75cm apart. The wooden gutties are plugged of the size 32mm× 8mm about 6.5 cm. Long are inserted in the drilled holes then for holding the cables links is made with tinned brass are fixed on the batten with an interval of 10cm. In case of horizontal and 15cm. In case of vertical then the teak wood batten of different sizes as applicable such as 13 ×13mm, 19 ×13mm, 25× 13mm and 31 ×13mm etc. Are fixed over the gutties by means of machine screws or wooden plugs with appropriate size. Then TRs or CTS cables are laid over the nail pins are twisted so as to hold the cable permanently. For providing the no. of cables and link pins the different size of batten are mentioned in the following table.

Batten size	Number and size of link clips	Number of single core cable to carried out
13mm ×13mm	1 ×38mm	2
19mm ×13mm	1 ×50mm	3
25mm ×13mm	2 ×28mm	4
31mm ×13mm	1× 38mm & 1 ×50 mm	5

Application-

This type of wiring is used for low voltage installation in domestic, commercial or industrial workshop.

(4) Conduit Wiring-

- In this wiring the demarcation is given on the wall surface at a height of 3 m from the ground using hand drill holes are created along the demarcation line at a distance of 75 cm apart the wooden gutties or plug of size 32 mm× 8mm about 6.5 long are inserted in the drilling holes. Then the base saddle is fixed on the gutties.
- In this wiring, all wires are enclosed in steel pipe known as conduit. It is metal is annealed to permit to easy bending. The inner surface of the conduit is carefully prepared so that the wires can be easily pulled into it with a minimum of effort.
- There are three types of conduit wirings
 - Concealed wiring
 - Surface conduit wiring
 - Flexible conduit wiring

Lead or metal sheathed wiring: -

The conductors having insulated covering of V.I.R are covered with an outer sheath of lead or lead alloy. The max^m thickness of lead covering thus formed may not exceed 1 mm or 1.5 mm. this metal sheath provides toughness and gives protection to the cable against mechanical injury and atmospheric corrosion.

Wire & cable: -

- The term wire is very much familiar in wiring system which meaning is a strip of bare conductor with negligible thickness.
- Similarly, the term cable is also a popular word used in wiring system. Its meaning is a wire covered with insulated materials.
- A cable may be single core, double core & more core.

Conductor materials used in cables: -

Conductor: -

- Generally, conductor is a medium through which electric current can easily flows. following are the important materials use for the conductors.

Copper: -

- Copper materials is used as a best material for the conductor. Its conductivity is comparatively high.
- At 20⁰c temperature the resistivity of copper is $1.786 \times 10^{-8} \Omega \text{ m}$.
- The specific weight of copper is 8900 kg/m^3 .
- It has high resistance to corrosion, oxidation and pitting.

Aluminium: -

- In the electrical field basically in transmission, distribution and utilization it dominates the copper material.
- It is the next immediate choice of material for the conductor.
- Its resistivity is $2.87 \times 10^{-8} \Omega \text{ m}$ at 20⁰c.
- This material is less cost ad used in different cables as well as overhead bare conductors.
- It is also affected by oxidation.

Insulating materials: -

- The sole purpose of insulating materials used in cable or covered with the bare conductor is to prevent leakage current. from the conductor o core.
- Following are the important properties of a insulating materials.
 - High resistivity
 - High dielectric strength
 - High resistant to moisture, acids & alkalies.
 - Capable of withstanding high rupturing voltage.
 - Capable of withstanding at high temperature.
 - High flexibility.

Types of insulating materials:-

Followings are the important insulating materials that are used in various electrical field.

- Rubber
- Vulcanized Indian rubber (VIR)
- Impregnated paper
- Polyvinyl chloride (PVC)
- Silk & cotton

Mechanical protection-

Generally, a cable should be design in such a manner that it can help mechanical stability. Usually in power cables to protect against mechanical injury two layers of steel tap are used or now a days aluminium sheathing is introduced.

Types of cables used in internal wiring: -

Generally, cables are categorized based on the conductors used, no of ores, amount of voltage supply a type of insulations. Hence following are the important cables used in internal wiring

- VIR (240v /415v and 650v /1100v)
- TRS or CTS (240v /440v and 650v /1100v)
- TRS-tough rubber sheathed
- CTS-cap tyre sheathed
- Lead sheathed cable (240v/415v)
- PVC (poly-vinyl chloride) (240v /415v and 650v /1100v)
- Weather proof cable (240v /415v and 650v /1100v)
- XLPE cable – it means cross link polyethylene insulated aluminium conductor armoured cable.

Multi- stranded cables: -

The multi – strand cable is composed of several fine copper wires.



Voltage grinding of cabels: -

It is the process of archiving uniform distribution of dielectric stress or voltage gradient in a dielectric of cable.

There different types voltage grade (240v/415v), (650/1100) v, (240/415) v mains: -

- Voltage between conductor & earth is 240v.
- Voltage between two conductors is 415 v.

General specification of cables: -

While purchasing or estimating the cable we must emphasise on following factors.

- Size of the cable (19/ 2.24 mm, 7/1.70 mm etc.)
- Types of conductors used (Aluminium or copper)
- No of core (single core, double core, 3 core etc)
- Voltage grade (240/ 415v or 650 /1100v etc.)
- Types of insulation material (PVC OR TRS etc)

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

Main switch & distribution boards: -

According to the IE rule a suitable linked switch has to be provided immediately after the meter board. Following are the important specifications of main switches according to their applications.

- 240v, 16A, DPIC switch for two wire DC. Circuit or 1- phase.
- 500v, 32A /63A/100A /150A TPIC main switch for 3 wire D.C. circuit.
- 415v, 32A /63a/ 100A /150 A TPICN used for 3- phase 4 wire A.C. circuit.

Similarly for distribution board we have main specifications as two ways, three ways, 4 ways etc.

Conduits: -

Generally, in household wiring we use following type of circuit

- Light gauge steel conduit
- Heavy gauge steel conduit
- Flexible conduit
- PVC conduit

Conduit accessories & fittings:

In the wiring system basically for conduit wiring following accessories are frequently used. Bend (L- conduit) conduits and T- conduits.

- Bushings or coupler (male or female conduits)
- Clip and saddles conduits.
- Conduit boxes (2 ways, 3ways, 4 ways etc.)

Lighting accessories and fittings: -

For lighting purpose, we use following accessories and fittings.

Switches: Following switches are generally used in household wiring

- One way switch
- Two way and two-way centre of switch
- DP main switch
- Push button switch
- Bed switch
- Table lamp switch
- Tumbler or surface switches
- Flush switches

Ceiling rose: -

Ceiling rose may be of two plates ceiling rose is basically used for ceiling fans.

Socket outlets: -

Depending on the field application a socket outlet may be of two pins, three pin, five pin and six pin of 240v ,6A/ 16A or 32A etc.

Lamp holders: -

We have following types of lamp holders

- Batter holder
- Pendant holder
- Angle holder
- Slanting holder
- Bracket holder
- Water type bracket holder
- Miniature lamp holder

From the above holders the specification may be 5A, 250A, back elite holder of any make.

Fuses: -

It is a low melting point electrical safety device that operates to provide over current protecting.

Important definitions: -

Fuse element or fuse wire:

It is made of zinc, copper, silver, aluminium or alloy. Best fuse is alloy of lead & tine which has low melting point & very high resistance.

Fuse link

It is that part of the fuse which needs replacement when the fuse blown out.

Current rating

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

Fusing current

It is defined as the minimum value of current at which the fuse element or fuse wire melts.

Cut – off current: -

The maximum value of fault current actually reached before the fuse melts is called cut – off current.

Fusing factor: -

It is defined as the ratio of minimum fusing current to the fusing rating of the fuse element i.e.

Fusing current = minimum fusing current / current rating of fuse element.

Determination of size of fuse – wire: -

The factor responsible for determine the size of fuse wire in an installation are

- i) Maximum current rating of the circuit.
- ii) Current rating of the smallest cable in the circuit protected by the fuse
 - For an ordinary lightning sub circuit wired with 1/1.12mm or 3/0.736mm cable a fuse wire of 21SWG is used
 - For a power circuit (2KW) wired with 7/0.736mm cable for 240volt supply, fuse wire used will be of current rating 8.33amp. is used.

Determine the current rating of a fuse: -

The value of current at which the installation is working without any damage is the current rating of the fuse. Following are the main factors which determine the current rating of a fuse:

Minimum size of cable or fuse for mechanical reasons.

- Voltage drops.
- Current carrying capacity.
- Type of insulation of the fuse.
- The unit of fuse is – ampere.

Different types of protective devices used both in domestic & factors

- Fuse
- MCB (miniature circuit breaker)

Fuse units: -

The various types of fuse units most commonly available are

- Round type fuse unit.
- Kit-kat type or rewirable fuse unit.
- Cartridge type fuse unit.
- HRC fuse unit.
- Semiconductor fuse unit.

Earthing conductor: -

- Earthing conductor is of high conductivity copper.
- Its shape is of either stranded, flat strips or circular or rectangular bar.
- It is protected against mechanical injury.
- Bare conductor is protected against corrosion.

Earthing: -

Earthing means connection of the neutral point of a supply system or the non-current carrying parts of electrical apparatus, such as metallic framework, metallic covering of cables, earth terminals of socket

outlet, stay wire etc. to the general mass of earth in such a manner that at all times an immediate discharge of electrical energy takes place without danger.

Methods of earthing: -

Following methods are adopted for earthing: -

- i. **Strip or wire earthing: -**
 - For copper dimension is 25mm × 1.6mm
 - For G.I. dimension is 25mm × 4mm
- ii. **Rod or spike earthing: -** Various rods are available in market for earthing that are 12.5 mm dia solid rods of copper and 2.5 m long .16 mm dia solid rods of G.I. or G.S. of 2.5 m long and 25mm dia G.I. of 2.5 m long.
- iii. **Pipe earthing: -** Pipe earthing the various type of pipes are available in different sizes that are 40mm with 2.5 m long G.I. and 19mm dia with 1.25 m long G.I.

