

PROJECT REPORT



INDUSTRIAL TRAINING TO ENGINEERING STUDENTS – ELECTRICAL– 4WEEK

Submitted by:

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Signature

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Introduction

Advancement in technology has necessitated continuous up-gradation in technologies used for electrical assets. For example, in engines, we have introduced ready to use (RTU) engines to cater to the huge demand of engines for small to huge loads located in the interior of the country. In lightings, from conventional fitting to mirrored and now to LEDs.

The power and air-conditioning has also to be introduced remote monitoring. This will go long way in better maintenance and less outages.

Hence remote monitoring systems need to be introduced. It has been introduced microprocessor based AC units, lifts and firefighting equipments. It is not only technologies that have to be upgraded from time to time but also design parameters, which have undergone a sea change from the past with introduction of new equipments and AC systems. Humidifiers systems and heaters in AC systems are now irrelevant in electronic exchanges.

All this has resulted in energy savings. Also with more fragile electronic equipments, highly susceptible to power fluctuations, control devices have to be introduced to prevent surges and spikes in electric supply. More electronics is coming into the traditional areas of electro-mechanical devices. Electronic chokes, microprocessor based controls etc. are becoming more reliable and desirable as they contribute towards energy saving as well as energy management.

In India, we have just started taking note of the developments and in the coming times, these electronics will become an integral part of our electro-mechanical devices. Energy savers, surge protectors and harmonic suppressors are to be used to improve the quality of power supply. Many products available in the market need to be

continuously upgraded by interaction with manufacturers as most of the equipments is imported while the electrical equipment is sourced locally.

Since the electricity supply is erratic in the country particularly so in the rural and hilly areas, Energy sources need to be tapped. Internationally, solar has been tried and successfully used for small energy consumption energy stations. In India, this needs to be considered for remote regions such as J&K, Ladakh and North East and also for rural and desert areas.

Role & Responsibility of Electrical Engineers

The Electrical wing of BSNL is responsible for carrying out original and maintenance works of following electro-mechanical services in BSNL/Telecom/Administrative Buildings and residential Quarters.

Telecommunication network place a key role in today's world and it required to be continuously operated even in the most adverse conditions.

The role of electrical department in BSNL is to install and maintain the following:

- Electrical substations
- Engine alternator sets
- Air conditioning
- Internal EI
- Water pump sets
- Fire detection and Firefighting system
- Lifts

The Electrical wing is also responsible for the up gradation to the latest trends in market. For example, we have upgraded from water cooled centralized air conditioned plants to package units which is more efficient and economical.

A solar power plant of 1 megawatt is also planned. This will reduce power intake from the electricity board and also save energy.

ELECTRICAL INSTALLATION

Introduction:

Electricity has become the lifeline of Modern Society. Homes, Offices, industry, Hospitals, Transportation, Communication, Markets; all depend on reliable Electric Supply. Life comes to standstill without electricity. It is also necessary to remember that electricity becomes destructive and dangerous, if not handled with care, safely confirming to laid-down safety standards and norms. In case of building fires, which often destroys property and lives causing sufferings to the affected people, the first culprit is often supposed to be **“Electric Short Circuit”**.

In the above context, the General Specifications for Electrical Works (Internal and External) aims to lay down general guidelines to ensure safe, efficient, reliable and economical use of electricity.

The revised specification takes into account latest technology available and the main emphasis is on –

- a) Proper Planning
- b) Design
- c) Quality materials and equipments
- d) Proper supervision
- e) Reliable, Safe Installation

f) Co-ordination with other services

g) Proper maintenance with emphasis on preventive maintenance

Factors Governing Wiring System:

- Class of structure
- Usage of structure
- Aesthetic consideration
- Economic consideration
- Future extension
- Maintenance feasibility

Types of Wiring:

- Recessed / concealed conduit wiring system – MS / PVC
- Surface conduit wiring system – MS / PVC
- PVC Casing and Capping

TECHNICAL GUIDELINES - : Important Features

1. Wiring –
 - a) Aluminium wiring discarded
 - b) Only Copper Conductor Cable to be used for Light & Power Wiring
 - c) Insulation improved to FRLS
 - d) Strict Colour Coding
 - e) Neutral and Earth wire to come to Switch Box
2. Switches – Modular type switches and socket outlets to be provided for better quality and service.
3. Loop Earthing Wire – In place of Bare Copper Wire, green / yellow insulated copper wire is to be used.
4. Loop earthing of all fans and fittings for safety.
5. DB – MCB / HRC type DB only, pre-wired type for better service and reducing fire hazard.
6. Telephone / TV wiring / Cabling – All colonies, quarters and buildings to be provided with telephone wiring / TV cabling for which provision to be kept in preliminary estimate.
7. Emphasize on inter-disciplinary co-ordination between user, civil, electrical, architecture and horticulture to have efficient building.
8. Stair case lighting as extension of road lighting for better security.
9. Meter Board not to be located under staircase of residential quarters for better safety.
10. All floor openings for carrying any wiring shall be suitably sealed after installation.

11. No bare conductor in phase and / or neutral or twisted joints in phase, neutral and /or protective conductors in wiring shall be permitted.
12. No structural member in the building shall be damaged / altered, without prior approval from the competent authority.
13. Addition to an installation - Any addition temporary or permanent to the existing electrical installation shall not be made without a properly worked out scheme / design to ensure that such addition does not lead to overloading, safety violation of the existing system.
14. The work shall be carried out in accordance with the drawings. All circuits shall be indicated and numbered in the wiring diagram and points shall be given the same number as the circuit to which they are electrically connected.
15. Quality of Materials –
 - a) Only quality materials as of reputed make specified in the tender will be used in work. All materials and equipments supplied by the contractor shall be new.
16. Inspection of materials and equipments -
 - a) The departmental officers shall inspect materials and equipments to be used in the work. Such inspection includes “Inspection at Manufacturer’s premises”, “To receive materials with Manufacturer’s Test Certificate(s)” etc.
 - b) Departmental officers will take adequate care to ensure that only tested and genuine materials of proper quality are used in work.
 - c) For fabricated equipments, after approval of dimensional drawing, suitable stage inspection at factory will be made to ensure proper use of materials, workmanship and quality control.
17. Similar parts of all switches, distribution boards, switchgears, ceiling roses, fans and all other fittings of the same type shall be interchangeable in each installation.

18. Good workmanship is an essential requirement to be complied with. The entire work of manufacturing / fabrication, assembly and installation shall confirm to sound engineering practice. The contractor shall engage suitably skilled / licensed workmen for execution of work supervised by Supervisor / Engineer of appropriate qualification and experience.
19. All tests prescribed before, during and after installation, shall be carried out and the test results shall be submitted to the Engineer-in-Charge in prescribed Performa, forming part the Completion Certificate.
20. The installation will be guaranteed against any defective design / workmanship and the materials for any manufacturing defect, inferior quality for a period of 12 months from the date of completion or date of handing over to the department.

PLANNING OF ELECTRICAL INSTALLATION:

The design and planning of an electrical installation involve consideration to meet the requirement of various functional needs, efficiency, economy, energy conservation, aesthetics, appropriate technology, safety and avoidance of possible fire hazards. Following are the few guiding factors –

- a) Adverse conditions like humidity, high / low temperature, dust etc. those are likely to affect the installation.
- b) The degree of mechanical and electrical protection necessary.
- c) Flexibility for future modification or extension.
- d) Energy cost, which requires proper examination of local electrical tariff.
- e) Energy conservation measures.
- f) Need of Building management System for efficiency and energy cost saving.
- g) Relative of various alternative methods.

- h) Safety aspects including provisions of built in safety measures.
- i) Specific measures for avoidance of possible firehazards.
- j) Use of appropriate technology.
- k) Quality control based on appropriate design and use of quality materials and equipments.
- l) Aesthetics requirement.
- m) Taking into account future growth of load.
- n) Need to provide related space / conduits / channels / cables / wire for services like: Communication cables, computer cabling, fire alarm cabling, UPS cabling etc.
- o) Reducing operation and maintenance cost with appropriate use of automation, sensors, remote control and microprocessor control for controlling various electrical and mechanical activities.
- p) Providing an efficient power distribution system to meet the various power requirements of equipments like Air-conditioning, Computers, Lifts and Pumps etc.

In modern building, besides electrical wiring, following allied services need to be provided –

- i. Telephone wiring
- ii. Communication cabling
- iii. Computer cabling, networking, dedicated Earthing
- iv. Audio-visual systems

- v. Security systems
- vi. Stage lighting
- vii. External lighting
- viii. Solar Energy system
- ix. Building Management System

ELECTRICAL POWER DISTRIBUTION AND WIRING

The electrical power will be received and distributed in a building, through cabling and switchgears or rising mains through tap-off box to floor main board to final DB and then wiring. Other loads like, A/C Plants, Lifts and Pumps etc. are fed by independent cables of suitable capacity from LT Panels with suitably designed switchgear having necessary control and safety features.

System of distribution and wiring –

1. Each main distribution board and branch distribution board shall be controlled by an incoming circuit breaker / SFU. Each outgoing circuit shall be controlled by a circuit breaker.
2. For non-residential buildings, as far as possible, DB shall be separate for Light and Power.
3. Only MCCB / MCB type DB shall be used.

4. Three-phase DB shall not be used for final circuit distribution as far as possible.
5. Power wiring shall be kept separate and distinct from light wiring, from the level of circuits, i.e. beyond the branch distribution boards. Conduits for light / power wiring shall be separate.
6. Wiring for essential / non-essential / UPS supply will have their own conduit system. No mixing of wiring is allowed.
7. Generally, no switchboard will have more than one source of incoming supply. More than one incoming supply will be allowed only at main board with proper safety and interlocking so that only one source can be switched ON at a time.
8. Each MDB / DB / Switchboard will have reasonable spare outgoing ways for future expansion.
9. Balancing of 3-phase circuit shall be done.

WIRING:

1. Sub-main Wiring: -

Sub-main wiring shall mean the wiring from one main / distribution switchboard to another.

2. Circuit Wiring: -

Circuit wiring shall mean the wiring from the distribution board to the 1st tapping point inside the switch box, from where point wiring starts.

Measurement of Sub-main and Circuit Wiring:

a. Circuit and sub-main wiring shall be measured on linear basis along the run of the wiring. The measurement shall include all lengths from end to end of conduit or channel as the case may be, exclusive of interconnections inside the switchboard etc. The increase on account of diversion or slackness shall not be included in the measurement.

b. The length of circuit wiring with two wires shall be measured from the distribution board to the nearest switch box from which the point wiring starts. Looping of switch boxes also will be counted towards circuit wiring, measured along the length of conduit / channel.

c. When wires of different circuits are grouped in a single conduit / channel, the same shall be measured on linear basis depending on the actual number and sizes of wires run.

d. Protective (loop earthing) conductors, which are run along the circuit wiring and the sub-main wiring, shall be measured on linear basis and paid for separately.

e. **NOTE:** Conduit carrying sub-main will not carry circuit / point wiring. Similarly conduit carrying circuit wiring will not carry sub-main / point wiring. Conduit carrying point wiring will not carry sub-main / circuit wiring.

POINT WIRING:

Definition:

A point (other than socket outlet point) shall include all work necessary in complete wiring to the following outlets from the controlling switch or MCB.

- a. Ceiling rose or connector (in the case of points for ceiling / exhaust fanpoints, pre-wired light fittings and call bells).
- b. Ceiling rose (in case of pendants except stiff pendants).
- c. Back plate (in the case of stiff pendants).
- d. Lamp holder (in the case of wall brackets, batten holders and fittings
Which are not pre-wired).

Scope:

Following shall be deemed to be included in point wiring –

- a. Conduit / channel as the case may be, accessories for the same and wiring cables between the switch box and the point outlet, loop protective earthing of each fan / light fixture.
- b. All fixing accessories such as clips, screws, Phil plug, rawl plug etc. as required.
- c. Metal or PVC switch boxes for control switches, regulators, sockets etc. recessed or surface type, and phenolic laminated sheet covers over the same.
- d. Outlet boxes, junction boxes, pull-through boxes etc. but excluding metal boxes if any, provided with switchboards for loose wires / conduit terminations.

- e. Control switch or MCB as specified.
- f. 3-pin or 6-pin socket, ceiling rose or connector as required. [2-pin and 5-pin socket outlet shall not be permitted].
- g. Connections to ceiling rose, connector, socket outlet, lamp holder, switch etc.

Measurement & Classification:

Unless and otherwise specified, there shall be no linear measurement for point wiring for light points, fan points, exhaust fan points and call bell points. These shall be measured on unit basis by counting, and point wiring shall be classified as under according to the type of building used.

a. Residential Buildings: -

- i. Group 'A', for point wiring for type I, type II and type III residential quarters and hostels.
- ii. Group 'B', for point wiring for type IV and above type of residential quarters and barracks.

b. Non residential buildings: -

Group 'C' for all type of non-residential buildings such as offices, educational institutions etc

Point wiring for socket outlet points;

- i. The light [6A] point and power [16A] point wiring shall be measured on liner basis, from the respective tapping point of live cable, namely, switch box, other socket outlet point, or the sub distribution board as the case may be, up to the socket outlet.

- ii. The metal / PVC box with cover, switch/MCB, socket outlet and other accessories shall be measured and paid as a separate item.

Note: There shall normally be no “on the board” light plug point.

- iii. The power point outlet may be 16A/6 A six pin socket outlet, where so specified in the tender documents.

Group control point wiring:

- i. In the case of points with more than one point controlled by the same switch, such point shall be measured in parts i.e.
 - (a) from the switch to the first point outlet as one point and classified according to Group 'A' / 'B' / 'C', and
 - (b) for the subsequent points, the distance from that outlet to the next one and so on, shall be treated as separate point(s) and classified according to Group 'A' / 'B' / 'C' or as per tender document.
- ii. No recovery shall be made for non-provision of more than one switch in such cases.

Twin control light point wiring:

- i. A light point controlled by two numbers of two way switches shall be measured as two points from the fitting to the switches on either side and classified according to Group 'A' / 'B' / 'C'.
- ii. No recovery shall be made for non-provision of more than one ceiling rose or connector in such cases.

Multiple controlled call bell point wiring;

- i. In the case of call bell points with a single call bell outlet, controlled from more than one place, the point shall be measured in parts i.e.

(a) From the call bell outlet to one of the nearest ceiling roses meant for connection to bell push, treated as one point and classified according to Group 'A' / 'B' / 'C' and,

(b) from that ceiling rose to next one and so on, shall be treated as separate point(s) and classified according to Group 'A' / 'B' / 'C' or as per tender document.

ii. No recovery shall be made for non-provision of more than one ceiling rose or connector for connection to call bell in such cases.

Wiring system:

i. Wiring shall be done only by the looping system. Phase/live conductors shall be looped at the switch box. For point wiring, neutral wire / earth wire looping for the 1st point shall be done in the switch box; and neutral/earth looping of subsequent points will be made from point outlets.

ii. In wiring, no joints in wiring will be permitted anywhere, except in switch box or point outlets, where jointing of wires will be allowed with use of suitable connector.

iii. The wiring throughout the installation shall be such that there is no break in the neutral wire except in the form of linked switchgear.

iv. Colour coding:- Following colour coding shall be followed in wiring:-

Phase	:	Red / Yellow / Blue (3-Phase wiring)
Live	:	Red (single phase)
Neutral	:	Black
Earth	:	Yellow / Green

v. Termination of circuit into switchboard: -

Circuit will consist of phase / neutral / earth wire. Circuit will terminate in a switch board (first tapping point, where from point wiring starts) which will have phase, neutral and earth terminal connector blocks to receive phase / neutral / earth wire.

Rating of Outlets:

(To be adopted for design)

i. Incandescent lamps in residential and non-residential buildings shall be rated at 60W and 100W respectively.

ii. **Ceiling fans shall be rated at 60W.** Exhaust fans, fluorescent tubes, CFL, HPMV lamps, HPSV lamps etc. shall be rated according to their capacity. Control gear losses shall be also considered as applicable.

iii. **6 A & 16 A socket outlet points shall be rated at 100W & 1000W** respectively, unless the actual values of loads are specified.