IS specifications regarding earthing of electrical installations: -

The various important specification regarding earthing as recommended by Indian standards are given below:

- **Distance of earth from the building: -**
In general the distance of earth electrode from the building should not be less than 1.5 m
- **Size of earth continuity conductor: -**
Normally we use 14 SWG or 16 SWG or 18 SWG G.I. or copper.
- **Resistance of earth: -**
According to IE rules the resistance should be low enough to cause the flow of electric quickly. The earth resistance is not equal in all places because it depends on the moisture contains and the type of soils etc. Therefore, following are the important values of earth resistance that can be permitted.
 - For large power station – 0.5Ω
 - Major power station - 1Ω
 - Small substation - 2Ω
 - In all other cases - 5Ω

The resistance from the earth plate to any point in the installation is 1Ω

Points to be earthed:-

According to IE Rules and IEE Regulations:

- (i) Earth pin of 3-pin lighting plug sockets and 4-pin power plug sockets should be permanently and efficiently earthed.
- (ii) All metal casings or metallic coverings containing or protecting any electric supply line or apparatus, such as iron clad switches, iron clad distribution fuse boards, G I pipes and conduits enclosing VIR or PVC cables, the down rods of electric fans, etc; should be connected to earth.
- (iii) The metal casings of portable apparatus such as heaters, refrigerators, hand lamps, soldering irons, electric drills etc., should be connected to earth.
- (iv) The frame of every generator, stationary motor, and as far as possible, portable motor and the metallic parts (not intended as conductors) of all transformers and any other apparatus used for regulating or

controlling energy and all medium voltage energy consuming apparatus should be earthed by two separate and distinct connections with earth.

(v) The neutral conductor of a 3 -phase, 4-wire system and the middle conductor of a 2 -phase, 3 -wire system should be earthed by not less than two separate and distinct connections with earth at the generating station and at the substation.

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

(vii) In a dc 3 -wire system the middle conductor should be earthed at the generating station.

(viii) Fabricated steel transmission line towers, tubular steel or rail poles carrying overhead conductors should be earthed.

(ix) Stay wires provided for overhead lines should be connected to earth by connecting at least one strand to the earth wire.

Determination of size of earth wire and earth plate for domestic and industrial installations: -

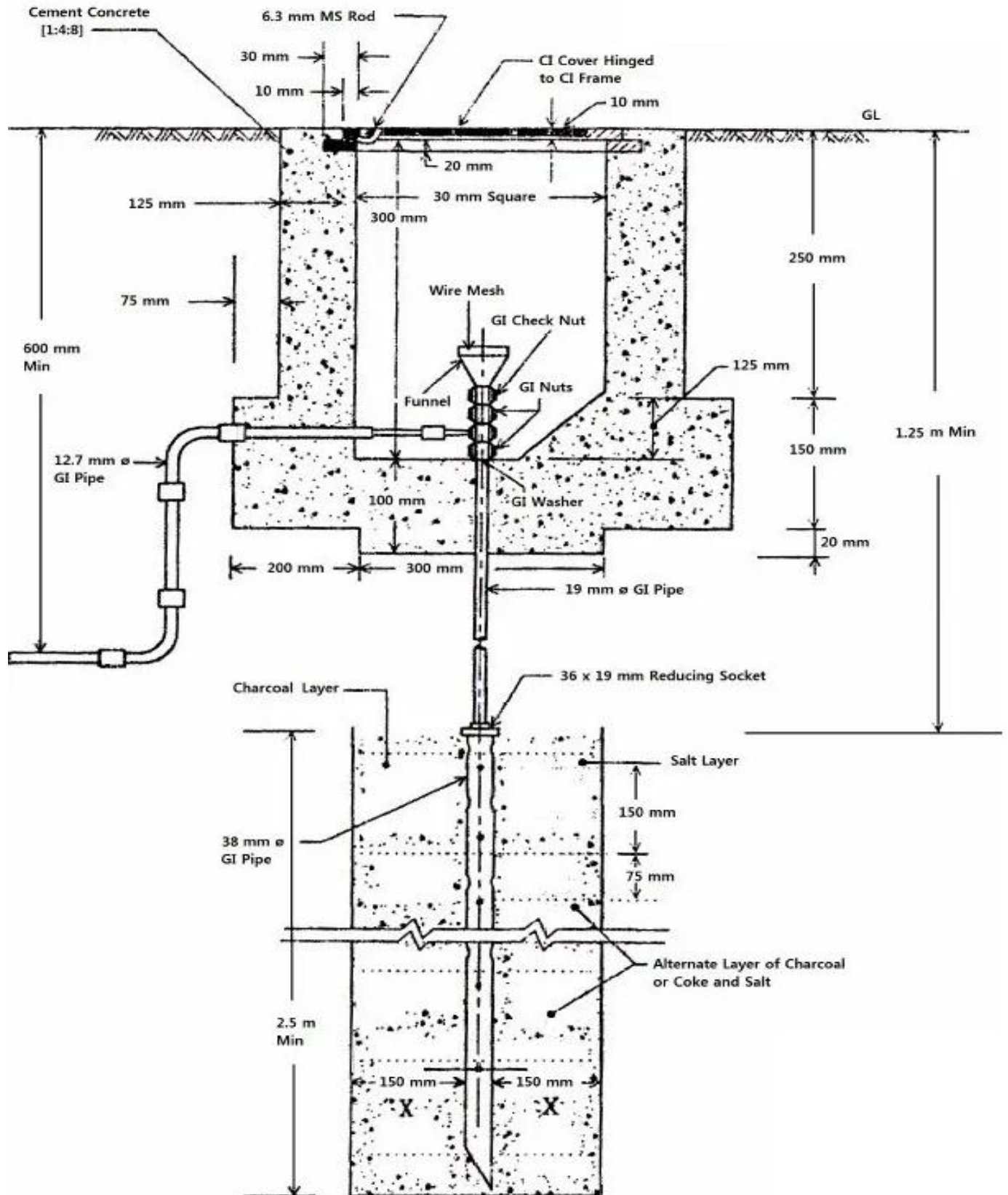
- Earth plate is not required for domestic or low voltage installations. GI or copper wire of no. 8SWG will be required to run from main distribution board to various sub main distribution boards for connecting earth terminals.
- From sub main distribution boards copper no. 14 SWG wire will be required to run to three-pin socket outlets and connected to their earth sleeve.
- In case of motor installations consumer is to provide his own earthing system.
- The size of earth wire and earth plate used will depend upon the rating of the motor for which it is to be used.
- The conductor used for earthing purpose should not be of cross-section less than that of 14SWG, and greater than 64.5 mm^2 from mechanical considerations.
- From electrical consideration the copper earth wire should not be of size lesser than half of the largest current carrying conductor.
- GI wire may also be used as earth wire provided its conductivity is not lesser than that of copper conductor.

The figures regarding size of earth wire for various capacity motors for guidance are given in Table

Capacity of Apparatus	Size of Earth Wire in SWG		Size of Earth Electrode	
	Copper	G.I	Copper	G.I
Up to 10 HP	No 08	No 08	60cm×60cm 3mm	60cm60cm×6mm
Above 10HP & upto 15HP	No 08	No 06	Do	Do
Above 15HP & upto 30HP	No 06	No 02	Do	90cm×90cm×6mm
Above 30HP & upto 50 HP	No 04	-	90cm ×90cm×6mm	-
Above 50HP & upto 100 HP	No 02 or strip 13mm × 2.5mm	-	Do	-
Above 100HP	Strip 25mm × 2.5mm	-	Do	-

Material required for Pipe earthing: -

Neat sketch for GI pipe earthing



The list of materials with complete specifications for GI pipe earthing is given below :

Sl. No	Description	Specification	Quantity
01	GI pipe	38mm diameter	2.5m
02	GI pipe for watering	19mm diameter	1.5 m
03	GI pipe	13mm diameter	4.0 m
04	GI wire	6SWG	12.0 m (1.2 kg)
05	GI lugs		02 nos
06	GI bolts & nuts	10mm diameter 32mm long	02 nos
07	GI bolts & washer	16mm diameter 40mm long	02 nos
08	GI bends	13mm diameter	01 nos
09	Cast iron frame	30cm square	01 nos
10	Cast iron cover	30cm square	01 nos
11	Funnel with wire mesh		01 nos
12	Charcoal		10 kg
13	Common salt		10 kg
14	Cement concrete	1:4:8	0.15 m ³

Plate earthing :-

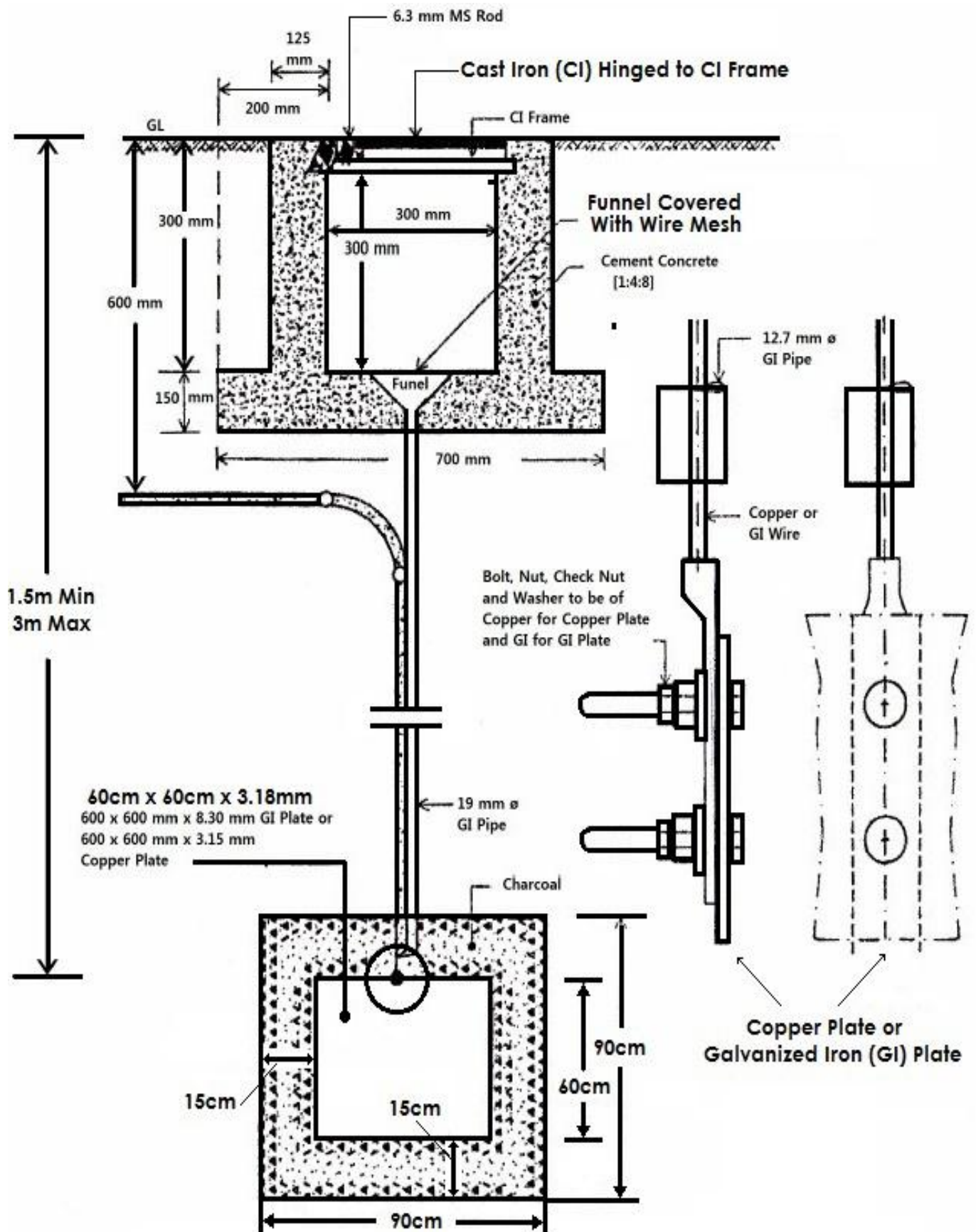
In plate earthing different sizes of plates are available in market that are

For copper plate size 60cm × 60cm × 3mm

For G.I. plate size 60cm × 60cm × 6mm

Material table :-

Si no.	Description	Specification	Quantity
01	G.I plate or Cu plate	60 cm × 60cm × 6.36mm 60 cm × 60cm × 3.18 mm	01 no 01 no
02	G.I. pipe for watering	20mm dia , 2m long	01 no
03	G.I pipe	12mm dia , 2.3 m long	01 no
04	GI wire	6 SWG	12 m
05	GI lugs	GI types	02 nos
06	G.I nut bolt	10mm dia , 16mm dia	04 nos
07	Cast iron frame	30cm × 30cm	01 no
08	Cast iron cover	30cm × 30cm	01 no
09	Funnel	-----	01 no
10	Charcoal	-----	10kg
11	Salt	-----	10kg
12	Sundries to complete hole job	-----	As per required



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

Aspects of good lighting services: -

Principles of Good Lighting.

Good Lighting is necessary for all buildings and has the primary aims e.g.

- (i) Promote work and other activities carried on within the buildings.
- (ii) Promote the safety of people using the building.
- (iii) Create, in conjunction with the structure and decoration, a pleasing environment conducive to interest and sense of well-being.

Realisation of these aims involves

- (a) Careful planning of the brightness and colour patterns within the working area and the surroundings so that attention is drawn naturally to the important areas.
- (b) Using directional lighting, where appropriate, to assist perception of task detail and to give good modeling.
- (c) Controlling direct and reflected glare from light sources to eliminate visual discomfort.
- (d) Minimizing flicker from certain types of lamps in artificial lighting installations and paying attention to colour rendering properties of the lights.
- (e) Correlating lighting throughout the building to prevent excessive differences between adjacent areas so as to reduce the risk of accidents.
- (f) Installing emergency lighting systems where necessary.

Good lighting design shall take into account the following

- (a) Planning the brightness pattern from point of view of visual performance, safety, amenities and surroundings.
- (b) Form and texture in the task areas and surroundings.
- (c) Controlling glare, stroboscopic effect and flicker.
- (d) Colour rendering.
- (e) Lighting for movement.
- (f) Provision for emergency.
- (g) Maintenance factors in lighting installations
- (h) Maximum energy effectiveness of the lighting system used in relation to specific needs of visual tasks to be performed.

Types of lighting schemes: -

- Direct lighting
- Semi – direct lighting
- Semi – indirect lighting
- Indirect – lighting

Direct lighting: -

This light is directly made to fall on the working plane, if proper reflectors are used, about 80% to 90% of total light flux can be made to fall on the working plane
It used industrial & outdoor lighting.

Semi – direct lighting: -

In this system semi direct reflectors are use as a result, 60 to 90% of the total light flux is made to fall on working plane.

Semi – indirect lighting: -

It produces very soft lighting system the 60% to 90% is thrown upward to the ceiling for reflect & the remaining light reaches the working plane directly.
This type scheme is adopted for indoor light decoration purposes.

Indirect lighting: -

In this system 90% to 100% of total light flux is thrown upward to the ceiling for diffused reflection by using inverted or bowl reflectors in this system glare is reduced is softer.
This scheme is used in decoration purpose.

Design of lighting schemes: -

Lighting scheme should be such that it may,

- i) Provide adequate illumination
- ii) Provide light distribution all over the working plane as uniform as possible.
- iii) Provide light of suitable colour.
- iv) Avoid glare and hard shadows as far as possible

Factory lighting: -

factory lighting are as follows bellow

- i) General lighting.
- ii) Local lighting.
- iii) Emergency lighting.

Public lighting installations: -

- i) It has permanent installation.
- ii) It has applied very carefully for traffic rules and city centre.
- iii) While designing this installation CIE guideline should be follows.

Street lighting: -

The main object of street light are

- i) To make the traffic and obstruction on the road clearly visible in order to promote safety and convenience.
- ii) To make the street more attractive.
- iii) To increase the community value of the street.

General rules for 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.
2. 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.
3. The conductor used is to be of such a size that it may carry load current safely.
4. The conductor installed is to be safe in all respects.
5. Every sub-circuit is to be connected to a distribution fuse board.
6. Every line (phase or positive) is to be protected by a fuse of suitable rating as per requirements.
7. A switch board is to be installed so that its bottom lies 1.25 metres above the floor.
8. (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, 5 A socket-outlets are to be used in all light and fan sub-circuits and only 3-pin, 15 A socket-outlets are to be used in all power sub-circuits.
(d) All socket outlets are to be controlled by individual switches, which are to be located immediately adjacent to it.
(e) For 5 A socket-outlets, if installed at a height of 25 cm above the floor level, the switch may, if desired, be installed at a height 1.30 metres above the floor level.
(f) In situations where a socket-outlet is accessible to children, it is recommended to use shuttered or interlocked socket-outlets.
(g) In case an appliance requiring the use of a socket outlet of rating higher than 15 A is to be used, it is to be connected through a double pole switch of appropriate rating. In no case a socket-outlet of rating higher than 15 A is to be installed.
(h) Socket-outlets are not to be located centrally behind the appliances with which these are used. Socket-outlets are to be installed either 25 cm or 1.30 m above the floor level as desired.
(i) No socket outlet is to be provided in the bath room at a height less than 1.30 metres.
(j) Depending on the size of the kitchen, one or two 3 -pin 15 A socket outlets are to be provided to plug-in hot plates and other appliances. Dining rooms, bed rooms.
9. (a) All incandescent lamps, unless otherwise required, are to be hung at a height of 2.5 metres above the floor level.
(b) Unless otherwise specified, all ceiling fans are to be hung 2.75 metres above the floor. (Refer IS 4648-1968).
10. (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 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.

(b) The load on each power sub-circuit is to be normally restricted to 3,000 watts. In no case more than two socket outlets are to be in one power sub-circuit. (Refer IS 4648-1968).

- 11 No fuse or switch is to be provided in earthed conductor.
- 12 Every circuit or apparatus is to be provided with a separate means of isolation such as a switch.
- 13 All apparatus requiring attention are to be provided with means of access to it.
- 14 In any building, light and fan wiring and power wiring are to be kept separate.
- 15 In 3 -phase, 4 -wire installation the load is to be distributed equally on all the phases.
- 16 No additional load is to be connected to an existing installation unless it has been ascertained that the installation can safely carry the additional load and that the earthing arrangements are adequate.
- 17 Lamp holders used in bath rooms are to be constructed or shrouded in insulating materials and fitted with protective shield and earth continuity conductor is not to be of size less than 7/0.915 mm.
- 18 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 shock due to leakage or failure of insulation.
- 19 Each sub-circuit is to be protected against excessive current (that may occur either due to overload or due to failure of insulation) by fuse or automatic circuit breaker.
- 20 All light conductors are to be insulated or otherwise safeguarded to avoid danger.
- 21 After completion of work the installations are to be tested before energisation.

Determination of number of points (light, fan, socket-outlets):-

Number of points is determined as per size of the room, illumination level required and the luminous efficiency of the lamps to be used.