Capacity of Circuits:

i. Lighting circuits shall feed light / fan / call bell points. Each circuit shall not have more than **800 watt connected load or more than 10 points.** However, in case of CFL points where load per point may be less, number of points may be suitably increased.

ii. Power circuit in non-residential building will have only one outlet per circuit.

iii. Each power circuit in residential building can feed following outlets:

a) Not more than 2 nos. 16 Amp outlets.

b) Not more than 3 nos. 6 Amp outlets.

c) Not more than 1 no. 16 Amp and 2 nos. 6 Amp outlets.

iv. Load more than 1 KW shall be controlled by suitably rated MCB and cable size shall be decided as per calculations.

v. Power wiring with Bus-Trunking:

It is permitted to meet large-scale power requirement in a hall or floor, with use of single phase or 3-phase bus bars running inside a metal enclosure i.e. factory fabricated bus-trunking conforming to relevant standards and with all standard accessories and with necessary safety features like over current, short-circuit and earth fault protection.

Socket Outlets:

i. Socket outlets shall be 6A 3 pin, 16A 3 pin or 16 / 6 Amp 6 pin. **2 pin or 5 pin socket outlets shall not be permitted.** Where specified, shutter type (interlocking type) of sockets shall be used.

ii. **Socket for the power outlets of rating above 1 KW shall be of industrial type with associated plug top and controlling MCB.**

iii. Every socket outlet shall be controlled by a switch or MCB (connected on the 'live' side), as specified.

iv. 5A/6A and 15A/16A socket outlets shall be installed at the following positions, unless otherwise specified.

a) Non-residential buildings – 23 cm above floor level.

b) Kitchen – 23 cm above working plate-form and away from the likely positions of stove and sink.

c) Bathroom – No socket outlet is permitted for connecting a portable appliance thereto. MCB may be provided above 2 M for fixed appliances, and at least 1 M away from shower.

d) Rooms in residences – 23 cm above floor level or as specified by the E-in-C.

Cables:

i. Copper conductor cable only is used for sub-main / circuit / point wiring.

ii. Minimum size of wiring:

Light Wiring : 1.5 sq. mm

Power Wiring : 4.0 sq. mm

Power circuit rated > 1 KW : Size as per calculation

iii. Insulation – Copper conductor cable shall be PVC insulated, **Fire retardant, low smoke (FRLS) type.**

iv. Multi stranded cables are permitted for use in electrical installation.

Wiring Accessories:

i. Control switches for point:

a) Control switches (SP switch) carrying not more than 16 A shall be modular type / piano type. The switch shall be 'ON' when the knob is down.

b) Modular type sockets, stepped type fan regulators and accessories shall be of same make of modular switch manufacturer.

c) It is recommended to provide double pole MCB in proper enclosure as power outlet for widow type AC units, geysers etc.

ii. Switch Box covers (for application other than modular type): Phenolic laminated sheets of 3 mm thickness shall be used for switch box covers.

Attachment of fittings and accessories:

i. Conduit wiring system:

a) All accessories like switches, socket outlets, regulators shall be fixed in flush pattern inside the switch boxes. Accessories like ceiling roses, lamp holders etc. shall be fixed on outlet boxes.

b) Aluminium alloy or cadmium plated iron screws shall be used to fix the accessories.

c) The switch box shall normally be mounted with their **bottom 1.25 M from floor level.**

Ceiling Fans:

i. All **ceiling fans shall be hung 2.75 M above the floor.**

Marking of Switch Boards:

i. Marking of each Main Board:

Each main board / sub-main board shall be marked indicating rating of each incoming / outgoing switch and details of load / area it feeds. Detail / size of incoming and outgoing cable shall also be marked indicating from where the incoming cable has originated.

ii. Marking of Distribution Board:

Each Distribution Board shall be marked indicating detail of incoming switch (size of cable and from where it is fed) and marking of each outgoing MCB indicating the area it feeds. Suitable marking sticker shall be suitably fixed to indicate such details.

iii. Marking of Power/Light DB:

Power / Light DB shall be marked "P" and "L" respectively.

iv. Marking of Main earthing Terminal:

Main earthing terminals in main / sub-main switchboard shall be permanently marked, as "**Safety Earth – Don't Remove**".

LT Distribution Switchgear:

Only following type switchboards will be used -

- i. Main / Sub-main switchboards of cubicle type.
- ii. DB – Only pre-wired type MCB DB to be used.

Location of Switchboards:

- i. Switchboards are to be located in dry and well-ventilated common areas like corridors, lobby etc. and not to be located in locked rooms.
- ii. As far as possible, main boards shall not be located in basement. Such main boards can be located in ground floor.
- iii. It is preferable to locate floor main boards in rising main shafts of adequate size, with steel doors (having ventilation) or in suitable room. Similarly, DB can be located in suitable niches in corridor walls having doors.

iv. Locating main boards under staircase or standing open in corridor is not a desirable practice, besides being highly unaesthetic.

Guidelines for planning residential areas:

i. For long-term economical maintenance, better reliability of service, safety, protection against heavy rains, storm, wind etc. and aesthetics, under ground cable system will be generally followed. Also considering the high cost of land, under ground system results in better economic utilization of land area, otherwise substantial land route has to be earmarked for overhead lines.

ii. Staircase lighting is to be treated as an extension of street lighting for security, safety and convenience of the residents. CFL (1 X 11 W) type stair case lighting may be provided to reduce the load (as well less energy consumption and higher burning hours).

iii. Kitchen:

a) Exhaust fans opening with one point outlet to be provided irrespective of yardstick of provision of exhaust fans.

b) In addition to one 16 A 6-pin power outlet for kitchen, one 3 pin 6 Amp outlet to be provided for water filter.

iv. Main Board of each quarter shall be MCB type with provision of ELCB with the incoming MCB.

v. Telephone wiring and TV cabling may also be provided from suitable point at ground floor. This provision may accordingly be made in Preliminary Estimate.

METALLIC CONDUIT WIRING SYSTEM

Application:

Recessed conduit is suitable generally for all applications. Flexible conduits may only be permitted for interconnections between switchgear, DB.

Material:

i. Conduits:

a) All rigid conduit pipes shall be of steel and ISI marked. The wall thickness shall be not less than 1.6 mm (16 SWG) for conduits up to 32 mm dia and not less than 2 mm (14 SWG) for conduits above 32 mm dia.

b) The maximum number of PVC insulated cables that can be drawn in one conduit shall not be exceeded as per table given below.. Conduit sizes shall be selected accordingly in each run.

b) No steel conduit less than 20mm in diameter shall be used.

Maximum number of PVC insulated 650/1100 V grade Al / Cu Conductor Cable that can be drawn in one conduit

Nominal cross sectional area of conductor in sq. mm	20 mm		25 mm		32 mm		38 mm		51 mm		64 mm	
	S	B	S	B	S	B	S	B	S	B	S	B
1	2	3	4	5	6	7	8	9	10	11	12	13
1.5	5	4	10	8	18	12	-	-	-	-	-	-
2.5	5	3	8	6	12	10	-	-	-	-	-	-
4	3	2	6	5	10	8	-	-	-	-	-	-
6	2	-	5	4	8	7	-	-	-	-	-	-
10	2	-	4	3	6	5	8	6	-	-	-	-
16	-	-	2	2	3	3	6	5	10	7	12	8
25	-	-	-	-	3	2	5	3	8	6	9	7
35	-	-	-	-	-	-	3	2	6	5	8	6
50	-	-	-	-	-	-	-	-	5	3	6	5
70	-	-	-	-	-	-	-	-	4	3	5	4

Note:

- 1) The above table shows the maximum capacity of conduits for a simultaneous drawing in of cables.
- 2) The columns headed 'S' apply to runs of conduits which have distance not exceeding 4.25m between draw in boxes and which do not deflect from the straight by an angle of more than 15 degrees. The columns headed 'B' apply to runs of conduit, which deflect from the straight by an angle of more than 15 degrees.
- 3) Conduit sizes are the nominal external diameters.

ii. Conduit accessories:

- a) All conduit accessories shall be of threaded type and under no circumstances pin grip type or clamp grip type accessories shall be used.
- b) Bends, couplers etc. shall be solid type in recessed type of works and may be solid or inspection type as required, in surface type of works.
- c) Saddles for surface conduit work on wall shall not be less than 0.55mm (24 gauges) for conduits up to 25mm dia and not less than 0.9mm (20 gauges) for larger diameter. The corresponding widths shall be 19mm and 25mm.

Girder Clips or Clamps

Size of conduit	Width	Thickness
20mm	19mm	0.9mm (20SWG)
25mm	19mm	0.9mm (20SWG)
32mm & above	25mm	1.2mm (18SWG)

iii. Outlets:

- a) The switch box or regulator box shall be made of metal on all sides, except on the front. In the case of cast boxes, the wall thickness shall be at least 3mm and in case of welded mild steel sheet boxes, the wall thickness shall not be less than 1.2 mm (18 gauge) for boxes up to a size of 20cm X 30cm and above this size 1.6 mm (16 gauge) thick MS boxes shall be used. The metallic boxes shall be duly painted with anticorrosive paint before erection.
- b) Where a large number of control switches and / or fan regulators are required to be installed at one place, these shall be installed in more than one outlet box adjacent to each other for ease of maintenance.
- c) An earth terminal with stud and 2 metal washers and terminal block shall be provided in each MS box for termination of protective conductors and for connection to socket outlet / metallic body of fan regulator etc.

d) Clear depth of the box shall not be less than 60 mm and this shall be increased suitably to accommodate mounting of fan regulators in flush pattern.

e) The fan regulators can also be mounted on the switch box covers.

f) Except where otherwise stated, 3mm thick phenolic laminated sheets shall be fixed on the front with brass screws, or aluminium alloy / cadmium plated iron screws.

iv. INSTALLATION:

Common aspects for recessed and surface conduit works:

1. Conduit joints

a) The conduit work of each circuit or section shall be completed before the cables are drawn in.

b) Conduit pipe shall be joined by means of screwed couplers and screwed accessories only. Threads on conduit pipes in all cases shall be between 13 mm to 19 mm long, sufficient to accommodate pipes to full threaded portion of couplers or accessories.

c) Cut ends of conduit pipes shall have no sharp edges, nor any burrs left to avoid damage to the insulation of the conductors while pulling them through such pipes.

2. Bends in conduit

a) All necessary bends in the system, including diversion, shall be done either by neatly bending by pipes without cracking with a bending radius of not less than 7.5cm, or alternatively, by inserting suitable solid or inspection type normal bends, elbows or similar fittings, or by fixing cast iron inspection boxes, whichever is most suitable.

b) No length of conduit shall have more than the equivalent of four quarter bends from outlet to outlet.

3. Painting after erection

After installation, all accessible surfaces of conduit pipes, fittings, switch and regulator boxes etc. shall be painted.

Additional requirements for surface conduit work:

- a) Painting before erection.
- b) Fixing conduit on surface: Conduit pipes shall be fixed, by saddles, at an interval of not more than one meter, but on either side of the couplers or bends or similar fittings, saddles shall be fixed at a distance of 30 cm from the center of such fittings.
- c) Fixing outlet boxes: Only portion of the switch box shall be sunk in the wall, the other portion being projected out for suitable entry of conduit pipes into the box.

Additional requirement for recessed conduit work:

- 1) Making chase: In the case of buildings under construction, the conduit shall be buried in the wall before plastering and shall be finished neatly after erection of conduit.
- 2) Fixing conduit in chase: The conduit pipe shall be fixed by means of staples, J-hooks, or by means of saddles, not more than 60cm apart or by any other approved means of fixing.
- 3) Fish wire: To facilitate subsequent drawing of wires in the conduit, GI fish wire of 1.6mm/1.2mm (16/18SWG) shall be provided along with the laying of the recessed conduit.

Earthing requirements

- a) The entire system of metallic conduit work, including the outlet boxes and other metallic accessories, shall be mechanically and electrically continuous by proper screwed joints, or by double check nuts at terminations. The conduit shall be continuous when passing through walls or floors.
- b) A protective (loop earthing) conductor(s) shall be laid inside the conduit between the metallic switch boxes and distribution switchboards and terminated into proper earth lugs/ terminals. Only PVC insulated copper conductor cable of specified size, green-yellow in color shall be allowed. Such conductor will not run external to the conduits.
- c) Gas or water pipe shall not be used as protective conductor (earth medium).

NON – METALLIC CONDUIT WIRING SYSTEM

Special precautions:

If the pipes are liable to mechanical damages, they should be adequately protected.

Material:

Conduits: The rigid conduit pipes shall be ISI marked. The conduit shall be designated by there nominal outside diameter.

The dimensional details of rigid non-metallic conduit (dimensions in mm) shall be as per the table given below:

Sr. No.	Nominal outside diameter (in mm)	Maximum outside diameter (in mm)	Minimum inside diameter (in mm)	Maximum permissible eccentricity (in mm)	Maximum permissible ovality (in mm)
1	20	20 ^{+0.3}	17.2	0.2	0.5
2	25	25 ^{+0.3}	21.6	0.2	0.5
3	32	32 ^{+0.3}	28.2	0.2	0.5
4	40	40 ^{+0.3}	35.8	0.2	0.5
5	50	50 ^{+0.3}	45.0	0.4	0.6

Conduit accessories: Rigid conduit accessories shall be normally of grip type and saddles for fixing conduits shall be heavy gauge non-metallic type with base.

Ordinary clips or girder clips

Size of conduit	Width	Thickness
20mm & 25mm	19mm	20 SWG (0.9144mm)
32mm & above	25mm	18 SWG (1.219mm)

Outlets

The switch box shall be made of either rigid PVC molding, or mild steel, or cast iron on all sides except at the front.

PVC boxes (IS: 14772-2000) shall be free from burrs, fins and internal roughness and the thickness of the walls and base of PVC boxes shall not be less than 2mm. The clear depth of PVC boxes shall not be less than 60mm.

Bends of conduit

a. All bends in the system may be formed either by bending the pipes by an approved method of heating or by inserting suitable accessories such as bends, elbow or similar fittings, or by fixing non-metallic inspection boxes, whichever is most suitable. Where necessary, solid type fittings shall be used.

b. Radius of bends in conduit pipes shall not be less than 7.5 cm. **No length of conduit shall have more than the equivalent of four quarter bends from outlet to outlet.**

c. Care shall be taken while bending the pipes to ensure that the conduit pipe is not injured, and that the internal diameter is not effectively reduced.

Additional requirement for surface conduit work –

Conduit pipes shall be fixed by heavy gauge non-metallic saddles with base, at an interval of not more than 60 cm, but on either side of couplers or bends, saddles shall be fixed at a closure distance.

Earthing requirements:

A protective (earth) conductor shall be drawn inside the conduit in all distribution circuits to provide for earthing of non-current carrying metallic parts of the installation. These shall be terminated on the earth terminal in the switch boxes, and/or earth terminal blocks at the DB's.

PVC CASING AND CAPPING WIRING SYSTEM

Scope:

PVC Casing and Capping is suitable for surface wiring work (indoor) where necessitated, either due to aesthetics or technical requirements, such as case of extension of existing wiring.

Preferred size of the PVC casing and capping should be 25 X 16 mm, 32 X 16 mm.

Material:

The thickness shall be 1 mm minimum.

Installation:

It shall be fixed by means of screws at intervals not exceeding 60 cm for all sizes and on either side of the joints; the distance of the fixing arrangement shall not exceed 15 cm from the joint.

It should be used only on dry walls and ceilings, avoiding outside walls as far as possible and shall not be buried in walls.

When conductors pass through floor or wall, the same shall be carried in an approved PVC conduit. **The conduit shall be carried 20 cm above floor level and 2.5 cm below ceiling level and neatly terminated into the casing.**

All joints shall be done using standard accessories like internal angle, external angle, flat angle (elbows), flat junction (T) and end caps.

No screws or nails shall be used for fixing PVC cover.

Maximum number of PVC insulated 650 / 1100 V Grade Al / Cu conductor cable that can be drawn in casing-capping:

Nominal cross sectional area	10/15 mm X 10 mm	20/15 mm X 10 mm	25/15 mm X 16 mm	32 mm X 16 mm	40 mm X 25 mm	40 mm X 40 mm
1.5	3	5	6	8	12	18
2.5	2	4	5	6	9	15
4	2	3	4	5	8	12
6		2	3	4	6	9
10		1	2	3	5	8
16			1	2	4	6
25				1	3	5
35					2	4
50					1	3
70					1	2

Note: Dimensions shown above are outer dimensions.

Electrical Power System

Electrical Services in the buildings housing modern technical network must perform to an exceptional degree of reliability so as to ensure that no breakdowns in the system.

'The Electrical wing of BSNL is responsible for carrying out original and maintenance works of following electro-mechanical services in BSNL

→Administrative Buildings and residential quarters.

→Electrical Sub-stations

→Engine Alternator sets

→Air-conditioning Installations

→Internal Eland Fans

→Water Pump sets

→Fire Detection and Fire Fighting System

→Lifts

→Lightening Protection

In BSNL, we are mainly concerned with the distribution substation where the main activity is to step down the higher voltage received through transmission line. This stepping down may be to a level of suitable voltage to feed the load equipment directly, via 415v or 230v. These voltages are stepped down by the step down transformers and other associated electrical switchgears for the protection, control, distribution and utilization of electrical energy.

The various components of a substation are discussed in the following:

HT Panel

The HT Panel switchgear incorporates the following features -

- a) 1 No. isolator as incomer incorporating trivector meter, voltmeter, ammeter, earth switch without protection.
- b) 2 Nos. HT OCB as outgoing, one each for transformer incorporating IDMT relay for overload, earth fault, short-circuit protection, on-off Indicating lamp, indication, voltmeter and ammeter.

The HT panel is provided with bus bar, cable end termination box for XLPE cables, trip and 50mmx5mm copper earth busbar.

Transformer

The transformer consists of different parts or components. These components depend upon the design, type and method of cooling etc. certain essential parts or components are discussed below.

→Steel Tank

It is meant for housing and mounting of all components including the core, the winding and the cooling substance etc. It is made of steel. Sometimes it contains heat-radiating tubes.

→Core

It is housed inside the steel tank and made of silicon steel sheet laminations having the thickness of 0.35 mm. These laminations are insulated to reduce the core loss. The core may be divided into two types Core and shell type.

→Windings

The windings are normally made of copper, concentric cylindrical type conductors. The primary and secondary windings are placed on the same limb of the core. Keeping in view of the rating, the design of the windings varies.

→Transformer Oil

It is a mineral oil. The core and the windings sometimes are immersed in it for insulation and cooling purpose.

→Conservator Tank

It is provided on the top of the transformer tank and connected through a suitable pipe. It is provided where oil is used for cooling and insulation. Is provided for the following reasons:

- I) With the increase and the decrease of temperature the volume of oil for accommodation of changes. The conservator tank provides suitable space for expanded volume of oil.
- II) During expansion and contraction, the minimum oil is exposed to air.
- III) It contains a glass and a scale for observation of oil level.
- IV) It has the provision of a breather.

The breather is connected to the conservator tank. It is provided with silica gel granules. Due to increase of temperature, the volume of oil and that it pushes air from the conservator tank to the outside air through the breather. Again when temperature decreases, the oil contracts and that causes the outside air to enter conservator tank through the breather. The silica gel grains provided in the breather absorb the moisture contained by the air. **When silica gel is completely dry, its color is blue. After absorbing moisture its color changes from blue to yellow and then to pink.**

→Thermometer

When the rating of the transformer is above 50 KVA, a thermometer is provided to indicate the oil temperature. Sometimes the sensor of the thermometer is fitted in the winding itself and the dial is provided outside the tank. Sometimes this temperature-sensing device also operates an alarm.

Overhead Bus bar Trunking

The connection from the transformer to the MV panel is by overhead Bus bar trunking. **The Bus bar trunking is normally done for transformer substation above 315KVA.** The Bus bar shall be made from rectangular section, high conductivity wrought Aluminum alloy and insulated by superior quality PVC sleeve. The Bus bar system shall be provided with coupling joints and expansion joint. The Bus bar shall be supported on hylum plates. The enclosure of the bus duct shall be fabricated from 12SWG MS sheet and two bottom end cover of 16SWG. The bus duct provided with rubber gaskets to make the duct dust proof.

M V Panel / LT Panel

The MV Panel is made of 16SWG MS sheet (1.6mm thick). The positioning of the panel shall be 75cm from the wall. The incoming to the panel from transformer by overhead Bus bar trunking or cable of adequate size. The MV panel is having Air break type circuit breaker (ACB) in order to eliminate the fire and explosion risk. Each ACB has detachable arc chutes on each pole for cooling, extinction of arc. The compartment doors should be so interlocked that they do not open when ACB is in the closed position. All TPN switch fuse unit shall be provided with HRC fuses. The MV panel is provided with IDMT relay, voltmeter, ammeter and indicating lamps. Earth busbar shall run along the panel.

Cables

On the HT sides, XLPE cables are used whereas LT sides, PVC cables are used. HV and LV cable shall be avoided to cross each other. At the time of laying cable, it must be checked that insulation It should be tested for continuity. Identification cable route markers shall be provided. All the ducts shall be covered.

Capacitor Panel

The panel is provided for power factor improvement. The capacitor panel is provided with capacitors. The capacitors can be connected in order to achieve the desired power factor. The capacitors can be connected by manual operation or Automatic operation. In manual, the capacitors are connected by manual operation of switches and in automatic operation, capacitors are connected by APFC relay. The capacitor panel is provided by power factor meter, dead band knob provide on the APFC for preventing hunting of capacitors and over correction. Each capacitor bank will have red indicating lamp to indicate the capacitors is ON or OFF and AUTO / MANUAL / OFF selector switch.

Earthing

It is recommended to provide copper earthing. The total No. of earthing should be normally $2N+2$ where N indicates the number of neutrals which is same as the number transformer. For body earthing 2Nos. bus bar shall be provided and the earth strips shall independently terminate on the body earth busbar.

Engine Alternator

The engine alternator is the combination of a diesel engine and an alternator. This combined unit is also called as a generator set or a DG set. Real power is in the form of mechanical power is generated by the engine and it is converted into electrical power

by the alternator. Therefore the output of the engine alternator mainly depends on the output of the engine. However the alternator coupled with the engine must match the load requirement.

Substation

In general, substation is the place where voltage and current levels from the electricity department is converted according to the user need.

1. Types, Selection and Designing

Types:

→Outdoor substation:

Outdoor substation receives the H.T. supply to a pole structure through air break switch, transformers are pre-installed near the pole structure which is constructed in open space. The L.T. supply from the transformer is extended to the L.T. panel in the indoor.

→Indoor substation

In this type of substation, all the necessary equipment are installed inside the building and H.T. supply is received through the H.T. panel provided in the indoor substation.

Selection and Designing:

Factors to be kept in mind while designing a substation:

Location of the substation

As far as possible, it should be located on the ground floor.

It should be approachable through a vehicle.

It should not be located below or adjacent to toilet or water source.

Must have sufficient earthing space and should be located near to the load center

Class of voltage

Generally the voltage class of the transformer decides substation rating. The voltage class of the substation is depends on the load requirement. Certain heavy machinery which requires 11kv to operate is also to be kept in mind.

Power requirement

On determining the power capacity of the substation, onward we select the equipment to be installed in the substation.

The electricity department has to provide the following details of the supply voltage:

The rated voltage which will be made available

Permissible percentage of voltage fluctuations at rated voltage of supply

Chances of changes in supply voltage in the future.

System maintainability

Any industry is voltage sensitive which means there has to uninterrupted power supply to the switches in the telephone exchanges.

Therefore it is critical to maintain the substation equipment at good condition.

To ensure this we have:

Standby equipment in case of any mishap

A maintenance team to repair the faulty equipment.

Auxiliaries

Auxiliaries are provisions for future upgradation of the substation equipment for example, power factor panels, automatic voltage regulators, etc. need to be installed in the substation at a later period auxiliaries are meant to accommodate them.

Future expansion

Future expansion setting is a must in all substations nowadays. As the ever growing energy demand, results in an increased demand on the substation. A well planned substation has provisions (aux) to extend its LT and HT panels.

2. Operation and maintenance

The operation and maintenance of a substation follow these steps:

→ Inspection

In this phase, all the equipment in the substation undergo scrutiny without dismantling it (visual and operational checks).

→ Servicing

In this phase, the substation equipment undergo cleaning, calibration, lubrication without dismantling it.

→ Examination

Unlike the other phases, here the equipment are dismantled, measurements, and non-destructive tests to obtain test data regarding to the condition of the components of the substation assemblies.

→ Overhaul

This refers to the work done with the objective of repairing worn-out parts and defective parts. The equipment, sub-assemblies are dismantled partly or completely. The condition of the components is inspected. Dimensions of the worn-out components are measure and either replaced or rectified.

3. Latest trends in Substations

When faults take place, heavy damage to transformers and auxiliary systems are reported. Instead of using rating of fuses, people have been using wires which are technically incorrect. A recent development in this field is **Unitized Sub Station**.

UNITIZED SUB STATION

This is a very advanced level of a substation in which everything is factory made to meet the customer needs. USS comprises of a factory built package having transformer, HT and LT panels. This is a fit and forget type of installation where everything is automatic. The connections are precise, secure and totally enclosed.

Hence ensuring safety. This also means that there is no chance of failure, corrosion and losses (to a considerable amount).

Engine Alternator Sets

1. Overview

A standby power supply is mandatory in all industrial buildings. It is usually diesel engine alternator set. The diesel engine is the prime mover which rotates the alternator set and the alternator produces electrical energy. In the first stage of energy conversion, the chemical energy of the fuel (diesel) is converted to mechanical energy at the common shaft of the engine alternator. This mechanical energy is converted to electrical energy at the alternator at the second stage of energy conversion.

2. Principle of operation

Alternator works on faraday's law of electromagnetic induction. There are two requirements for the working of the alternator.

1) Magnetic field and

2) Rotation.

Magnetic field is produced by passing direct current through the field windings of the alternator and rotation is achieved by the means of coupling the alternator to the engine.

The automatic voltage regulator is provided in the alternator for maintaining the terminal voltage within the close limits over wide operating condition.

3. Diesel Engine

→ Lubrication systems

The moving parts of the diesel engine are lubricated for their optimum operation by this lubrication systems. A dipstick in the oil tank serves to check the oil level. The lube oil level is the lubricant oil pressure that is to be checked for satisfactory performance and long life of the engine. The engine is relived of frictional loses, heating issues and wear and tear issues.

The system is to be regularly checked for high oil consumption, low oil pressures, high oil pressures, oil in coolant, coolant in oil, and fuel in oil.

→ Fuel systems

Depending on the position of the fuel, the fuel is supplied to the distributing pipe through fuel filter either by natural head form an elevated tank or by a fuel pump. Fuel is supplied inside the cylinder by injection nozzles.

The fuel nozzle controls the quantity of fuel to each cylinder, ensures that fuel is delivered at correct time, at the correct condition and govern the engine speed.

The problems that the engine fuel systems needs to be checked regularly are engine starting, loading problems, surging, high fuel consumption and wear of fuel components.

→ Air systems

For the engine to run the combustion chamber need a sufficient supply of fresh and filtered air. After the combustion, the exhaust gasses have to be taken out of the combustion chamber through a suitable ducting or piping. This is known as exhaust system of the engine.

The engine may malfunction if the air system provides insufficient air for combustion. This may result in unburnt diesel, loss of power and excessive exhaust temperatures.

→ Cooling systems

Cooling systems is essential for cooling the engine body and to act as a heat exchange for lubricating oil. This can be either water cooled or air cooled. Malfunctioning of cooling system may cause over heating of the engine and ultimately seizure of the engine.

→ Starting systems

The diesel engine can be equipped with starting system i.e. with an electric starter self with a pinion, which engages with the fly wheel of the engine. The power to the electric starter is provided by the means of a battery which is kept in charged condition by the means of a dynamo or a rectifier.

3.1. Acoustic treatment of the generator room

The sound proof treatment of the generator room has become very important because of **CPCB (Central Pollution Control Board)** norms. The following has to done to sound proof the generator room.

- 1) The acoustic treatment of the room is to be designed for minimum 25dB insertion loss. **Final sound level shall not be more 75dB at a distance if 1m.**
- 2) Mineral glass wool of density 24kg/cubic meter & 75mm thickness conforming to IS-8183 should be used.
- 3) High quality gaskets are to be used to avoid leakage of sound.
- 4) A specially designed large pusher fan or axial flow fan for forced ventilation inside the room shall be provided.
- 5) Specially designed circuitry to ensure the fan starts when the generator is switched on and when the generator is switched off the fan must automatically to AC mains which continues to run for minimum 3 minutes to ensure that the engine is cooled.

6) The temperature inside the enclosure shall not exceed 5°C then the ambient temperature during testing.

2. Selection and Installation

To select a diesel generator, we need to understand the types of load it has to supply.

There are two types of loads

1) Linear loads

2) Non-Linear loads

→ LINEAR LOADS

A linear load is one for which load impedance remains constant regardless of applied voltage. For alternating current, current increases proportionally as the voltage increases and decreases proportionally as the voltage decreases. Motor, incandescent lighting and heating load etc. are linear in nature. For a sinusoidal voltage, the current is also sinusoidal, these are called linear loads.

→ NON LINEAR LOADS

A non-linear load is one in which the load current is not proportional to the instantaneous voltage. Often, the load current is not continuous. Solid state devices are non-linear in nature. Rectifier load, thyristor load, computer load, etc. are non-linear in nature. Non-linear load currents are not sinusoidal in nature even when the source is sine wave.

2.1. Factors Affecting Rating of Engine Alternator Sets

While selecting an Engine-alternator set, proper deration should be allowed so that engine should not under perform at the site. Following factors should be considered for deration of engine or the alternator.

→ Altitude

Engines are generally rated for atmospheric pressure at mean sea level. As the altitude increases the density of air starts reducing. Low pressure injection to the engine results in lower output and therefore, deration is allowed for higher altitudes.

→ Temperatures

Ambient air temperature is important for cooling of engine and alternator. As the air temperature rises, the engine temperature also goes up and therefore, a deration factor is used. Winding resistance of alternator also increases with increase in temperature.

→ Humidity

Efficiency of the engine reduces with increase in relative humidity of supply air. For more humid applications the engine is suitably derated.

→Non linear

Non-linear load on the alternator is also important factor. **Most of the alternators are designed for 40% non-linear load applications.** In case the non-linear load increases this value, the alternator should be properly sized.

2.2. Selection Approach of a Diesel EA Set

For selecting the capacity of an Engine-alternator, the following factors are considered

- i) Linear load.
- ii) Non-linear
- iii) Altitude
- iv) Ambient temperature
- v) Relative humidity

3. Selection of an alternator

For selecting the capacity of alternator, the following steps should be followed.

- i) Calculate the nonlinear load to be fed by EA set after applying the factor for each and every type of load (say X KVA).
- ii) Calculate the linear load to be fed by EA set after applying the load factor for each and every type of load (say Y KVA).
- iii) After considering the derating of alternator on account of nonlinear load select, the alternator as to meet the total load requirements (X+Y KVA) and X KVA non-linear load for applications.

4. Selection of an Engine

For engines, there is no need to derate engine capacity on account of nonlinear load. However, the engine selection shall be made on the basis of derating atmospheric conditions e.g. altitude, ambient temperature and humidity.

5. Latest installation practices of EA set

→ Microprocessor based AMF control panel

1. Close coupling between Engine and Alternator
2. Diesel tank is fabricated as a welded part of Base Channel
3. Starting battery is in the frame which is welded the base channel
4. The control panel is mounted on the alternator
5. The exhaust silencer is supported from the Base Channel

Energy management

1. Introduction

The fundamental goal of energy management is to produce goods and provide services with the least cost and least environmental effects. One definition of energy management is: ***"The judicious and effective use of energy to maximize profits and enhance competitive positions"***.