Fan size in mm	Type	Air delivery in
900mm	Capacitor dc	140 140
1200mm	Capacitor dc	215 215
1400mm	Capacitor dc	270 270
1500mm	Capacitor dc	300 300

The number of fan points is determined as per measure (length, width and height) of the room and the size of the fans to be used. Ordinarily 3 air-exchanges are expected to take place per hour in room.

The air delivery for fans of different sizes at test voltage and at full speed is given in above Table

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

Location	Number of 5 A Socket-outlets	Number of 15 A Socket-outlets
Bed room	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 per 10 m ²	1
Verandah	1	1
Bath room	1	

Determination of total load

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

- (i) Fluorescent lamps (choke type) 50 W(40 W + 10 W)
- (ii) Incandescent lamps, fans and socket-outlets –60 watts
- (iii) Power socket-outlets –1,000 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 3,000 watts and the number of socket-outlets, which can be provided is 2 .

POSSIBLE SHORT TYPE QUESTIOS WITH ANSWER

- (1) **According to rural electrification an I.E. rules each circuit contains haw many points and power ratings.**

Ans :- according to rural electrification and I.E rules each circuit contains 10points and 800watt.

- (2) **What is height of ceiling, switch board, horizontal run up and ceiling fan from the ground?**

Ans :-according to I.E rules the height of ceiling must be 3.5m from the ground and height of switch board is 1.5m and the height of horizontal run up is 3m and the height of ceiling fan is 2.75m.

- (3) **In a 1- phase A.C. supply fuse is connected to which wire.**

Ans :- in a 1- phase A.C. supply fuse is connected to fuse wire.

- (4) **Write the specification of main switch which is used for lighting purpose only.**

Ans :- the standard specification of a main switch for lighting is DPIC, 6A 240v

- (5) **What is the general rule to install a switch board in a room near the entrance door?**

Ans :-generally in left side of the entrance door of a room switch board is installed.

- (6) **Write the full form of SPST switch and DPDT switch.**

Ans :- the full form of SPST switch is single pore single through.

The full form of DPDT switch is double pole double through.

- (7) **What is the permissible voltage drop of internal house wiring? [12,13,14,15,16,17,18,19-S]**

Ans :-the permissible voltage drop of internal house wiring is $\pm 2\%$.

- (8) **What is the full form of PILC ? [16-S]**

Ans :- the full form of PILC is PVC insulated live conductor.

- (9) **What is the full form of AAC , ACSR, TRS, VIR and PVC? [17-S]**

Ans :- the full form of

AAC- all Aluminium conductor

ACSR – Aluminium conductor steel reinforced.

VIR – Tough Rubber Seathed.

PVC – poly vinyl chloride.

- (10) **Why fuse is not provided in neutral of A.C. supply?**

Ans :- since neutral wire is the return path of A.C. supply in case of unbalanced load or any fault condition the heavey current returns to that neutral path of fuse it place then the current can not pass to that path. And the system will be damage.

- (11) **State the criteria required to fulfil for selecting a conductor for an installation.**

Ans :- the criteria required to full fill for selecting a conductor for an installation are

- (i) Types of conductor

- (ii) No. Of core
- (iii) Current carrying capacity
- (iv) Voltage grade
- (v) Types of insulation

(12) State the difference between main distribution board and sub-distribution board.

Ans :-main distribution board

The main distribution board provide power feeds to other distribution board or sub-distribution board but the sub distribution board will provide power feed to the individual load.

(13) What is the difference between fuse & MCB. [12-S]

Ans:- fuse:-

- It is made up of piece of metal that melts when over heated or large amount of current flows.
- It is melts then it replace by now one.

MCB :-

- The miniature circuit breaker have an internal switch mechanism that can be tripped by an abnormal cases or when excess of current flows.

(14) What is TPIC and TPICN main switch and where it is used? [19-S]

Ans :-the full form of TPIC is triple pole iron clad.

- It i used in three wire D.C. distribution line.
- The full form of TPICN is triple pole iron clad with neutral link. And it is used in 3- phase A.C. supply.

(15) Write the full form of DPIC main switch and where it is used.

- The full form of DPIC is double pole iron clad and it is used in 1-phase A.C. and two wire D.C. distribution line.

POSSIBLE LONG TYPE QUESTIOS

- (1) Prepare the list of materials required for plate earthing and also draw the neat sketch. [12-S]
- (2) Prepare the list of materials required for pipe earthing and also draw the neat sketch. [19-S,24]
- (3) Give a comparison between various system of wiring [15,17-S]
- (4) Why earthing is required in domestic house wiring ? mention a list of material for a plate earthing. [16-S,S-24]

CHAPTER NO.-03

INTERNAL WIRING

Learning objectives:

- 3.1 Type of internal wiring, cleat wiring, CTS wiring, wooden casing capping, metal sheathed wiring, conduit wiring, their advantage and disadvantages comparison and applications.
- 3.2 Prepare one estimate of materials required for CTS wiring for small domestic installation of one room and one verandah within 25 m² with given light, fan & plug points.
- 3.3 Prepare one estimate of materials required for conduit wiring for small domestic installation of one room and one verandah within 25 m² with given light, fan & plug points.
- 3.4 Prepare one estimate of materials required for concealed wiring for domestic installation of two rooms and one latrine, bath, kitchen & verandah within 80m² with given light, fan & plug points.
- 3.5 Prepare one estimate of materials required for erection of conduct wiring to a small workshop installation about 30m² and load within 10 KW.

3.1 Type of internal wiring, cleat wiring, CTS wiring, wooden casing capping , metal sheathed wiring, conduit wiring, their advantage and disadvantages comparison and applications:

Types of wiring :-

- In the wiring system may be domestic or industrial following wiring systems are adopted
- 1. Cleat wiring.
- 2. Wooden casing & capping wiring.
- 3. CTS or TRS or Batten wiring.
- 4. Conduit wiring.
- 5. LEAD or Metal sheathed wiring

(1) Cleat wiring:-

At first in this wiring demarcation is given on the wall surface, using hand drill holes are made along the demarcation at 3cm to 60cm apart then wooden gutties (plugs) of size 38mm×38mm of 6.5c.m. long are placed in the drilled holes. Then the base cleats are to be fixed on the gutties then VIR cables are taken through the base cleats and immediately after it the top cleats are screwed over the base cleat. Now the cables are permanently placed in the cleats.

Advantages-

- It is easiest method of installation
- Fault finding is easy & repairing is also required very less time
- Dismantling is easy & quick

Disadvantages-

- It is temporary wiring system.
- It is not good looking

- Since the cables are exposed to the air ,so it may chemically affected which causes damage to the insulations.

Application :-

- This wiring system is basically used in un damped places and also where a temporary wiring is needed.

(2)Wooden casing & capping wiring :-

In this wiring demarcation is given on the wall surface at a height of 3m from other ground. Using drilling holes are made along the demarcation line with 15cm apart. The wooden gutties (plugs) are inserted in the drilled holes the wooden casing are fixed on the gutties by means of screw. The length of such casing is about 2.5m to 3m. After it PVC or VIR cables are drawn through the casing then the top cover named as capping is now fixe by the help of screws.

Advantages :-

- To same extend it is easy to installed.
- Fault finding and repairing is also easy.

Disadvantages :-

- There is a risk of fire hazard.
- It is costlier now a day.
- It cannot be used in damped places.

Application :-

- This wiring system is basically used in low voltage (1-phase , 240v) domestic wirings. Normally in dry places where there is no risk of fire.

(3)CTS or TRS or batten wiring :-

- In this wiring demarcation is given on the wall surface and height 3m from ground using hand drill holes are created along the demarcation line of distance 75cm apart. The wooden gutties are plugged of the size 32mm× 8mm about 6.5 cm. Long are inserted in the drilled holes then for holding the cables links is made with tinned brash are fixed on the batten with an interval of 10cm. In case of horizontal and 15cm. In case of vertical then the teak wood batten of different sizes as applicable such as 13 ×13mm, 19 ×13mm, 25× 13mm and 31 ×13mm etc. Are fixed over the gutties by means of machines screws or wooden plugs with appropriate size. Then TRs or CTS cables are laid over the nail pins are twisted so as to hold the cable permanently.
- For providing the no. Of cables and link pins the different size of batten are mentioned in the following table.

Batten size	Number and size of link clips	No. of single core cable to carried out
13mm ×13mm	1 ×38mm	2
19mm ×13mm	1 ×50mm	3
25mm ×13mm	2 ×28mm	4
31mm ×13mm	1× 38mm & 1 ×50 mm	5

Advantages:-

- It is highly durable.
- It can withstand the action of acids and alkalies.
- Its installation is easy.
- Fault finding can be detected easily.

Disadvantages-

- It is very costlier now a days.
- There is a risk of fire.
- It cannot be used in damp place.
- Skilled labour is required for making the smooth batten.

Application-

- This type of wiring is used for low voltage installation in domestic, commercial or industrial workshop.

(4)Conduit wiring-

In this wiring the demarcation is given on the wall surface at a height of 3 m from the ground using hand drill holes are created along the demarcation line at a distance of 75 cm apart the wooden gutties or plug of size 32 mm× 8mm about 6.5 long are inserted in the drilling holes. Then the base saddle is fixed on the gutties .

In this wiring, all wires are enclosed in steel pipe known as conduit. It is metal is annealed to permit easy bending. The inner surface of the conduit is carefully prepared so that the wires can be easily pulled into it with a minimum of effort.

There are two types of conduit wirings

1. Concealed wiring.
2. Surface conduit wiring.

(5)LEAD or Metal sheathed wiring :-

The conductors having insulated covering of V.I.R are covered with an outer sheath of lead or lead alloy. The maximum thickness of lead covering thus formed may not exceed 1 mm or 1.5 mm .this metal sheath provides toughness and gives protection to the cable against mechanical injury and atmospheric corrosion.

Advantages :-

- It can be used in places exposed to sun or rain, provided no joint is exposed.
- It may have comparatively a longer life.