The objective of energy management is to achieve and maintain optimum energy procurement and utilization throughout the organization and to minimize energy costs without affecting their quality.

Main principles of energy management systems:

- Manage energy use at highest efficiency possible.
- Reusing and recycling energy by cascading.
- Use the most appropriate technology which is best for the job.
- Reduce the commonly avoidable losses.

Different energy management strategies are employed to ensure effective energy management. They are reviewed annually and revised if necessary.

→ Identifying a strategic corporate approach

The starting point in energy management is to identify a strategic corporate approach to energy management. Clear accountability for energy management needs to be established, appropriate financial and staffing and resources must be allocated and reporting procedures initiated. An energy management program requires commitment from the whole organization in order to be successful.

→ Appoint an energy manager

The energy manager, who should be a senior staff member, will be responsible for the overall coordination of the program and will report directly to the top management. Energy managers need to have a technical background, need to be familiar with the organization's activities and have appropriate technical support.

→ Set up an energy monitoring and reporting system

Successful energy management requires the establishment of a system to collect, analyze and report on the organization's energy costs and consumption. This will enable an overview of energy use and its related costs, as well as facilitating the identification of savings that might otherwise not be detected. The system needs to record both historical and ongoing energy uses, as well as cost information from billing data and be capable of producing summary reports on a regular basis. This information will provide the means by which the trends can be analyzed and tariffs reviewed.

→ Conduct energy audit

An energy audit established both where and how energy is being used and potential for energy savings. It includes a walk-through survey, a view of energy using systems, analysis of energy used and the preparation of energy budget and provides a baseline from which energy consumption can be compared over time. An audit can be conducted by an employee of the organization who has appropriate expertise or by a specialist-auditing firm. An energy audit report also includes recommendations for actions, which will result in energy and cost savings. It should also indicate the costs and savings for each recommended action and the priority order of implementations.

2. Conducting an “*energy audit*”

This is a key to a systematic approach for decision making in the area of energy management. It attempts to balance the total energy inputs with its use and serves to identify all the energy streams in the facility.

It quantifies energy usage according to its discrete functioning. Industrial energy audit is an efficient tool in defining and pursuing comprehensive energy management program.

As per the energy conservation act, 2001. “The verification, monitoring and analysis of use of energy including submissions of technical report containing recommendations for improving energy efficiency with cost benefit analysis and an action plan to reduce energy consumption.”

Power quality management

The need of power quality management is important so as to save electricity. **“electricity saved is electricity produced”**. It is also the most widely discussed topic among engineers. There are various electronic equipment which are invented to increase power quality that are wide spread in the industry.

Two questions arise at this moment

→why does poor power quality arise?

→what can we do to avoid them?

To understand the above concepts first we need to know, what is supply power quality?

Most electrical equipments are designed to operate from a power supply that is to deliver voltages and currents in a purely sinusoidal waveform and to maintain the voltages and frequency within permissible limits of variation. There is an expectation on the part of the customer that the supply will be always available and maintained with tolerances. But this is not economically viable at the price power is sold.

Unlike many other commodity, the quality of power cannot be assessed before delivery. Hence the supply companies measure the quality at particular intervals and take corrective steps to ensure minimum poor power quality levels.

→Supply Interruption:

Is the complete loss of power supply for longer duration which may be caused by generation and/or distribution station failures, line fault, shedding by the authorities. They will lead to the complete shutdown of the plant and to overcome this, one must install alternate sources of power such as captive generation, UPS etc.

→Transients:

They are sudden changes in voltage or current or both, that are momentary in nature. They may be caused by lightning surges, sudden tripping of grid supply, sudden switching operations of reactive loads, etc. They may cause irreparable damage to equipment and installation. The Solution of this is to go for surge absorbent.

→Transient interruption

This is momentary power failure, lasting generally less than a minute. Usually the result of auto-reclosers in transmission system, reclosing after the fault. These may cause data loss and data errors in communication equipment and computers. Installation of UPS would help overcome this problem.

→Voltage dip/ Voltage surge

These are short duration disturbances, outside the permitted variations. These are the result of large motor starting or shut down. While the voltage dips may cause equipment shut down, voltage surges may cause insulation breakdown in the equipment. **Installation of surge absorbers would overcome the problems caused by surges.** For voltage dips, one may have to use alternate power sources like voltage stabilizer UPS etc., for voltage sensitive equipment.

→Under voltage/Over voltage

These are long duration variations in voltage outside permissible limit. Under voltage may cause unreliable operation, heating of motors etc. over voltage may cause insulation damage. To safeguard the equipment from these damages, one has to go for voltage operated releases/relays which will trip the associated circuit breakers in any event of abnormality.

→Voltage Unbalance

This is caused by unequal loading of phases in a three phase network. This results in circulating currents in thus transformers and generators thus cause increased heating. In the motor's core which may cause reduced efficiency problems. Care must be taken to distribute single phase loads equally over the three phases. Protective measure is to install a voltage balance protection scheme.

Renewable Energy Sources

An-Overview

Introduction:

As the conventional energy sources are becoming scarce and they pollute the environment. There is a need to switch on to non-conventional energy sources. Most of the new, alternative Energy sources (some of them have in fact been known and used for centuries now) are nothing but manifestations of solar energy, e.g. wind, sea waves, ocean thermal energy conversion (OTEC), etc. In this section we shall discuss the possibilities and potentials of various methods of using solar energy.

Learning Objective: After going through this handout, the participants must be aware of the use of Solar energy and renewable sources of energy wind energy, wave energy, ocean thermal energy conversion (OTEC), Magnetohydrodynamic , Biogas,Tidal energy , Geothermal etc.

Solar Energy

Solar Energy is the earliest source of energy known to mankind and is also the origin of other forms of energy used by man. The average incident solar energy received on the earth's surface is about 600W/m^2 but the actual value varies considerably. India receives solar energy equivalent to over 5000 trillion KWHr/Sqm, which is far more than the total energy consumption of the country. The daily average solar energy incident over India varies from 4-7 KWHr /Sqm depending upon the location.

Advantages

- It is free of cost,
- Non-exhaustible
- Completely pollution-free.

Disadvantages

- The energy density per unit area is very low.
- It is available for only part of the day, cloudy and hazy atmospheric conditions greatly reduce the energy received.
- There are extreme seasonal variations.

Therefore, harnessing solar energy for electricity generation throws up some challenging technological problems, the most important being that of the collection and concentration of solar energy audits conversion to electrical form through efficient and comparatively economical means.

At present two technologies are being developed for conversion of solar energy to the electrical form.

Solar Thermal Technology :In this technology, collectors with concentrators are employed to achieve **temperatures high enough (700°C) to operate a heat engine at reasonable efficiency to generate electricity**. However, there are considerable engineering difficulties in building as single tracking bowl with a diameter exceeding 30m to generate perhaps 200kw. The scheme involves large and intricate structures involving huge capital outlay and today is far from being competitive with conventional electricity generation.

The solar power tower generates steam for electricity production. There is a 10 MW installation of such a tower to the Southern California Edison Co. in the USA being 1818 plane mirrors coupled to an electric generator. A solar pond at Ein Borek in Israel Produces a steady 150 Kw from 0.74 ha at a bus bar cost of about \$ 0.10k/Wh.

Other examples of Solar of thermal systems commonly used are solar cookers, solar geysers, solar air heaters and dryers.

At present,in India, there is total capacity of 5,00,000 Sqm solar thermal collector area.

Direct conversion to electricity (photovoltaic generation): This technology converts solar energy to the electrical form by means of silicon wafer photoelectric cells known as 'solar cells'. Their theoretical efficiency is about 25% but the practical value is only

about 15%. But that does not matter, as solar energy is basically free of cost. The chief problem is the cost and maintenance of solar cells. With the likelihood of a breakthrough in the large-scale production of cheap solar cells with amorphous silicon, this technology may compete with conventional methods of electricity generation, particularly as conventional fuels become scarce.

Although these devices do not pollute, they will have an environmental effect for large-scale power generation. Because of the solar energy not reaching the ground under the large area of the collectors/reflectors. Solar energy could at the most supplement up to 5-10% of the total energy demand. It has been estimated that to produce 10^{12} kWh per year, the necessary cells would occupy about 0.1% of US land area as against highways which occupy about 1.5% (in 1975), assuming 10% efficiency and daily in in Solar Energy

Geothermal Energy :-

In a geothermal power plant, heat deep inside the earth acts as a source of power. There has been some use of geothermal energy in the form of underground steam in the USA, Italy, New Zealand, Mexico, Japan, the Philippines and some other countries. In India feasibility studies for a 1 MW station at Puggy Valley in Ladakh are being carried out. Another geothermal field has been located at Chumantang. There are a number of hot springs in India, but the total exploitable energy potential seems to be very little.

The present installed geothermal plant capacity in the world is about 500MW and the total estimated capacity is only about 2000MW. Since the pressure and temperatures are low, the efficiency is even less than conventional fossil-fuelled plants, but the capital costs are less and the fuel is available free of cost.

Wind Energy:-

Wind is essentially created by the solar heating of the atmosphere. Several attempts have been made since 1940 to use wind to generate electric energy and development is still going on. However, the techno-economic feasibility has yet to be satisfactorily established.

Wind as a power source is attractive because it is plentiful, inexhaustible and non-polluting. Further, it does not impose an extra heat burden on the environment. Unfortunately, it is unsteady and undependable. Control equipment has been devised to start the wind power plant whenever the wind speed reaches 30km/h. Methods have also been found to generate constant frequency power with varying wind speeds and consequently varying speeds of windmill propellers. Wind power may prove practical for small power needs in isolated sites; but for maximum flexibility, it should be used in conjunction with other methods of power generation to ensure continuity.

For wind power generation, there are three types of operations:-

- a. Small, 0.5 –10kW for isolated single premises;
- b. Medium, 10-100Kw for communities; and
- c. Large, 1.5 MW for connection to the grid.

The theoretical power in wind stream is given by

$P = 0.5 \rho A V^3$ (W), where

ρ = density of air (1201 gm/m³ at NTP);

V = mean air velocity (m/s); and

A = Swept area (m²).

For a rotor of 17m diameters and a velocity of 48 km/h, the theoretical power is 265 k and the practical power would be roughly half of this value.

There are some distinctive energy features of wind power systems:

- A. Most wind power sites are in remote rural, island or marine areas.
- B. Rural grid systems are likely to be 'weak' in these areas, since they carry relative low voltage supplies (e.g. 22kV).
- C. There are always periods without wind.

In India, wind power plants have been installed in Rajasthan and parts of Gujarat (Okha, 0.5 MW; Mandvi, 1.8 MW), where wind blows at speeds of 30km/hr during summer.

Five wind farm projects of aggregate capacity 4.29 MW have been operative successfully at Okha and Mandvi in Gujarat; Tuticorin in Tamil Nadu; Puri in Orissa; and Deogarh in Maharashtra. A preliminary estimate of the wind resource potential in the country indicates a potential in excess of 20,000MW for power generation alone. Prospects are considered good for exploration of the potential of wind energy as a cost-effective alternative to conventional sources of electric power.

Wave Energy

The energy content of sea waves is very high. In India, therefore, with several hundreds of kilometers of coastline, a vast source of energy is available. The power in the wave is proportional to the square of the amplitude and to the period of the motion. Therefore the long period (~10s), large amplitude (~2m) waves are of considerable interest for power generation, with energy fluxes commonly averaging between 50 and 70 kW/m width of the oncoming wave. Though the engineering problems associated with wave-power are formidable, the amount of energy that can be harnessed is large and development work is in progress.

Mini and micro Hydel Plants

Many countries such as Nepal, Bangladesh and India have tremendous potential of having many mini (1-5MW), micro (less than 1MW) and small (5-15MW) hydel plants which can generate cheap and clean power for villages situated far away from the grid power.

Tidal power plants

A tidal power plant is successfully working in France on the river La Rance having tidal height of 9.2 m and tidal flow of $18,000\text{m}^3/\text{sec}$. Several such sites exist elsewhere and must be developed.

Ocean thermal Energy Conversion (OTEC)

The ocean is the world's largest solar collector. Temperature difference of 20°C between the warm, solar absorbing surface water and the cooler 'bottom' water can

occur. This can provide a continually replenished store of thermal energy which is in principle available for conversion of other energy forms. OTEC refers to the conversion of some of this thermal energy into work and thence electricity.

Biogas

Biogas is generated when bacteria degrade biological material in the absence of oxygen, in a process known as anaerobic digestion. Since biogas is a mixture of methane (also known as marsh gas or natural gas) and carbon dioxide, it is renewable fuels reduced from waste treatment. Anaerobic digestion is basically a slow process carried out in a number of steps that can use almost any organic materials as a substrate - it occurs in digestive systems, marshes, rubbish dumps, septic tanks and the Arctic Tundra.

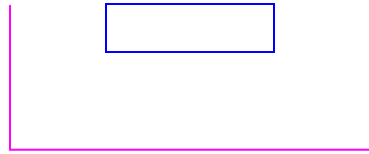
Biogas plant is being used in India in Villages. These units recycle the cattle dung to harness its fuel value without destroying the manure value. Toilet linked biogas plants are also popularized for sanitary treatment of human waste.

Magnetohydrodynamic (MHD) Generation - In thermal generation of electric energy, the heat released by the fuel is converted to rotational mechanical energy by means of thermocycle. The mechanical energy is then used to rotate the electric generator. Thus Two stages of energy conversion are involved in which the heat to mechanical energy conversion has an inherently low efficiency. Also, the rotating machine has its associated losses and maintenance problems. In MHD technology, electric energy is directly generated by the hot gases produced by the combustion fuel with out the need for mechanical moving parts.

In an MHD generator, an electrically conducting gas at a very high temperature is passed in a strong magnetic field, thereby generating electricity. High temperature is needed to ionize the gas, so that it has good electrical conductivity. The conducting gas is obtained by burning a fuel and injecting a seeding material such as potassium carbonate in the products of combustion. The principle of MHD power generation is illustrated in wind, sea waves, ocean thermal energy conversion (OTEC). About 50% efficiency can be achieved if the MHD generator is operated in tandem with a conventional steam plant.

Though the technological feasibility of MHD generation has been established, its economic feasibility yet to be demonstrated. India has recently started research and development project in collaboration with the former USSR to install a pilot MHD plant

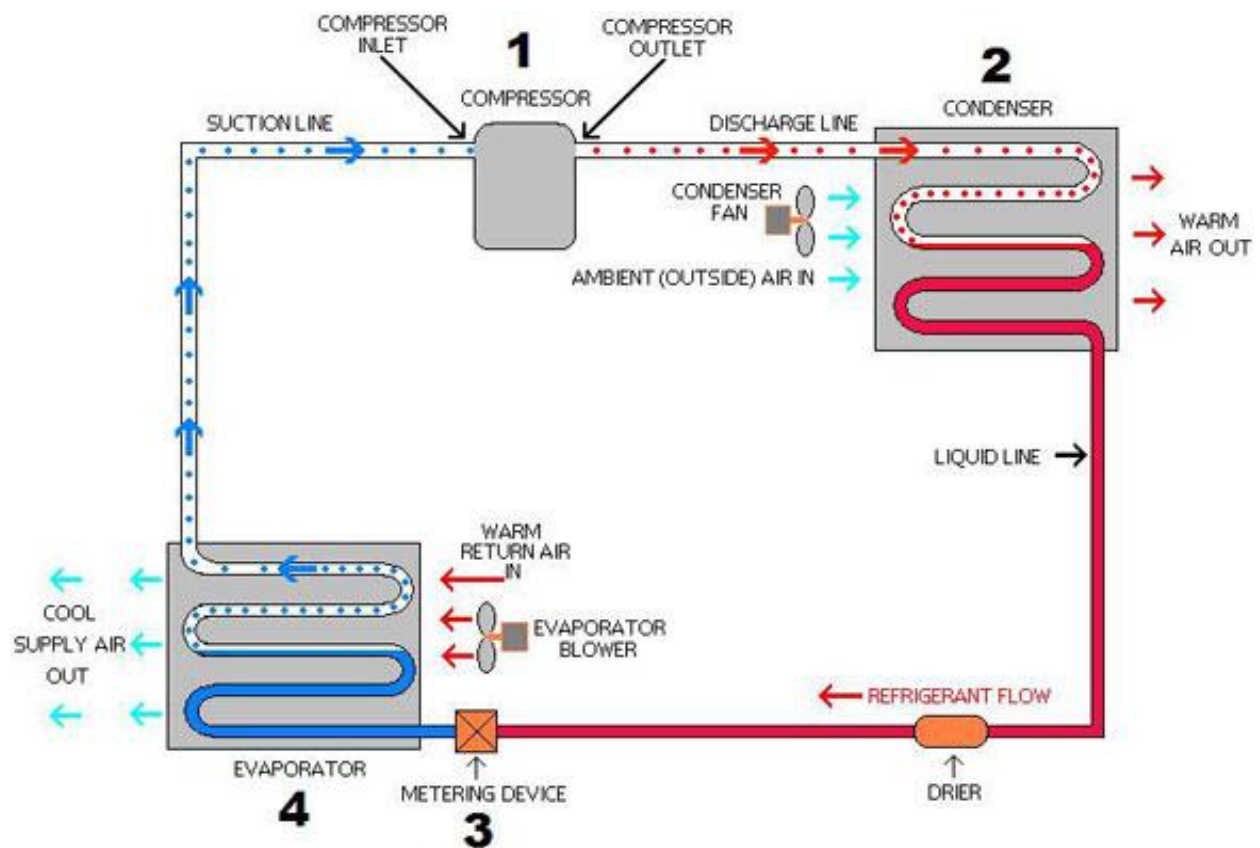
based o coal and generating 2 MW power. In the former USSR , A 25 MW, MHD plant which uses natural gas as fuel has been in operation for some years.



Air conditioning

As conventional definitions, would have the believe that air conditioning means chilled air, is completely wrong. Air conditioning means

- Maintaining the air at a desired temperature.
- Controlling the moisture content of the air.
- Hold air contamination to an acceptable level.
- circulate air properly in order to have correct proportion of oxygen in all parts of the room.



1. Basics

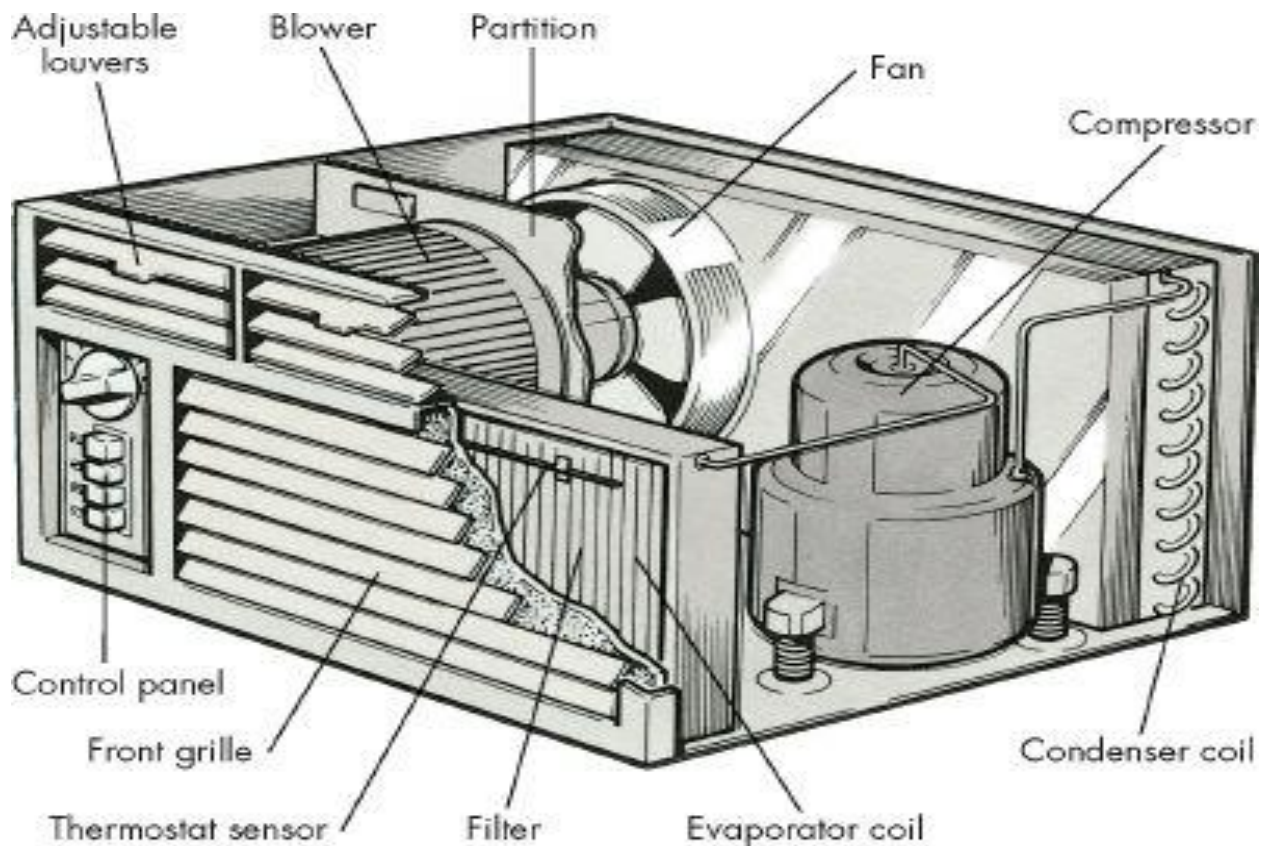
All air conditioning systems can be classified into the following types:

- Window type units
- Split type units
- Package units
- Centralized air conditioned system

→ Window type units:

Window type units are totally self-contained units which mean they have all the components inside the same unit i.e. compressor, condenser, refrigerant piping and air filters.

However they have no humidity control, no fresh air control, and no effective dust control.



→ Split type units

Split type air conditioners are functionally similar to window type air conditioners. However in this type of units the compressor and condenser unit is kept outdoor and the cooling coil unit is kept indoor. They are connected by means of an insulating copper pipe which feeds the refrigerant inside and outside.

→ Package units

These units are also functionally similar to window models but are much bigger in size and therefore installed on the floors. The unit itself is placed in a hermitically sealed chamber. The chamber has provisions for fresh air intake, conditioned air outlet and return air duct. The control panel is also located in the room itself.

→ Centralized air conditioned system

The working principle of the centralized air conditioning system is slightly different than the above types. These come into picture only when there is a huge demand and a large area to be air conditioned. Shopping malls or a whole office block for instance. This will also prove to be a costly option compared to the others. Here water is the refrigerant and is cooled in a cooling tower where water is dropped from a height in order to cool it (water temp. is about 4° to 5°).

2. Selection criteria& Factors affecting A.C load

There are various factors by which we select an air-conditioning unit, like inside and outside conditions, estimation of the required conditions or heating equipment, selections of suitable cooling/heating systems etc. A major factor by which the air conditioning unit is selected which is the amount of heat the building absorbs heat from the sun.

→ Selection of interior design conditions:

Interior conditions depends on the intended use of the building/room.

The need of the air conditioning i.e. whether it is for human occupancy or for machine cooling.

If the air conditioning is installed for comfort then what is the desired temperature setting.

If the air conditioning is installed for internal switches then what is the desired temperature setting for the optimal operation of the switches.

→ Selection of exterior design conditions:

In this case, sunlight plays a major role in the designing, such as intensity of sunlight, length of the day and night. The orientation of the room which is to be air conditioned.

The geographical location i.e. on which hemisphere the spot is located. This is to calculate the exact amount of time and the side of the wall on which sun light will prevail.

The humidity level of the environment plays a drastic effect on the performance of the air conditioner. It is a directly proportional relationship. I.e. if the humidity is high the unit consumes more energy.

If the room is on the ground floor, then the heat transfer to the ground is also taken into account.

If the walls of the sides are glass then the heat transfer from the outside is more as compared to a brick walled surface. Care is to be taken at the time of designing the building the glass walled surface should not face direct sunlight for better cooling.

4. Latest trend in air conditioning systems

Some innovative strategies are employed in Bharat Sanchar Nigam Limited (BSNL) for efficient operations of the A/c units. Some are stated below:

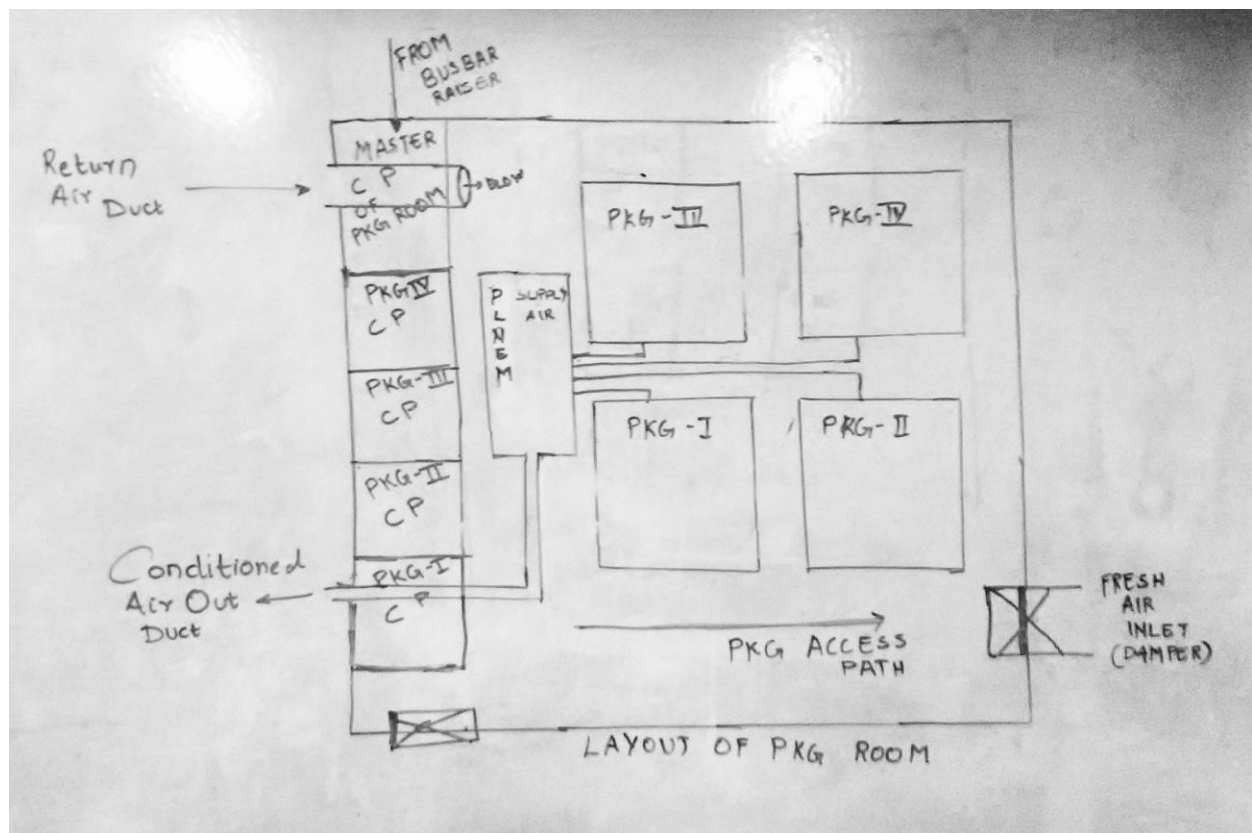
- Building orientation/architectural features
- Establishing baseline performance indices
- High sensible air-conditioning system
- Automation and building management system
- Variable voltage and variable frequency drive
- Heat recovery wheel
- Panel cooling
- Vapor absorption machines
- Roof top chillers
- Cooling by total air displacement

Advance Level Question:

Draw a layout of a typical package room with 4 package units.

Answer:

(Drawn on the whiteboard in the classroom)



EARTHING

1.0 Introduction: -

Though Electrical Equipments are manufactured and installed to give trouble free service, failure of various components cannot be ruled out. Failure of Electrical equipments or system due to-

- i. Insulation puncture.
- ii. Accidental contact between low & high voltage line.
- iii. Break-down of insulation between primary and secondary of a transformer.
- iv. Lightning strokes.

may cause severe damage to life and property. A need was felt to provide protection against above failure so as to content the damage to the minimum. Earthing is the measure in this direction.

2.0 OBJECTIVE: -

At the end of the lesson, participants shall be able to know-

- a. System earthing and
- b. Equipment earthing

3.0 BODY: -

Earthing or grounding means to connect the equipment or electrical system to the general mass of the earth. There are two types of earthing

- a. System earthing
- b. Equipments earthing

3.10 SYSTEM EARTHING: -

It means connecting to the earth, the neutral point i.e. the star point of generator, transformer, rotating machines and of grounding transformer. If neutral point of a system is earthed, the phase to ground voltage under earth fault condition does not rise to high value.

Let us consider a system in which neutral is not earthed. If there is Earth fault on B-phase, the voltage of R and Y (healthy) phases to the earth becomes equal to the line voltage. The rise in voltage causes stress on the insulation. Earthing provides protection against such rise.

3.20 EQUIPMENT EARTHING: -

It constitutes the connecting of non-current carrying metal parts of an equipment to the earth. It provides protection to operating personnel and equipment by ensuring operation of protective control gear.

4.0 ADVANTAGES OF NEUTRAL EARTHING: -

Connecting the neutral of an electrical system to earth has following advantages.

- i. Arching grounds are eliminated.
- ii. Voltage of healthy phases with respect to earth does not rise to $\sqrt{3}$ times to normal value.
- iii. Insulation is prevented from stress of high surge voltage & hence provides long life to insulation & equipment.
- iv. Stable neutral point.
- v. Earth fault relaying becomes simple & reliable.
- vi. Greater safety to personnel & equipment.

5.0 TYPE OF EARTHING: -

Sub-station earthing is mainly of two types

- i. Mesh earthing.
- ii. Electrode earthing.

5.1 Mesh earthing: - It is formed by steel rods (30 to 40 cm dia) laid horizontally at a depth of about 0.5 metre below ground surface to give a shape of mesh. The lengths and breadths are formed by welding of steel rods.

5.2 Earth electrode: - Earth electrodes, which are in use, are -

- a. Rod & pipe electrode.
- b. Strip electrode.
- c. Plate electrode.

5.2.1 ROD OR PIPE ELECTRODES: -

Pipe electrode shall not be smaller than 40-mm. internal diameter if of galvanized iron. The length of the pipe electrode shall be minimum 4.5 metres. If one electrode fails to give the required resistance, No. of such electrodes shall be installed and connected in parallel. The distance between two electrodes shall not be less than twice the length of electrodes. The G.I. Pipe shall be cut tapered at bottom and provided with holes of 12 mm dia drilled not less than 7.5 cm. from each other upto 2 mt. length from bottom.

5.2.2 STRIP ELECTRODES: -

It shall not be smaller in size than 40 Sqmm. section if of copper and 25 x 4 mm if of galvanized iron. For round conductors, it should be not less than 4 mm² if of copper and 5 mm² if of galvanized iron. The length of buried conductor shall not be less than 15 metres laid in trench not less than 0.5-metre depth.

5.2.3 PLATE ELECTRODE: -

In it, the plate is made of either copper or galvanized iron. This type of earthing (as shown in Fig. 2) is mostly used in our department. Size of copper plate shall not be less than 600 x 600 x 3 mm. and that of G.I. be 600 x 600 x 6 mm. Plate shall be put vertically under-ground so that minimum distance of ground level & top edge shall be 3 metres. Where earth resistance is not sufficient with one plate, two or more plate electrodes may be connected in parallel. This type is most suited for generating stations & sub-stations.