Disadvantages :-

- It is costly as compared to TRS wiring system
- If proper earthing is not done an insulation is damaged, the metal sheath becomes alive & gives electric shock
- Skilled labour is required to execute the work
- It may not be suitable for places where chemical corrosion may occur .

Industrial wiring-

In this wirings the different rating of motors are used , so the power equipment's are used in this wiring such as main switch board , starter etc

Determination of input power of motor—

Input in watt = (rated BHP of motor $\times 735.5$)/motor efficiency

Determination of input current of motor-

Input current= (rated BHP of motor $\times 735.5$)/(p.f \times voltage \times efficiency) ----(1- ϕ)

Input line current= (rated BHP of motor $\times 735.5$)/($\sqrt{3} \times$ p.f \times voltage \times efficiency) ----(3- ϕ)

Selection & rating of cable---

The selection & rating of cable depends upon current drawn by motor at full load . but starting current greater than full load current. So finally selection of cable is chosen by starting or over load current .choosing of cable from below table.

Selection of size of conduit---

The selection of conduit pipes depends upon no of cables of different sizes that are to be accommodated.

Selection & rating of main switch—

Selection of main switch is depends upon starting current of motor

Selection & rating of distribution board—

It depends upon no of ckts (for motors & other loads)

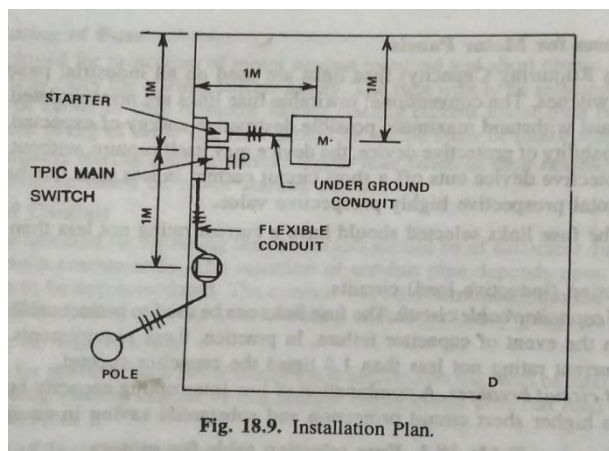
3.5 Prepare one estimate of materials required for erection of conduct wiring to a small workshop installation about 30m² and load within 10 KW

PROBLEM-1

Prepare estimates & material table to install a power connection of 3-phase 5 HP induction motor for an agriculture tube well in the room size 3m \times 3m \times 3m .the motor is 1 m away from two nearest walls.

- Electrical wiring plan
- Single line diagram ,showing earth wires also.
- Decide the rating & specification of important materials and calculate the length of wire,conduit,earth wire & prepare a complete list of materials required .

Ans-



Assumption-

- 1- Height of main board from floor =1.5m
- 2- Two earth wires enclosed of 15mm dia G.I pipe
- 3- Motor is installed 0.25m above floor on a suitable foundation.

$$\begin{aligned}\text{full load current} &= 5 \times 735.5 / (\sqrt{3} \times \text{p.f} \times \text{voltage} \times \text{efficiency}) \\ &= 5 \times 735.5 / (\sqrt{3} \times 0.85 \times 400 \times 0.75) \\ &= 8 \text{ amp}\end{aligned}$$

SELECTION & RATING OF MS-

Assume total current drawn by motor = 8+ (50% of 8)=12 amp

It is very close to 16 amp, the next higher rating main switch 32 amp available in market. So specification is TPIC 32A ,500v grade MS.

SELECTION & RATING OF WIRE-

We refer above rating of cable table ,it suggested that pvc insulated Al conductor size 6mm^2 Or 1/2.80 mm dia.

CALCULATION OF HEAVY GAUGE CONDUIT PIPE,25 MM DIA---

From main board to top of motor foundation=1.5 +0.25(depth of trench)+1.0(along trench)+0.25+0.25=3.25m

Total length of conduit = 3.25 +10% wastage =3.57m nearly say 4m

CALCULATION FOR LENGTH HEAVY GAUGE CONDUIT PIPE ,15mm DIA FOR EARTH WIRE---

From main board to top of motor foundation=3.25×2 pipe=6.5m

For 10% wastage so, total length=6.5+0.6=7.1m or 7m

CALCULATION FOR LENGTH OF FLEXIBLE CONDUIT OF SIZE 25mm DIA ---

from energy meter to main board=1.0m

from main switch to starter=0.5m

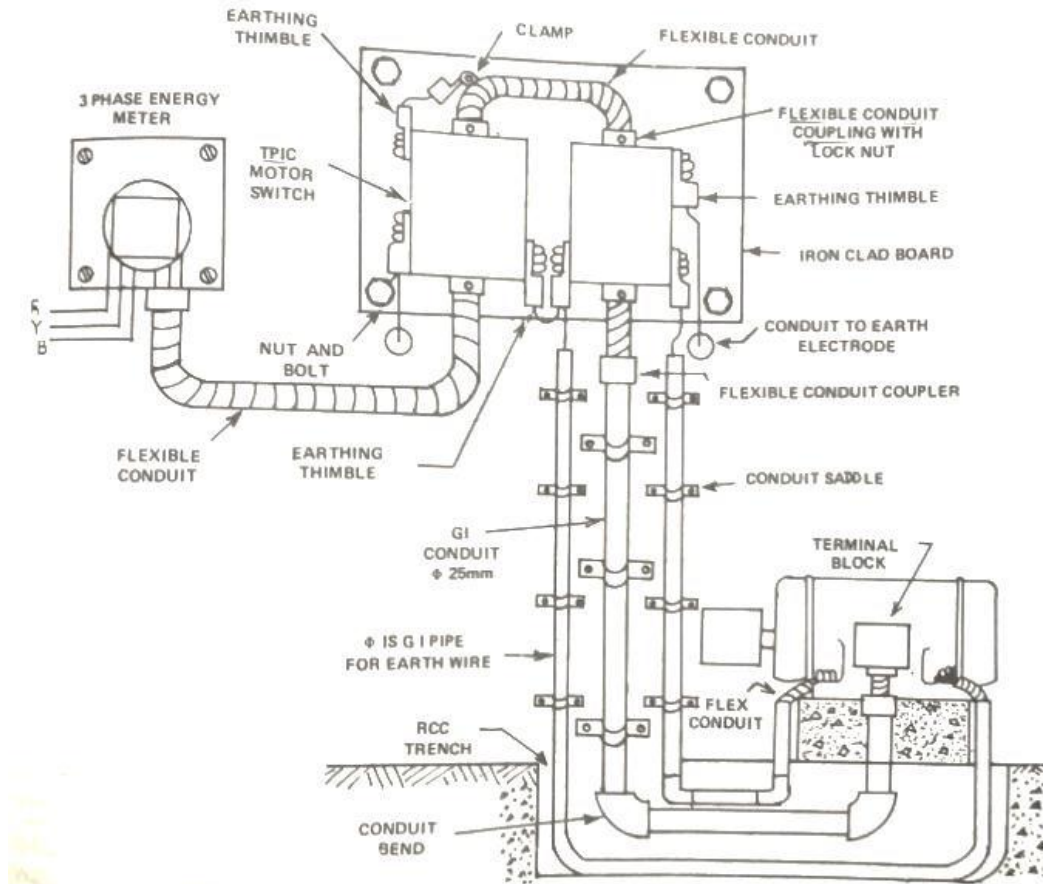
from starter to conduit mouth=0.25m

from motor foundation to motor terminal block=0.25m

total length of flexible conduit=1.0+0.5+0.25+0.25=2m

for 10% of wastage

so total is=2+0.2=2.2m say 2.5m



CALCULATION FOR LENGTH OF WIRE OF 6mm^2 or 2.80 mm DIA---

Conduit has 3 wires for 3-phase DOL starter,so

Toatal Length of wire =length of conduit (rigid+flexible) \times 3 wires

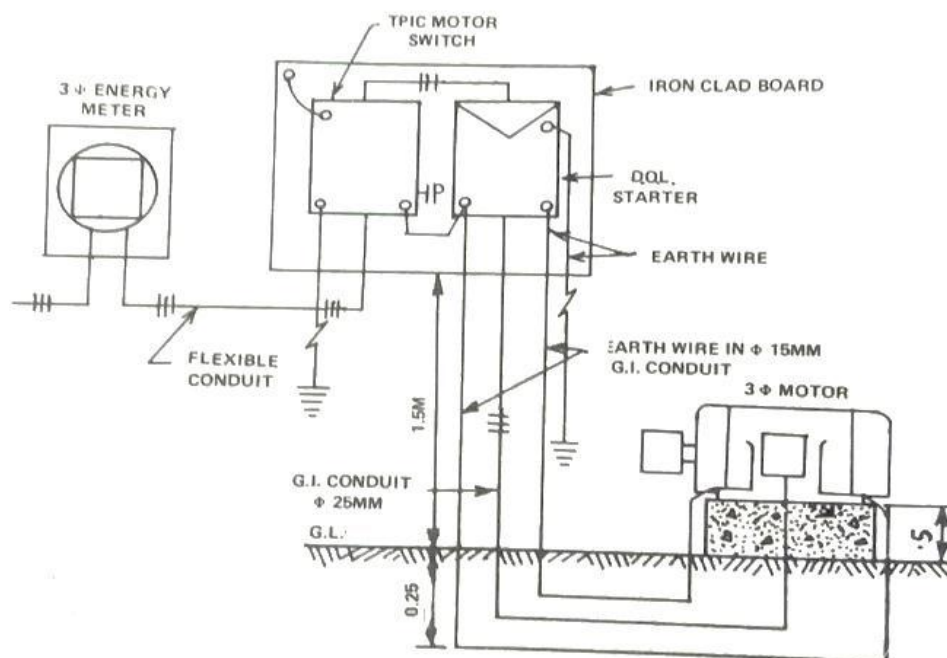
$$=(3.25+2.0) 3=15.75 +2.5\text{m}(15\% \text{ wastage})=18.25 \text{ m say } 19\text{m}$$