5.2.4 EARTHING CONDUCTOR:

The conductor from Earth Electrode to Earth shall be of the same material as earth electrode i.e. G.I. or copper and be in the form of strip or wire size of Earthing conductor shall not be less than the following

- a. 4 mm dia copper wire
- b. 5 mm dia G.I. Wire
- c. 25 x 4 mm² G.I. Strip
- d. 20 x 3 mm² Copper Strip However Earthing conductor shall not be more than 150 Sq. mm in Case of G.I., or 100 Sq. mm in case of copper, unless otherwise specified.

METHOD OF PLATE EARTHING

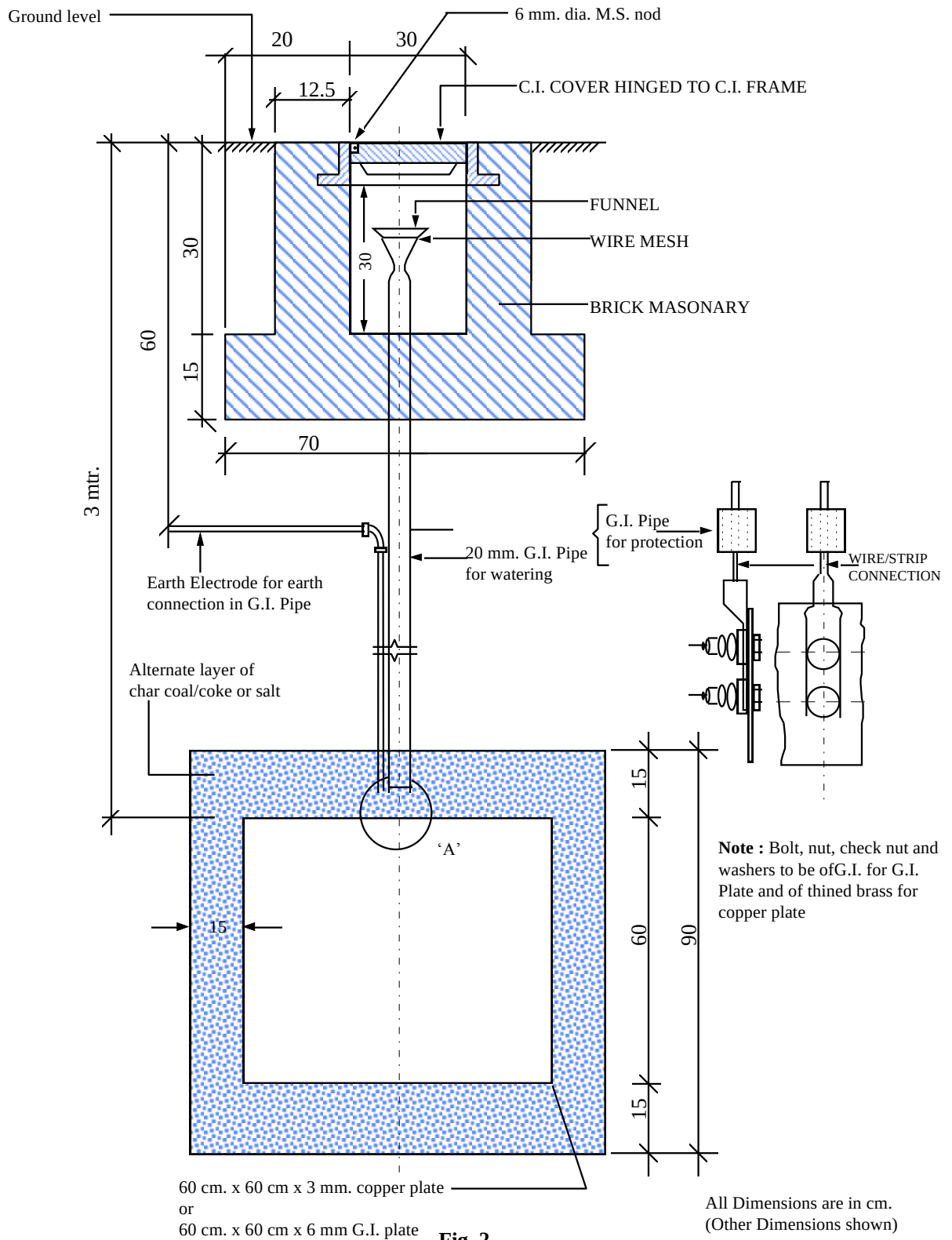


Fig. 2

5.2.5 EARTH BUS: -

Two copper strips each of size 50 mm x 5 mm shall be provided as earth bus in H/T Sub-station or diesel generating station. Both earth buses shall be bounded together. Each earth bus shall be connected to an independent earth electrode. Body of transformer, switchgear, panels etc. shall be connected by two leads each one to the bus.

The neutral of transformer or alternator or D.G. set shall not be connected to this earth bus. Each neutral of transformer or Alternator of D.G. set shall be connected to two independent earth electrodes. Thus for a sub-station with two transformers, two earth electrodes are required for neutral of each transformer and two earth electrodes for body earthing. Thus total six earth electrodes are needed.

5.2.6 WATERING ARRANGEMENT: -

In case of plate Electrode, a watering pipe of size 20 mm dia G.I. shall be provided upto the plate and funnel with wire mesh be provided at top. At the top a masonry enclosure of size 30 cm x 30 cm x 30 cm with M.S cover of 6 mm thickness shall be provided. The cover shall be equipped with locking arrangement.

5.2.7 EARTH RESISTANCE:

The resistance of Earth Electrode shall not be more than 5 ohms. In rocky areas it may be up to 8 ohms.

6.0 FACTORS AFFECTING EARTH RESISTANCE: -

Resistance of earth electrode depends upon resistivity of the soil in which electrode is installed. Soil resistivity depends upon.

- a. Nature of soil
- b. Moisture content in soil
- c. Presence of salt in the moisture.

Wet marshy soil is preferable for earthing. Effect of moisture on soil resistivity is indicated in Fig. 3. If moisture content falls less than 20%, resistivity of soil increases rapidly. Therefore water during dry season shall be added periodically so as to keep minimum 20% moisture in soil.

6.1 ARTIFICIAL TREATMENT OF SOIL: -

Water alone in absence of natural salts cannot provide adequate conductivity. Earth electrodes installed in streams of pure water will offer high resistance. However if water is added along with sodium chloride (common salt) calcium chloride etc. resistivity of soil can be reduced drastically. Effect of salt on soil resistivity is indicated in Fig. 4. From Fig. 3 it is seen that for salt content more than 5%, very little advantage is obtained.

6.2 METHOD OF CHEMICAL TREATMENT: -

Approximately 90% of resistance between an electrode and earth lies within a radius of 2 metres. Therefore it is advisable to dig a trench about 30 cm. deep around electrode as indicated in Fig. 5 and then pouring the chemical treated material into it. Water will cause diffusion of salt in soil.

7.0 MEASUREMENT OF EARTH RESISTANCE: -

Earth resistance of an electrode can be measured by earth tester. E is the electrode whose resistance is to be measured.

P&C are auxiliary electrodes of dia 15-20 mm. & 40 cm long bars. C is put about 25 mt. from E and P is put at central point between E & C. Two more readings are taken by moving P at a distance of 3 Mtr on either side. All the three readings should be constant (approximately). However if much difference is there, C should be moved away by 6 m. from E. The process is repeated till readings are constant.

SELECTION OF TYPE OF ELECTRODES:

The following are general guidelines for the selection of the type of electrodes.

TYPE OF ELECTRODE	APPLICATION
G.I. Pipe	- Internal electrical installations, with incoming switch gear upto 200 Amps.
G.I. Plate	- (a) For internal electrical installations with incoming switch gear larger than 200 Amps. (b) Neutral earthing of transformers, E/A sets upto 500 KVA. (c) Lightning Conductors.
Copper Plate	- Neutral earthing of transformers/E/A Sets above 500 KVA.
Strip/Conductor	- Locations where it is not possible to use other types.

NOS. OF EARTH ELECTRODES FOR VARIOUS USES:

The number of earthing electrodes for sub-stations & generating sets shall be as under.

- | | | | |
|-----|--|---|---------|
| (a) | For neutral earthing of transformer | - | 2 sets. |
| (b) | For body earthing of all the transformers
H.T/L.T. panels and other electrical
equipments in the sub-station/power house. | - | 2 sets. |
| (c) | For neutral earthing of each generating sets | - | 2 sets. |
| (d) | For body earthing of all the generating
sets, L.T. Panels & other electrical
equipments in the generator room | - | 2 sets |
| (e) | Where the generator & sub-station equipments are located together in the same building, the body earthing can be common for all the electrical equipments in the building. | | |

- Separate earth electrodes shall be provided for lightning arrestor/lightning conductors.
- Non-current carrying metal parts of all apparatus utilized power supply at voltage exceeding 250 volts shall be earthed by two separate & distinct connections to the earth bus or to two separate & distinct earthing set.

CONCLUSION:

Thus, earthing is must for any electrical installation. There are two types of earthing, system earthing & equipment earthing. System earthing provides protection to equipment, while equipment earthing provides protection to personnel.

LIGHTNING PROTECTION SYSTEM

PROTECTION OF BUILDING AGAINST LIGHTNING

PRINCIPLE OF PROTECTION

- i. The principle of protection of bldg. against lightning is to provide a conducting path between earth and the atmosphere above the bldg. through which the lightning discharge may enter the earth without causing damage to the bldg. If adequate earthed metal parts of proper proportions are provided and spread properly on and around the bldg., damage can be largely prevented.
- ii. The required conditions of protection are generally met by placing all the air terminals, whether in the form of verticals finials, or horizontal conductors, on the upper most part of the bldg. or its projections, with lightning conductors connecting the air terminals with each other and to the earth.

ZONE OF PROTECTION

The zone of protection is the volume within which a lightning conductor gives protection against a direct lightning stroke by directing the stroke to it-self. For a vertical conductor rising from ground level, the zone is described as a cone with its apex at the tip of the conductor and its base on the ground. For a horizontal conductor, the zone is defined as the volume generated by a cone with its apex on the horizontal conductor from end to end. Protective angle- This can not be precisely stated, since it depends upon the severity of the stroke and the presence within the protective zone of conducting objects providing independent path to earth. All that can be stated is that the protection afforded by a lightning conductor increases as the protective angle decreases.

However for the practical purpose of providing an “acceptable degree” of protection for an ordinary structure, the protective angle of any single component part of an air terminal network, namely, either one vertical, or one horizontal conductor is considered to be 45 degrees.

PRINCIPLE COMPONENTS:

The principle components of a lightning protective system are:-

- a) Air terminations
- b) Down conductors
- c) Joints & bonds,
- d) Testing Joints,
- e) Earth Terminations and
- f) Earth Electrodes

Air Terminations : Air terminations network may consist of vertical or horizontal conductors, or combination of both. For the purpose of lightning protection, the vertical and horizontal conductors are considered equivalent and the use of pointed air terminals, or vertical finial is, therefore, not regarded as essential.

Down conductors:

The function of a down conductor is to provide a low impedance path from the air termination to the earth electrode so that lightning current can be safely conducted to the earth. In practice, depending upon the form of a building, it is often necessary to have many down conductors in parallel, some or all of which may be a part of the building structure itself. The recommended number for different types of structures will be as below:

- (i) A structure having a base area not exceeding 100 sqm need have only one down conductor, except when built on a bare rock, or where access for testing is difficult.
- (ii) For a structure having base area exceeding 100 sqm, the number of down conductors shall be at least the smaller of the following:
 - (a) One plus an additional one for each 300 sqm, or a part thereof, in excess of the first 100 sqm.,

OR

- (b) One for each 30 M of the perimeter of the structure protected.
- (iii) Tall structure presenting inspection difficulties - For Tall structure, where testing and inspection could be difficult, at least two down conductors will be required for such tests.

MATERIALS:

1) The material of air terminals, down conductors, earth terminals, etc. of the protective system shall be reliably resistant to corrosion, or be adequately protected against corrosion. The material shall be one of the following, as specified.

- (a) **Copper:** Solid or flat copper strip of at least 98% conductivity shall be used.
- (b) **Copper clad steel:** Copper clad steel with copper covering permanently and effectively welded to the steel core shall be used. The proportion of copper & steel shall be such that the conductance of the material is not less than 30% of conductance of the solid copper of the same total cross section area.
- (c) **Galvanized Steel:** Steel thoroughly protected against corrosion by a zinc coating shall be used.

(d) **Aluminium:** Aluminium, 99% pure, and with sufficient mechanical strength, and protected against corrosion shall be used.

- 3) Aluminium should not be used underground, or in direct contact with walls.
- 4) All air terminals shall be of GI and all down conductors shall be of GI or aluminium, except where the atmospheric conditions necessitates the use of copper or copper clad steel for air terminals and down conductors.

5. The recommended shape and minimum size of conductors for use above & bellow ground are given in tables below –

Shapes and minimum size of conductors for use above ground

Sl.No.	Material and shape	Minimum size
1. Round copper wire or copper clad steel wire		6 mm diameter
2. Stranded copper wire		50 sq. mm or (7/3.00 mm dia)
3. Copper strip		20 mm X 3 mm
4. Galvanized iron strip		20 mm X 3 mm
5 Round aluminium wire		8 mm diameter
6 Aluminium strip		25 x 3 mm

Shapes and minimum size of conductors for use bellow ground

Sl. No.	Material and shape	Minimum size
1. Round copper wire or copper clad steel wire		8 mm diameter
2. Copper strip		32 X 6 mm
3. Round galvanized iron wire		10 mm X 6mm
4. Galvanized iron strip		32mm X 6 mm

LAYOUT:

1) Air terminations:

i. Air termination networks may consist of vertical or horizontal conductors, or combination of both two. For the purpose of lightning protection, the vertical and horizontal conductors are considered equivalent and the use of pointed air terminals, or vertical finial is, therefore, not regarded as essential

ii. A vertical air termination, where provided, need not have more than one point, and shall project at least 30 cm, above the object, salient point or network on which it on fixed

iii. For a flat roof, horizontal air terminations along the outer perimeter of the roof shall be used. For a roof of larger area a network of parallel horizontal conductors shall be installed. No part of the roof should be more than 9 M from the nearest horizontal protective conductor.

iv. Horizontal air terminations should be carried along the contours such as ridges, parapets, and edges of the flat roofs, and, where necessary over flat surfaces, in such a way as to join each air terminal to the rest, and should themselves form a closed network.

v. All metallic projections including reinforcement, on or above the main surface of the roof which are connected to the general mass of the earth, should be bonded and form a part of the air termination network.

vi. If portion of a structure vary considerably in height, any necessary air terminations or air termination network for the lower portion should be bonded to the down conductor of the taller portion, in addition to their own down conductors.

DOWN CONDUCTORS:

i. The number & spacing of down conductors shall be as specified, or as directed by the Engineer-in-charge.

ii. ROUTING

a) A down conductor should follow the most direct path possible between the air termination network and the earth termination network. Where more than one down conductor is used, the conductors should be arranged as evenly as practicable around the walls of the structures.

b) The walls of the lift wells may be used for fixing down conductors, but lift shaft should not be used for this purpose.

c) Metal pipes leading rainwater from the roof to the ground may be connected to the down conductors, but cannot replace them, such connection should have disconnecting joints.

d) In deciding on the routing of the down conductor, its accessibility for inspection, testing and maintenance should be taken into consideration.

iii. Provision when external route is not available a) Where the provision of external routes for down conductor is impracticable, for example, in building of cantilever construction from the first floor upward, down conductors should not follow the outside contours of the building. To do so would create a hazard to persons standing under the over hangs. In such cases, the down conductors may be housed in an air space provided by a nonmetallic and non-combustible internal duct and taken straight down to the ground.

a) Any suitable covered recess, not smaller than 76mm X 13mm, or any suitable vertical service duct running the full height of the building may be used for this purpose, provided it does not contain an unarmored or a non-metal sheathed cable.

b) In cases where an unrestricted duct is used, seals at each floor level may be required for fire protection. As far as possible, access to the interior of the duct should be available.

iv. The lightning protective system should be so installed that it does not spoil the architectural or aesthetic beauty of the buildings.