CALCULATION FOR LENGTH OF 8SWG, G.I EARTH WIRE---

Length of earth wire= length of conduit \times 2wires

$$=3.25 \times 2 \text{ wires}=6.5 \text{ m}+2\text{m around main board}$$

$$=8.5\text{m} =9\text{m}$$



Material table—

Si no	Description	specification	Quantity
01	Main switch (TPIC)	32 amp,500v	01 no
02	Iron clad board fabricated with angle iron & MS sheet with fitting accessories	30cm×30cm	1set
03	Heavy gauge conduit pipe with it's fitting accessories	25mm dia	4m
04	G.I conduit pipe with fitting accessories	15 mm dia	7m
05	Flexible conduit pipe with it's fitting accessories	25mm dia	2.5m
06	Pvc insulated Al conductor	Single core, 6mm ² or 1/ 2.80 mm dia	18m
07	Earth wire with it's fitting accessories	G.I type 8swg	9m
08	MS sheet fix with wall fitting accessories	---	1 set
09	Conduit bend ,saddle	---	As per required
10	Danger plate	440v	01
11	Sundries to complete the whole job	----	As per required

DOMESTIC WIRING—

SEQUENCE TO BE FOLLOWED IN CARRYING OUT THE ESTIMATE---

- 1- Drawing installation plan
- 2- Calculation for total connected load in amperes
- 3- Selection & rating of main switch and sub main switch
- 4- Selection of main distribution board
- 5- Calculation for conduit pipe or batten
- 6- Calculation of length of phase & neutral wire
- 7- Calculation of length of earth wire
- 8- Preparing material table

ARRANGEMENT OF APPARATUS-

Energy meter--- to--- DPIC main switch-----to----- main DB----to---sub circuits (switch board)

- Every sub circuit contains light,fan, & 5-amp socket loads
- each sub circuit is having not exceeding 10 no of points or 800 watts

SELECTION OF WIRE—

It depends upon specified load in ckt which considered as

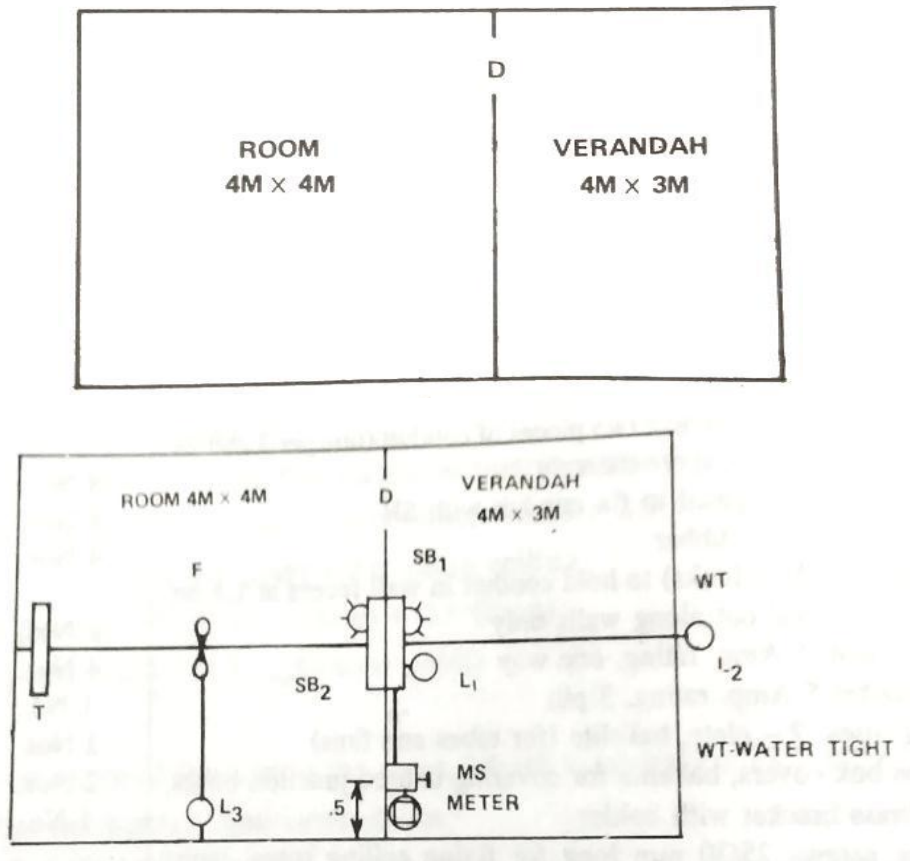
- (1) Insulated wire for mechanical reason
- (2) Voltage drop
- (3) Current carrying capacity
- (4) Types of insulation is used i.e VIR ,pvc, TRS etc
- (5) Grade i.e 250v, 500v, 660v etc

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

PROBLEM-2

A room & a verandah, the plan of to be provided with electrical wiring. Mark the location of energy meter, main switch & switch board & electrical points suitable & draw the installation plan showing supply path to each point & wiring diagram. Calculate the total length of wire required for wiring the room & veranda in batten system of wiring .prepare a list of materials with complete specification of each item .

Ans-



From this plan we required

- Room contain –two light points, one fan & 5 amp socket load
- Varandah contain –two light points, 5 amp socket load

ASSUMPTION-

- Total height of ceiling =3.5m
- Height of HR from floor =3.0m
- Height of SB from floor =1.5m
- Location of energy meter & main switch board =0.5 m inside varandah on room wall.
- All dimension in meter

Calculation of load-

Lamps= $3 \times 60 = 180w$

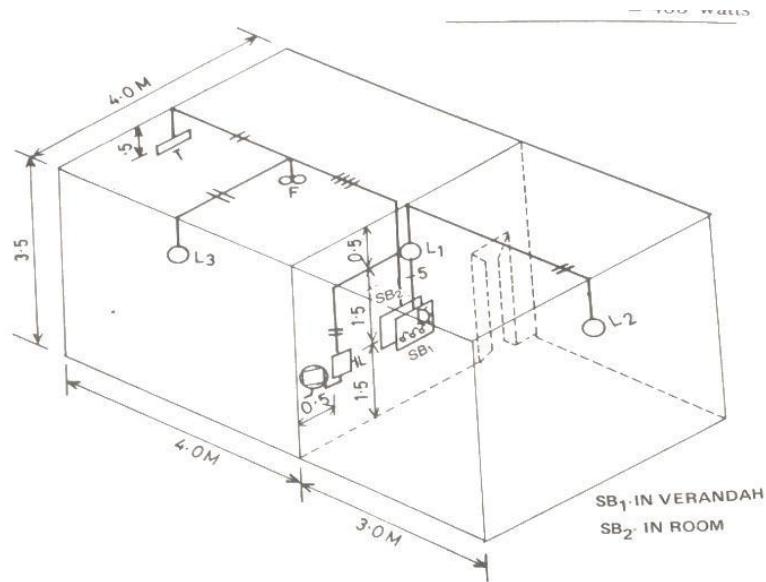
Fan= $1 \times 60 = 60w$

Socket outlet 5amp= $2 \times 100 = 200w$

Fluorescent tube= $1 \times 40 = 40w$

Total load= $480w$

Load in amp = watt/volt=480/230=2.1amp



SELECTION & RATING OF MAIN SWITH—

D.P.I.C Main switch of 5 amp rating 250 v grade is selected

SELECTION & RATING OF DB—

Total points are 7points, so no distribution board is required.

CALCULATION FOR LENGTH OF BATTEN---

From main board to L₁—(13mm×13mm) 2wires =1.5+1.5=3m

L₁ to SB₁ --(31mm×13mm) 5wires =1.5m

L₁ to L₂ --(13mm×13mm) 2 wires =0.5+3+0.5=4m

SB₂ to fan --- (25mm×13mm) 4 wires =2+2=4m

Fan to L₃ --- (13mm×13mm) 2 wires =2+0.5=2.5m

Fan to tube point --- (13mm×13mm) 2 wires =2.5 m

TOTAL LENGTH OF BATTEN OF SIZE---

13mm×13mm = 3+4+2.5+2.5=12m+(10% wastage)=13.2m=13m

25mm×13mm = 4m +((10% wastage)= 4.4m=4.5m

31mm×13mm =1.5m+(10% wastage)=1.6m=2m

CALCULATIONS OF LENGTH OF AL CONDUCTOR VIR WIRE OF SIZE 1.5mmsq—

Length of wire calculated from length of batten of various sizes

$$13\text{mm} \times 13\text{mm} = 12\text{m} \times 2\text{wires} = 24\text{m}$$

$$25\text{mm} \times 13\text{mm} = 4\text{m} \times 4\text{wires} = 16\text{m}$$

$$31\text{mm} \times 13\text{mm} = 1.5\text{m} \times 5\text{wires} = 7.5\text{m}$$

Total length of wires on batten = 47.5m

Total length of wires = 47.5m + 1m (wall crossing) + 15% wastage = 55.7 m says 56m

CALCULATION OF LENGTH OF EARTH WIRE OF SIZE 14 SWG GALVANISED STEEL---

From MS -to-SB₂ through SB₁ = 1.5+1.5+1.5+0.25= 4.75 m

Total length= 4.75 +0.47= 5.2m say 5m

Material table—

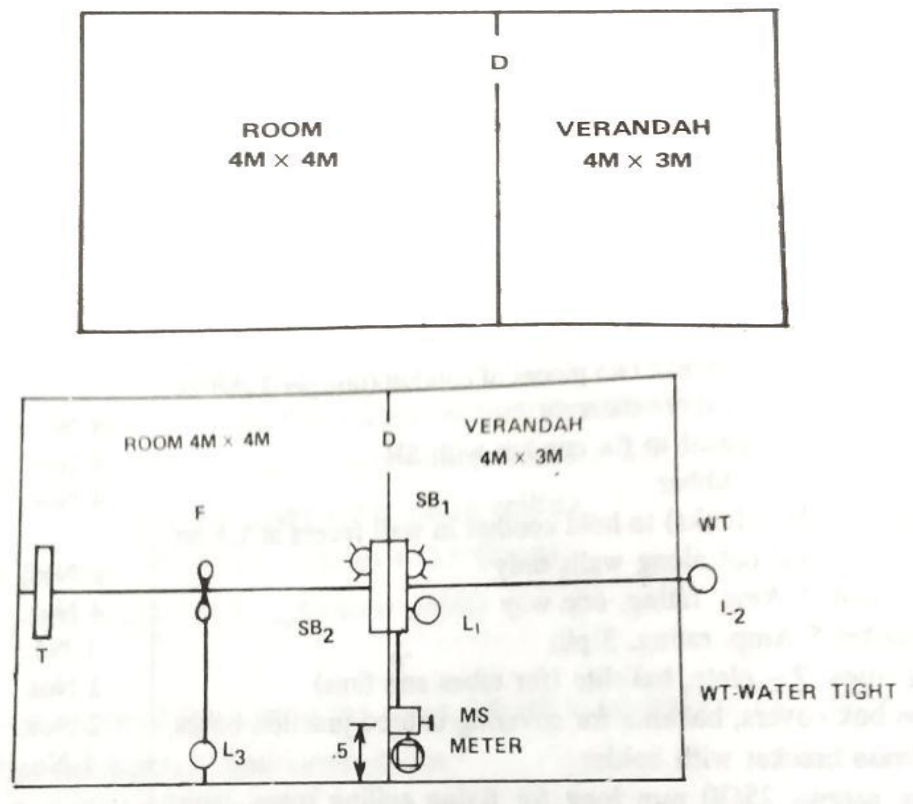
Si no	Description	specification	Quantity
01	DPIC main switch	5amp, 250v grade	01
02	Teak wood main box for enclosing MS & DB	30cm× 30 cm	01
03	Teak wood batten size	13mm×13mm 25mm×13mm 31mm×13mm	13m 4.5m 2m
04	VIR Al conductor	1.5mmsq ,250v grade	56m
05	Earth wire	14 SWG ,G.I type	5m
06	Conduit pipe for wall crossing	20mm dia	0.25m
07	Switch board with fitting accessories	20cm×10cm 20cm×25cm	01 no 01no
08	Flush switch	5amp, one way	06 no
09	Socket	5amp, 3-pin	02 no
10	Ceiling rose	2 plate, backlite	02 no
11	Teak wood round block	10mm dia	04no
12	Teak wood plugs (gutties)at 0.75 m interval	-----	30 no
13	Holder	---	02no
14	Link clips ,aluminium 40mm long (one clip on two wires 10cm apart (length of wire+2×10 clips)	----	300 no or 3 boxes
15	Wood screws 25mm long to fix batten with gutties at 0.75 m interval	----	30no
16	Wood screws 15mm long	----	15 nos
17	Sundries to complete the whole jobs	----	As per required

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

PROBLEM-3

A room & a verandah, the plan of to be provided with electrical wiring. Mark the location of energy meter, main switch & switch board & electrical points suitable & draw the installation plan showing supply path to each point & wiring diagram. Calculate the total length of wire required for wiring the room & verandah in conduit wiring .prepare a list of materials with complete specification of each item .

Ans



From this plan we required

- Room contain –two light points, one fan & 5 amp socket load
- Verandah contain –two light points, 5 amp socket load

ASSUMPTION-

- (f) Total height of ceiling =3.5m
- (g) Height of HR from floor =3.0m
- (h) Height of SB from floor =1.5m
- (i) Location of energy meter & main switch board =0.5 m inside verandah on room wall.
- (j) All dimension in meter

Calculation of load-

$$\text{Lamps} = 3 \times 60 = 180\text{w}$$

$$\text{Fan} = 1 \times 60 = 60\text{w}$$

$$\text{Socket outlet 5amp} = 2 \times 100 = 200\text{w}$$

$$\text{Fluorescent tube} = 1 \times 40 = 40\text{w}$$

$$\text{Total load} = 480\text{w}$$

$$\text{Load in amp} = \text{watt/volt} = 480/230 = 2.1\text{amp}$$

SELECTION & RATING OF MAIN SWITH—

D.P.I.C Main switch of 5 amp rating 250 v grade is selected

SELECTION & RATING OF DB—

Total points are 7points, so no distribution board is required.

CALCULATION FOR LENGTH OF conduit pipe 25mm dia---

$$\text{From main board to } L_1 = 1.5 + 1.5 = 3\text{m}$$

$$L_1 \text{ to } SB_1 = 1.5\text{m}$$

$$L_1 \text{ to } L_2 = 0.5 + 3 + 0.5 = 4\text{m}$$

$$SB_2 \text{ to fan} = 2 + 2 = 4\text{m}$$

$$\text{Fan to } L_3 = 2 + 0.5 = 2.5\text{m}$$

$$\text{Fan to tube point} = 2.5\text{ m}$$

$$\text{TOTAL LENGTH OF CONDUIT PIPE} = 3 + 1.5 + 4 + 4 + 2.5 + 2.5 = 17.5 + (10\% \text{ wastage}) = 19.2\text{m say } 20\text{m}$$

CALCULATIONS OF LENGTH OF PHASE WIRE—

$$\text{From main board to } L_1 = 1.5 + 1.5 = 3\text{m}$$

$$L_1 \text{ to } SB_1 = 1.5\text{m} \times 3 \text{ wire} = 4.5\text{M}$$

$$L_1 \text{ to } L_2 = 0.5 + 3 + 0.5 = 4\text{m}$$

$$SB_2 \text{ to fan} = 2 + 2 = 4\text{m} \times 3 \text{ wire} = 12\text{M}$$

$$\text{Fan to } L_3 = 2 + 0.5 = 2.5\text{m}$$

$$\text{Fan to tube point} = 2.5\text{ m}$$

Total length of phase wire= $3+4.5+4+12+2.5+2.5=28.5+0.25(\text{wall crossing})+(10\% \text{ wastage})=32.3\text{m}$ say 32.5m

CALCULATIONS OF LENGTH OF NEUTRAL WIRE—

From main board to L_1 — $=1.5+1.5=3\text{m}$

L_1 to SB_1 -- $=1.5\text{m}\times 2\text{wire}=3.0\text{M}$

L_1 to L_2 -- $=0.5+3+0.5=4\text{m}$

SB_2 to fan --- $=2+2=4\text{m}=4\text{M}$

Fan to L_3 --- $=2+0.5=2.5\text{m}$

Fan to tube point --- $=2.5\text{ m}$

Total length neutral wire= $3+3+4+4+2.5+2.5=19+0.25(\text{wall crossing})+(10\% \text{ wastage})=21$

CALCULATION OF LENGTH OF EARTH WIRE OF SIZE 14 SWG GALVANISED STEEL---

From MS –to- SB_2 through SB_1 $=1.5+1.5+1.5+0.25=4.75\text{ m}$

Total length= $4.75 +0.47=5.2\text{m}$ say 5m

Material table—

Si no	Description	Specification	Quantity
01	DPIC main switch	5amp, 250v grade	01
02	Phase wire	1.5mmsq ,250v grade	32.5m
03	Neutral wire	1.5mmsq ,250v grade	21m
04	Earth wire	14 SWG ,G.I type	5m
05	Conduit pipe	25mm dia	20m
06	Switch board with fitting accessories	20cm×10cm 20cm×25cm	01 no 01no
07	Flush switch	5amp, one way	06 no
08	Socket	5amp, 3-pin	02 no
09	Ceiling rose	2 plate, backlite	02 no
10	Conduit pipe accessories for 25 mm dia 1 way junction box 3 way junction box	---	03 no 01 no
11	Conduit bend	---	06 no
12	Holder	---	02no
13	Conduit socket accessories	---	As per required
14	Crampets of MS hooks to hold conduit in wall at 1.5m interval		11 no
15	Sundries to complete the whole jobs	----	As per required

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

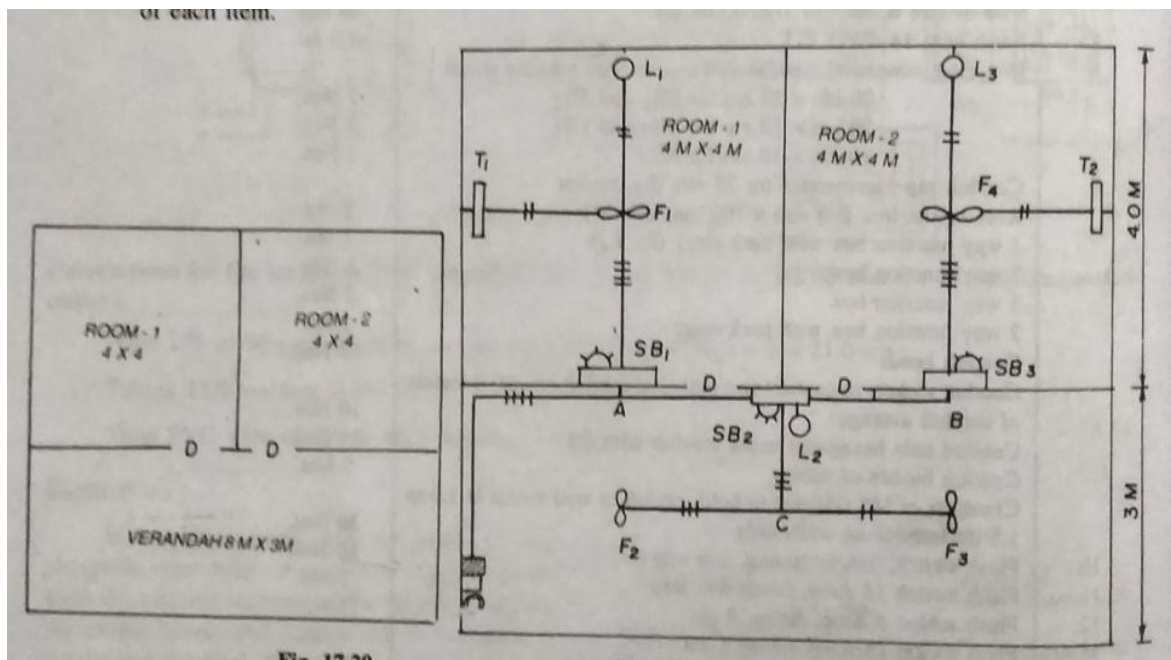
Problem-4

The plan of two room ,one varandah office building is given below, the building is required to be provided with electrical conduit wiring at 230 v single phase, suggest electrical points suitable in rooms & varandah.solve the estimate in the following sequence.