INSTALLATION:

1. General:

i) The entire lightning protective system should be mechanically strong to withstand the mechanical forces produced in the event of lightning strike.

ii) Conductors shall be securely attached to the building, or other object to be protected by fasteners, which shall be substantial in construction, not subjected to breakage, and shall be of galvanized steel or other suitable materials, with suitable precautions to avoid corrosion.

iii) The lightning conductor shall be secured not more than 1.2 M apart for horizontal run, and 1 M for vertical run.

2. Air Terminations:

All air terminals shall be effectively secured against overturning either by attachment to the object to be protected, or by means of substantial bracings and fixing which shall be permanently and rigidly attached to the building. The method & nature of the fixing should be simple, solid and permanent, due attention being given to the climatic conditions and possible corrosion.

3. Down Conductors:

i) The down conductor system, where practicable, be directly routed from the air terminal to the earth terminal network, and as far as possible, be symmetrically placed around the outside walls of the 108 structure starting from the corners. In all cases consideration to side flashing must always be given.

ii) (a) Practical reasons may not sometimes allow the most direct route to be followed. While sharp bends, such as arise at the end of roof are in- escapable (and hence permissible), re-entrant loops in a conductor can produce high inductive voltage drops so that the lightning discharge may jump across the open side of a

loop. As a rough guide, this risk may arise when the length of the conductor forming loop exceeds 8 times the width of the open side of the loop.

(b) When large re-entrant loops as defined above cannot be avoided, such as in the case of some cornices or parapets, the conductors should be arranged in such a way that the distance across the open side of a loop complies with the requirement indicated above. Alternatively, such cornices or parapets should be provided with holes through which the conductor can pass freely.

iii) Bonding to prevent side flashing: Any metal in or forming a part of structure, or any building services having metallic parts which are in contact with the general mass of the earth, should be either isolated from, or bonded to the down conductor. This also applies to all exposed large metal items having any dimension greater than 2 M whether connected to the earth or not.

4. Joints and Bonds:

1. Joints:-

i) A lightning protective system should have as few joints as possible.

ii) Joints should be mechanically and electrically effective, for example, clamped, screwed, bolted, riveted, or welded.

iii) With overlapping joints, the length of the overlap should not be less than 20 mm for all types of conductors. 109

iv) Contact surfaces should first be cleaned, and then inhibited from oxidation with a suitable non-corrosive compound.

v) Joints of dissimilar metals should be protected against corrosion or erosion from the elements, or the environment and should present an adequate contact area.

2. Bonds:-

i) Bonds have to join a variety of metallic parts of different shapes and composition, and cannot therefore be of a standard form.

ii) There is the constant problem of corrosion and careful attention must be given to the metals involved, i.e. the metal from which the bond is made, and those of the items being bonded.

iii) The bond must be mechanically and electrically effective, and protected from corrosion in and erosion by the operating environment.

iv) External metal on, or forming part of a structure, may have to discharge the full lightning current, and its bond to the lightning protective system should have a cross sectional area not less than that employed for the main conductors.

v) Structure supporting overhead electric supply, telephone and other line must not be bonded to a lightning protective system without the permission of the appropriate authority.

vi) Gas pipe in no case shall be bonded to the lightning protective earth termination system.

3. Test Joints:

Each down conductor should be provided with a test joint in such a position that, while not inviting unauthorized interference, it is convenient for use when testing.

4. Earth Termination Network:

i) An earth station comprising one or more earth electrodes as required should be connected to each down conductor. This shall be specified.

ii) Each of the earth station should have a resistance not exceeding the product given by 10 ohms multiplied by the number of earth electrodes to be provided therein. The whole of the lightning protective system, including any ring earth, should have a combined resistance to earth not exceeding 10 ohms without taking account of any bonding.

iii) If the value obtained for the whole of the lightning protective system exceeds 10 ohms, a reduction can be achieved by extending or adding to the electrodes, or by interconnecting the individual earth terminals of the down conductors by a conductor installed below the ground, sometimes referred to as a ring conductor. Buried ring conductors laid in this manner are considered to be an integral part of the earth terminal network, and should be taken into account when assessing the value of resistance to earth of the installation.

iv) A reduction of the resistance to the earth to a value below 10 ohms has the advantage of further reducing the potential gradient around the earth electrode when discharging lightning current. It also further reduces the risk of side flashing to the metal in, or of structure.

v) Earth electrodes should be capable of being isolated and a reference earth point should be provided for testing purpose.

Bonding to prevent side flashing

- 1** Air termination
- 2** Down conductor
- 3** Bond to aerial
- 4** Bond to vent
- 5** Bond to re-bar
- 6** Bond to metal staircase
- 7** Bond to metal window frame
- 8** Bond to vent pipe
- 9** Bond to steel door/frame
- 10** Test clamp
- 11** Indicating plate
- 12** Main earthing terminal of electrical installation
- 13** Earth termination point

MAINTENANCE ASPECT

1. Organized maintenance based on preventive maintenance is essential to ensure:

- a) Un-interrupted Service
- b) No Break-down
- c) Safety, no mishaps
- d) Economic Operation
- e) Lower Energy Bill
- f) Long Useful Life

2. Therefore, due importance is to be given for maintenance.

2. General Guidelines –

- a) Persons engaged in maintenance works should be competent for the type of work involved and should possess necessary license.
- b) Safety procedures should be duly followed.

c) In any building, additions and alterations are bound to occur at any time. When such additions / alterations are to be undertaken, it is very important to check in advance the likely loading of the distribution system and to strengthen the system as necessary before allowing the extra load to be connected, so as to avoid overloading of any part of the system. Each phase balancing may need to be re-done so as to keep the neutral current low. To enable compliance to this safety aspect, the detailed distribution schematic diagram indicating also the wire / cable sizes, current rating of switchgears / fuses, loading on individual circuits etc. should be available at site. This may be kept up in register form, with different pages for

different floors / wings, for ready reference at any time. This should be supplemented with detailed inventory. These should be updated, as and when additions / alterations are carried out so that the data may be fully relied upon, for further references. In fact, if any major additions alterations / rewiring are carried out; proper record should be kept in the history book for the installation. It is necessary that those responsible for the site maintenance should have a clear knowledge about the distribution system.

- c) The number of items to be maintained in a building may be many like fittings, fans, DB, earth sets etc. In order to achieve compliance to the prescribed periodicities for the various activities on them as per this schedule, each of these items may be divided into convenient numbers, to carry out the respective activities in sub periods, in cyclic (sequential) order e.g. if DB are to be checked every month, and there are 50 DB in a building, these may be checked at the rate of 2 or 3 DB every day in a sequential order (programmed in advance) so that all DB are checked in a month.
- d) Maintenance activities carried out as per this schedule should be noted in the Maintenance Register. When tests are carried out, the test result should be recorded with appropriate identification references (e.g. – SDB 7; Earth Pit No. 4; Room No 105 – Wing ‘A’ etc.)
- e) The voltage of supply, total load current and power factor should be noted in logbook every day, preferably during peak loading time of the day. If any instrument is not provided, provide the same now. If any of the instrument defective, get it repaired early.
- f) Inspection of electrical installations is intended primarily from fire safety considerations. Following points need to be observed as part of inspection, and corrective action as necessary should be taken immediately, including coordination with the user concerned, as may be required.
 - i. Check that – there is no sign of heating up, burning smell, de-colouration or sparking at any of the boards (SDB as well as MB), and Rising Mains. These may occur due to overloading or loose terminations. Highly unbalanced 114 loading may cause heavy neutral currents and consequent heating of neutral conductors and terminals.
 - ii. No temporary wiring exists anywhere in the building.
 - iii. There is no joint in cords connecting the window air conditioner units / voltage regulators / office equipments like photocopier, PC etc.
 - iv. No bare wiring exists over the flooring without mechanical protection by a metallic conduit / channel.
 - v. There is no misuse of socket outlets, such as connecting power load to light socket, connection of multiple loads to one socket, use of heaters in record room,

library etc. In such cases of additional demand of outlets, these should be provided early, after taking approval of the competent authority.

- vi. The shafts / spaces for electrical services are not misused, for storage or for dumping rubbish.
 - vii. The spaces in front of DB and sockets are free (without any storage of files / papers etc.)
 - viii. No additions / alterations are done by the users to the electrical installations by themselves.
- h) A record of loading up to DB level (in each phase in case of 3-phase DB) should be maintained, after measurements using a clip on ammeter. Such measurements should be done, as far as possible during peak season (summer or winter), when the loads are likely to be the highest.
- i) The pf should be maintained above 0.98 or near to unity. Examine the adequacy of the capacitors (if any) accordingly. Note down from the electricity bills, details of maximum demand, energy and pf to examine the trend of loading, penal charges, if any etc. (even if the bills are 115 directly paid by the user) review of contract demand, strengthening of system, pf correction requirements etc. should be done with this review.
- j) While cleaning fittings and fans, the fixing / suspending arrangements should also be checked and attended to as necessary. Care should be taken that the alignment is not disturbed.
- k) In the case of ceiling fans, remove the blades, and wash the same with detergent, without causing any deformation of blade angle. Check the shackle and replace if damaged. Check that down rod is fully screwed up to the last thread on both ends and that thread are not loose. If so required, replace with new down rod of the same size, thickness and length of threading (not less than 20 mm). Check split pins and replace if any strain deformation or damage is observed. If any other system of suspension had been adopted, check the soundness of the same and tighten as necessary. Fix fan blades tightly to the body. Operate the fan at different speeds; the run should be without wobbling / noise. As per specifications, lubrication needs to be done as necessary. In such cases, the fan needs to bring down, after removing the blades. The old grease should be replaced with a fresh one, after cleaning the bearing. If damaged, the bearing should be replaced. When reinstalling the fan, the suspension bolts should be well tightened.
- l) Insulation test should be done during monsoon season. Earth continuity test and earth electrode resistance test should be conducted during summer season. Record the test results giving identification references. If results are not satisfactory in any part of the installation, reasons should be checked and corrective action be taken immediately.

PREVENTIVE MAINTENANCE

1. Cleanliness is the mother of preventive maintenance. Keep areas clean.
2. Have schematic diagram for each installation.
3. No loose wiring.
4. No overloading.
5. Preventive maintenance of switchboards, DB every six months.
6. For multi-storied building go for fuse less switchgear like ACB, MCCB and MCB, as a precaution against fire on account of short circuit.
7. Prepare preventive maintenance schedule for each installation.
8. Proper manning / supervision of installation.
9. Maintenance of logs records and history sheet of events and breakdowns.
Ensure working of all measuring and indicating instruments.
10. Take safety measures.
11. Annual inspection to ensure system adequacy, safety, efficiency and take remedial measures.
12. Replacement of old / outlived equipments.
13. Six monthly survey reports of dismantled materials.
14. Display important telephone numbers.
15. Entrust repairs and maintenance to only skilled personnel and firms.
16. No short cut to problem like patchy repairs.
17. Compound Lighting: Annual painting poles. 3 monthly cleaning of fittings. Weekly check of working of all fittings. This ensures a bright and safe premises during night.
18. For proper maintenance of electrical installations, the following items of work shall be carried out regularly as per periodicity stated below and a proper record of such works shall be maintained.
 - (a) Earth testing - Once in a year
 - (b) Insulation test - Once in a year
 - (c) Cleaning of E.I.
 - (i) Residential Buildings - Once in a year
 - (ii) Non-residential Buildings - Once in a year
 - (d) Painting of E.I.
 - (i) Residential Buildings - Once in 3 years
 - (ii) Office Buildings - Once in 2 years
 - (iii) Important public buildings - Once in a year
 - (iv) Spray painting of ceiling fans - Once in 5 years
 - (e) Painting of outdoor metallic items like MS poles, feeder pillars etc. - Once in a year
 - (f) Oiling and greasing of fans - As & when required
 - (g) Checking of regulators, replacement of carbon brushes etc., when required - Once in a year
 - (h) Polarity test - Once in 5 years

WATER PUMPS

TYPE OF PUMPS

The pump is a mechanism by which a liquid or vapour can be compressed from the lower pressure level to a higher-pressure level. The water pumps compress water from lower pressure head to higher pressure. Normally this pressure head is converted into velocity head and liquid is lifted from lower level to higher level. The pressure on the liquid can be generated in various ways. On the basis of the method of the compression, the water pumps can be divided into the following categories. They can be further divided into various categories on the basis of design of compression mechanism, the usage etc. as described below: -

1.1 ROTODYNAMIC PUMPS: -

All pumps where centrifugal force is used to create pressure fall under this category of the pumps such as ordinary centrifugal pumps, ejecto pumps, turbine pumps etc. In this system, force is applied on the liquid by rotational movement of all elements called impeller.

1.2 POSITIVE DISPLACEMENT PUMPS: -

In this type of pumps the pressure is created by compression through Positive displacement of an element called piston / Ram / Plunger.

The positive displacement pump can be further subdivided into two categories
-

(A) RECIPROCATING PUMPS

(B) ROTORY PUMPS

These pumps can be further divided into various types keeping in view their design and application.

CENTRIFUGAL PUMPS: - (Surface)

In this type of pump pressure on water column in the discharge pipe is created by centrifugal force by circular motion of the impeller. This pump can work both with suction head and suction lift. Means if the level of the water supply source is above the centre line of the impeller it is called suction head and if the level of the water supply source is lower it is called suction lift.

An ordinary centrifugal pump where the impeller is above the water supply source can work satisfactorily up to a level difference of 25 –26 feet. Means it can lift water from a depth of 25 –26 feet, considering friction loss in the suction pipe, vapour pressure etc.

But discharge can vary from model to model. If we require higher head for discharge, we shall have to select a multistage pump. Discharge head also varies with R.P.M. and H.P. of the driving motor. But lower quantity of water and higher head require multi-stage pump. **Multistage pump means, there will be more than one impeller fitted on the same shaft.**

In the multistage pumps, first impeller from the suction port compresses water to the second impeller, which in turn compresses water to the third impeller and so on. So total discharge pressure increases and higher pressure is obtained at the discharge side of the pump. So we can divide the centrifugal pumps in respect of number of impellers into single stage and multistage categories. It should be noted that the multistage pump increases the discharge head but the suction

lift or head is not affected by increasing the number of stages. But to achieve higher head more power is to be injected to the pump to produce higher pressure at the discharge side.

Following points may be concluded.

Particulars	Single stage	Multistage
(I) Keeping H.P. same	More discharge of water, Less discharge head, Suction lift unchanged	Less discharge of water, More discharge head, Suction lift unchanged
(II) For same discharge of water	Less H.P. is required	More H.P. is required

These pumps are suitable for surface installation and where the source of water is within 25 ' to 26 ' lower than the pump. If the water source is beyond that level, these pumps are not suitable, because water column will not be available to the impeller of the pump. We can define these pumps as Surface Centrifugal Pumps.

Here the point of application of power remains on the surface.

The impeller of these pumps may be made of cast iron, gunmetal and stain less steel. On the basis of transmission of power to the pump impeller the ordinary centrifugal pumps can be divided into the following categories.

1. MONOBLOCK PUMP: The electric motor and pump belongs to same framework. Electric rotor and impeller are fitted to the same shaft. Since there is no coupling, the loss in coupling is not there and there is no alignment problem. However this type pump is limited to smaller capacity only.

2. DIRECTLY COUPLED PUMP: In this type of coupling, both the motor shaft and pump shaft centre lines are in same axis. Different types of couplings may be used like flanged coupling, rubber coupling or flexible coupling. Since coupling is used, some power is lost in the coupling. Centre lines of both shafts should be in the same line and same plane. That is why expertise is required for alignment of the pump and motor. Both the pump and the motor are independent and facilitate individual repair or replacement. This type of pump set can be of any capacity.