- Installation plan on the plan of building starting from energy meter
- Wiring diagram
- Calculate the total materials
- Prepare the list of materials

ASSUMPTION-

- Total height of ceiling =3.5m
- Height of HR from floor =3.0m
- Height of SB from floor =1.5m
- Location of energy meter & main switch board =0.5 m inside varandah on room wall.
- All dimension in meter



CALCULATION KOF LOADS-

$$\text{Lamps} = 3 \times 60 = 180\text{w}$$

$$\text{Fans} = 4 \times 60 = 240\text{w}$$

$$\text{Fluorescent tube} = 2 \times 40 = 80\text{w}$$

$$\text{Socket 5amp} = 3 \times 100 = 300\text{w}$$

$$\text{Total load} = 800\text{w}$$

$$\text{Current in amp} = \text{watt/volt} = 800/230 = 3.5 \text{ amp}$$

SELECTION & RATING OF MAIN SWITCH---

DPIC main switch 15 amp rating, 250v grade is selected

SELECTION & RATING OF DISTRIBUTION BOARD---

There are 12 points so two sub ckts are selected

Sub circuit 1---- points controlled from SB₁

Sub circuits 2---- points controlled from SB₂ & SB₃

It is suggested that a two way MCB, each 5 amp rating along with double pole MCB with neutral link should be used.

CALCULATION OF LENGTH OF CONDUIT PIPE OF 25MM DIA—

$$\text{Main board to } L_2 = 1.5 + 2.5 + 4 = 8\text{m}$$

$$L_2 \text{ to junction 'c'} = 0.5 + 1.5 = 2\text{m}$$

$$\text{'c' to fan 2} = 2\text{m}$$

$$\text{c' to fan 3} = 2\text{m}$$

$$L_2 \text{ to SB}_2 = 1.5\text{m}$$

$$L_2 \text{ to HR above SB}_3 = 2\text{m}$$

$$\text{SB}_3 \text{ to fan 4} = 1.5 + 0.5 + 2 = 4\text{m}$$

$$\text{Fan 4 to tube light 2} = 2 + 0.5 = 2.5\text{m}$$

$$\text{Fan 4 to } L_3 = 2 + 0.5 = 2.5\text{m}$$

$$\text{SB}_1 \text{ to fan 1} = 1.5 + 0.5 + 2 = 4\text{m}$$

$$\text{Fan 1 to } L_1 = 2 + 0.5 = 2.5\text{m}$$

$$\text{Fan 1 to tube light 1 (T}_1\text{)} = 2 + 0.5 = 2.5\text{m}$$

$$\text{Total length} = 35.5 \text{ m}$$

$$\text{Total length of pipe} = 35.5 + (0.25 + 0.25) \text{ wall crossing} + 10\% \text{ of wastge} = 39.6 \text{ say } 40\text{m}$$

CALCULATION PHASE WIRE---

Main board to junction A = $1.5+2.5+2=6\text{m}\times 2\text{wire}=12\text{m}$

Junction A to L_2 = 2m

L_2 to junction 'c' = $0.5+1.5=2\text{m}\times 2\text{wire}=4\text{m}$

'c' to fan 2 = 2m

c' to fan 3 = 2m

L_2 to SB_2 = $1.5\text{m}\times 4\text{wire}=6\text{m}$

L_2 to junction B = 2m

SB_3 to HR above the SB_3 = $1.5\text{m}\times 4\text{wire}=6\text{m}$

HR above the SB_3 to fan 4 = $0.5+2=2.5\text{m}\times 3\text{wire}=7.5\text{m}$

Fan4 to tube light 2 = $2+0.5=2.5\text{m}$

Fan4 to L_3 = $2+0.5=2.5\text{m}$

SB_1 to HR above SB_1 = $1.5\text{m}\times 4\text{wire}=6\text{m}$

HR above SB_1 to fan1 = $0.5+2=2.5\text{m}\times 3\text{wire}=7.5\text{m}$

Fan 1 to L_1 = $2+0.5=2.5\text{m}$

Fan1 to tube light 1(T_1) = $2+0.5=2.5\text{m}$

Total length = 67m

Total phase wire = $67+(0.25+0.25)\text{ wall crossing}+10\%\text{ wastage}=74\text{m}$

CALCULATION OF NEUTRAL WIRE—

Total length of neutral wire= length of conduit pipe= $36\text{m}+10\%\text{ wastage}=39.6=40\text{m}$

CALCULATION FOR LENGTH OF EARTH WIRE OF SIZE 14 SWG OF GALVANISED STEEL---

From MB to SB_3 = $1.5+2.5+6+0.25(\text{wall thickness})+1.5=11.75\text{m}$

From HR to SB_1 = $0.25+1.5=1.75\text{m}$

From HR to SB_2 = 1.5m

Total length of earth wire= $11.75+1.5+1.5=15\text{m}+10\%\text{ wastage}=16.5\text{m}=17\text{m}$

MATERIAL TABLE—

Sl no	Description	Specification	Quantity
01	DPIC main switch	15 amp, 250v grade	01
02	Phase wire	1.5mmsq ,250v grade	74m
03	Neutral wire	1.5mmsq ,250v grade	40m
04	Earth wire	14 SWG ,G.I type	17m
05	Conduit pipe	25mm dia	40m
06	Switch board with fitting accessories SB ₁ SB ₂ & SB ₃	30cm×30cm 20cm×25cm	01 no 02no
07	Flush switch	5amp, one way	11 no
08	Socket	5amp, 3-pin	03 no
09	Ceiling rose	2 plate, backlite	06 no
10	Conduit pipe accessories for 25 mm dia 1 way junction box 2 way junction box 3 way junction box	---	04 no 05 no 02no
11	Conduit bend	---	06 no
12	Holder	---	03no
13	Conduit socket accessories	---	As per required
14	Crampets of MS hooks to hold conduit in wall at 1.5m interval		27 no
15	Sundries to complete the whole jobs	----	As per required

POSSIBLE SHORT TYPE QUESTIONS WITH ANSWER

Q.1-what is the maximum load that can be connected in a power sub ckts?

Ans- the maximum load that can be connected in a power sub ckts is 3000W.

Q.2-what is the maximum no of outlet that can be connected in power sub ckt?

Ans-2

Q.3 –what is minimum size of alluminium size that can used for wiring of a power ckt?

Ans—2.5 mm dia.

Q.4- what type of starter can be used for 5 kw 1-φ I.M

Ans- push button DOL starter.

Q.5- what type starter you recommend for a 20 kw squirrel cage I.M ?

Ans- auto transfer starter

Q.6- According to rural electrification (RE) & I.E rules each ckt contains how many points & power rating

Ans-800 watt

Q.7-what is the size of batten for carrying 10 single core cable?

Ans- (63mm×13mm)

Q.8-what is permissible voltage of internal house wiring?

Ans- +/- 2%

Q.9- what is full form of PILC?

Ans- pvc insulated line conductor

Q.10- why fuse is not provided on neutral of AC supply?

Ans- neutral wire is the returning path of AC, in case of any fault ,the heavy fault current passes through the electrical apparatus before melt of fuse, so apparatus are damaged.

Q.11-what is the full form of AAC,ACSR,TRS,VIR?(S-24)

Ans- - AAC- all aluminium conductor

ACSR- aluminium conductor steel reinforced

TRS- tough rubber sheath

VIR-vulcanised indian rubber

Q.12-why concealed conduit wiring is not suitable on workshop?

Ans- in this wiring fault finding & repairing is very difficult so concealed conduit wiring is not suitable on workshop.

Q.13- what is full form of CTS?

Ans- CTS- cab type sheathed.

POSSIBLE LONG TYPE QUESTIONS

Q.1-Estimate the list of materials required for connecting a 20 HP ,3-phase,50HZ squirrel cage I.M as an irrigation pump from exiting main switch in the pump house 6m distance.

Q.2-list out materials required to provide internal connection with small workshop having a work floor of 4m×6m & consist of

(i) A 415 v,3-phase,10kw welding T/F

(ii) a 230v I.M operated lathe m/c

230 v 50HZ 1.5 HP bench grinder Provide required fan & light point.

Q.3 A 37kw connection is to be given to an agriculture field at 415v, 3-phase ,50hz . the connection is to be given from a 3-phase 11kv O.H distribution line which is at a distance of 40m. The motor has a full load efficiency of 85% & p.f 0.8 .make a neat sketch & estimate the quantity of material required.

Q.4-Discuss conduit type of wiring briefly

Q.5 -Estimate the material required to provide internal wiring for a building whose plan (8m×3m)size of floor is having room size (4m×3m) & varandah (4m×3m),using conduit wiring . draw electrical wiring diagram & preapare list of material

Q.6- what are the different types of wiring explain about conduit system of wiring