3. INDIRECT COUPLED PUMP SET: In this pump set, the power is extended to the pump through belt or through gear mechanism.

In mono block and directly coupled pump sets, the R.P.M. of the motor and the pump is same. But in indirect coupled pump sets the R.P.M. of the motor and pump may be same or different on the basis of the pulleys of the pump and motor.

In the indirect coupled pump sets there will be more power loss in the coupling.

SUBMERSIBLE PUMP (CENTRIFUGAL): We have discussed the centrifugal pumps, which are suitable for surface installation and has limitation in suction lift. Keeping in view this limitation a specially designed centrifugal pump immersed in the water source itself where the point of application of power is also transferred into liquid itself through power cables. This type of pump is called Submersible pump.

Normally it is multistage centrifugal pump directly coupled with the motor shaft.

The driving motor along with the pump are immersed into water. Normally this type of pump is used in the bore well. However it can be used in the well, pond etc. The cable used for transferring the power is special cable. It is flexible copper cable – two cores or three cores. Commercially it is called submersible cable. Since the complete pump set is immersed in water, **no suction pipe or foot valve is required.** Since pump has only discharge line and has multistage pump, it can be put into the greater depth and the shortcomings of the ordinary centrifugal pump are overcome.

It is easy to install and maintain. Its efficiency is also very high. During running the pump must be immersed in the water. So before designing the yield data of the bore well, water level and draw down must be obtained. **The pump should never be run in dry condition. To prevent the motor running dry condition a water level guard is provided.**

As soon as the draw down water level falls below the pump motor level, the water level guard disconnects the motor from the circuits by operating the normally closed contact provided in the control panel. Some times water pressure gauge also can be provided in the discharge line of the pump. By observing the pressure it can be said whether the pump is running dry or not.

DEEP WELL TURBINE PUMPS: - It has been seen that at N.T.P. condition a surface installed centrifugal pump set can draw water from the maximum depth of 25 – 26 feet considering the various losses in the suction pipes etc. Sometimes we are to draw water from the greater depth. Such place surface installed centrifugal pump does not work. For this purpose a different type of pump called deep well turbine pump can be used. In this pump pressure on water column is generated by the centrifugal force. That is why this pump also belongs to centrifugal category.

Here the deep well pump is put into the water and electric motor remains on the surface. The power is transmitted to the pump through a vertical shaft. That is why the electric motor is placed just on the top of the bore well and in vertical position. The impeller of the pump is fitted on the same shaft. The pump can be single stage or multistage like submersible pump. Since power is transmitted through a long shaft, alignment problems are there. However supports are provided for the shaft in the casing pipe or bore well pipe. This pump can be used where water requirement is more.

EJECTO PUMP: - It has been seen that the centrifugal pump installed above the level of the source of supply can work up to a limited suction lift, where atmospheric pressure push up the liquid column through the suction pipe. The maximum velocity head can be attained is 25' – 26'. Beyond this depth other types of pumps are to be used. Ejecto pump is one of those pumps, which can lift water from more depth than 25'-26'. We have studied submersible pump and deep well turbine pump which are capable to lift the water from greater depth, where pump is put into the liquid and power is extended to the pump through the cable or metallic shaft. But in the ejecto pump the impeller is not put into the liquid. Hydraulic pressure is created into the bottom of the well and this pressure is converted into the velocity head by a mechanism called Ejector. The construction and working of the ejector and ejecto pump are discussed here after.

EJECTOR: - An ejecto pump is installed above the level of the source of water; but the ejector assembly is immersed in the water. From the pump two pipes are extended to the ejector. One is the pressure pipe and the other is delivery pipe. Both are connected to the ejector. The ejector pump compresses the water through the pressure pipe to the ejector. The end of the pressure pipe is converged into a nozzle producing very high pressure. Due to this

pressure when water comes out from the mouth of the nozzle, the pressure head is converted into velocity head forming a jet.

This high velocity water column creates vacuum in the surrounding area of the nozzle, where pressure drops below the atmospheric pressure. It causes the opening of the foot valve and to fill that vacuum place around the nozzle water comes in. This water mixes with the water jet coming out of the nozzle and enters to the venturi. The venturi has cylindrical shape with upper portion wider than lower portion i.e. mouth. This divergent design of the venturi converts the velocity head of water column coming out of the nozzle into the pressure head and the water column is pushed up to the level of suction lift of the pump through the delivery pipe.

EJECTO PUMP SET

The ejecto pump is installed above the level of the source of water. Energy is supplied to the pump set. A portion of this energy is supplied to the ejector through pressure pipe. The pump is designed specially for this purpose. It has two casings, one of which is diffuser casings positioned inside the outer casing and producing necessary pressure for the ejector. The pump has three outlets.

Two outlets are used for the ejector and the third is used for discharge of water.

The discharge pipe is provided with pressure regulatory valve. It is used for the regulating the pressure in the pressure pipe to generate correct pressure at the nozzle of the ejector. Otherwise ejector will fail to push up the water column through the delivery pipe within suction lift limit.

The ejecto pump and ejector must match each other keeping in the view the various parameters of the nozzle, venturi, pipe sizes etc. The operation of the ejecto pump can be made automatic. Ejecto pump can be further classified as under

(I) Shallow well ejecto pump

(II) Deep well ejecto pump

1. Shallow well Ejecto pump: - It is used in the shallow well. In this pump the ejector assembly is located in the pump itself and can draw water from maximum depth of 28 feet.

2. Deep well Ejecto pump: - The deep well ejecto pump can easily draw water from a depth of 200 feet. A specially designed pump can draw water from a depth of even 300 feet.

RECIPROCATING PUMP: -

The reciprocating pump comes under the group of positive displacement pump category. Here forward and backward movement of an element is used to compress water in a chamber to build up pressure instead of circular motion of impeller in a centrifugal pump.

When the piston moves upward, suction valves open and water comes in the cylinder and discharge valve remains closed. When the piston moves downwards the suction valve closes and discharge valve opens pushing water in the discharge line. The above-mentioned pump has single piston. That is why it is called simplex and one complete cycle of motion gives only one compression-stroke in the discharge line; that is why it is called single acting. This can be designed as simplex double acting. When the piston moves upwards the lower suction valves opens and water enters to the lower portion of the cylinder while the discharge valve of the upper portion opens and the water of the upper portion of the cylinder is pushed into the discharge line. At the same time the suction valve at the upper portion and discharge valve at the lower portion remains closed.

In the next stroke, means when the piston moves downwards the function of all the valves reverse; means the upper discharge valve and

lower suction valve remain closed and the upper suction valve opens allowing water to enter the upper portion of the cylinder and lower discharge valve opens allowing water from the lower portion of the cylinder to be pushed into the discharge line. So in the double acting pump in both the strokes water is sucked into the cylinder and water is discharged into the discharge line.

In the single acting reciprocating pump, one stroke is used for suction and another stroke is used for discharge. In double acting pump the performance is better than that of the single acting pump. As far as the movement of the piston is concerned, there may be two types of reciprocating pump – one is single acting and the other is double acting – In the same manner the number of piston also can be more than one.

So, on the basis of number of pistons, there can be single acting triplex, doubleacting triplex and so on.

The reciprocating pumps are capable of generating very high pressure and have very high efficiency. It can generate even a pressure up to 500 PSI at the discharge line. But its suction lift is similar to that of centrifugal pump i.e. up to a maximum 25'-26' considering the head loss in suction line and foot valve.

Some models are also called as Bulldozer pump keep in view its tardiness and heavy-duty performances.

Rotary pump: -

This pump works on the principle of circular motion of piston or van, one inside the other. In this pump, a roller a rotor on an eccentric shaft rotates in a cylinder. Due to the eccentric rotation of the rotor the van or rotor moves up and down in the slot. When the rotor moves to the upper position the water in the cylinder gets compressed and forced out to the discharge line. A spring-loaded van has been provided in the upper portion of the cylinder and works as a partition between the discharge line and suction line. Due to the eccentric rotation when the radius of the rotor increases to the maximum at the discharge port and then it passes through the spring loaded van and then to the intake port of the suction line and the gap between the cylinder and the rotor increases slowly and creating vacuum and thus provide suction lift.

In the similar manner rotary van type is also available. Rotary gear pump is also available; where two gears are aligned in such a manner that water is sucked and discharge due to their circular motion.

PUMPS – SPECIFICATIONS AND SELECTING THE CAPACITY

TERMINOLOGIES

HEAD

Normally the meaning of head in pumps is the vertical distance of the source of water to the place of delivery. Actually head bears a lot of implications, which are discussed here. It refers to both stationary and dynamic status of liquid.

STATIC HEAD: - It is vertical distance through which liquid is to be lifted when the liquid is in static condition. Static head again can be divided into three groups

(a) Static Discharge Head: - It is the vertical distance of overhead tankwater level to the centerline of the impeller of the pump.

(b) Static Suction Lift: - It is the vertical distance between the water level of the source of supply to the centerline of the impeller where the source of water is below the centerline of the pump impeller. Some times it is called suction head also.

(c) Static Suction Head: - It is the vertical distance between the center line of the pump impeller to the top level of the water source when it is above the center line of the pump.

TOTAL STATIC HEAD: - This is the vertical distance between the source of supply liquid level to the discharge liquid level. If the source of supply is below the impeller of the pump, Then

Total static head = static discharge head + static suction(lift) head

If the source of the water is above the impeller of the pump, then

Total Static Head = static discharge head - static suction head

FRICTION LOSSES: - When a liquid flows through a cylinder or a pipe, the outer laminations of the liquid column rubs with the inner surface of the cylinder or the pipe slowing down the velocity of the liquid. This is the friction loss in the cylinder or pipe in the same manner there are friction losses in the bends, elbows, valves etc. due to design and performance. These losses are also different for the different diameters of the pipes. The friction loss can be referred as head loss due to friction

DYNAMIC HEAD: -

(a) Total Suction Lift (Dynamic Lift): -

It is the sum of static suction lift and friction losses in pipe and fittings including foot valve etc. when the liquid is in motion. So the atmospheric pressure of 1.033 Kg/sq cm or 14.7 lbs / sq inch must overcome the gravity of the water column plus the friction forces.

(b) Total Suction Head: -

It is the static suction head minus the frictional head loss in the suction pipe and fittings when the liquid is in motion. The difference between the total suction lift and total suction head is that, in case of total suction lift friction losses are added; while in case of total suction head losses are deducted from the static suction head.

(c) Total Discharge Head: -

It is the sum of static discharge head, friction losses in the discharge line and velocity head. Since velocity head is negligible in comparison of other losses, we don't consider the velocity head.

$$h = \frac{V^2}{2g}$$

(d) Velocity Head: - It is the head required to create the velocity of the flow of liquid. It is the height through which when liquid falls it will attain that velocity .It is given by formula:

Where h = height through which liquid falls

V = velocity is attained

g = acceleration due to gravity

TOTAL DYNAMIC HEAD: -

It is the sum of total suction lift plus discharge head if the required level of supply source is below the centerline of the pump impeller. If the supply source is above the centerline of the impeller the total dynamic head is the total discharge head minus the total suction head.

PRESSURE HEAD: -

We have studied that the source of supply of liquid is subjected to atmospheric pressure and the liquid is also delivered to an open tank where the surface of the liquid is also subjected to atmospheric pressure. Means suction and discharge heads are open to atmospheric pressure.

However, sometimes it may happen that the supply source of the liquid is under the positive pressure and the liquid is discharged to a closed chamber having a positive pressure. Under these circumstances the following head are obtained.

(a) Static suction head = Height of the liquid column + pressure in the chamber.

(b) Total suction head = static suction head – friction losses

(c) Static discharge head = Height of the liquid column + pressure in the chamber

(d) Total discharge head = Static discharge head + friction losses

(e) Total Static head = Static discharge head - static suction head

(f) Total dynamic head = Total discharge head – Total suction head

2. VELOCITY, FRICTION LOSS AND QUANTITY OF LIQUID

We have studied that friction loss in the cylinder or the pipe is caused due to velocity of liquid. If the velocity is zero, the friction loss in the system will also be zero. Friction loss increases with the increase of the velocity. It means friction loss is directly proportional to the velocity.

The quantity of liquid discharged by the pump is affected by the velocity and diameter of the pipe.

If both the cross section of the pipe and velocity of water column change, the discharge of water will be directly proportional to the product of the cross section and velocity.

Conclusion: -

(a) Water discharge / unit time = cross section of the pipe x velocity

Or cross section of the pipe = $\frac{\text{water discharge}}{\text{Velocity}}$

(b) Water discharge $\propto$ cross section of the pipe

(c) Water discharge $\propto$ velocity

(d) Water discharge $\propto$ cross section of the pipe x velocity

FRICTION LOSS

We have studied that when the liquid has no motion in the pumping system, there is no friction loss. But the motion or velocity causes the friction loss in the different portion of the pumping system. Following items of the pumping system causes the friction loss: -

- 1) Foot valve
- 2) Non return valve
- 3) Strainer
- 4) Gate valve
- 5) Strain valve
- 6) Bend
- 7) Elbow etc. and
- 8) Pipes

All these items cause friction loss. But quantum, of loss of each item is different from other. The following points affect the quantum of friction loss.

- 1) Pipe & pipe fittings
- 2) Type of the material of the pipe
- 3) Smoothness of inner surface of the Pipe
- 4) Velocity of the pipe
- 5) Viscosity
- 6) Temperature of the pipe

1. PIPE AND PIPE FITTINGS: -

When the liquid moves through a pipe, the outer surface rubs with the inner surface of the pipe and causes friction loss. The quantum of the friction loss is directly proportional to the velocity or the quantity of liquid passing during unit time. Pipe fittings such as elbows, bends valves etc. cause reasonable friction loss. This is expressed in equivalent length of straight pipe i.e. the length of straight pipe, which would cause the same friction loss what actually caused, by that fitting.

2. Type of Material of Pipe: -

Different materials of the pipe cause different amounts of loss.

3. Smoothness of Inner Surface: -

Smoothness of the inner surface also affects the amount of friction loss when the pipe is new it offers the least friction loss. More and more pipe becomes old the friction loss increases.

4. Velocity of the Liquid: -

With the increase or decrease of velocity of the liquid the friction loss increases or decreases. Keeping the diameter of the pipe constant the quantity of liquid discharged varies with change of velocity. So friction loss can be referred to the quantity of the liquid delivered.

5. Viscosity: -

It is the property of the liquid, which is also responsible for the quantity of friction loss. Since we deal with only water, viscosity may be taken as unity.

PUMP HEAD AND CAPACITY

Pump head means total dynamic head. It includes the total static head i/c the pressure head plus the friction loss in piping system.

Total pump head = Total static head + friction loss

Total static head = Vertical distance between the level of water at suction source and discharge.

Friction loss = All friction in piping system

$$\text{HP of the Pump} = \frac{Q \times H \text{ (In FPS Unit)}}{33000 \times E}$$

Where Q = Discharge in Pounds/ minutes.

H = Total head in feet.

E = Efficiency of the pump

We can calculate the H.P of the pump in other formula using S.I. units.

$$\text{HP} = \frac{Q \times H}{75 \times E}$$

Where Q = Discharge in liters / sec

H = Total head in meters

E = Efficiency of the pump set

EFFICIENCY

The efficiency of any system whether man or machinery, it refers to the quality of performance of that system. Technically it may be called as the relation between the input and output of power of that system or it is

the ratio of output and input. Let us take a electrical motors. Its input powers is 10 HP and its out put power, called Brake Horse Power is 8 HP. So the efficiency is $(8 \times 100) / 10 = 80 \%$.It means that out of 10 HP input power 2 HP is lost in the motor itself and remaining 8 HP is available at the shaft of the motor. In pump system the following components are involved.

- 1) Driving Mechanism – Electric motor or an engine
- 2) Pump section – Comprising coupling, impeller etc.
- 3) Piping system –

All these items cause some kind of friction loss resulting decrease in net output

(A)Efficiency of the driving mechanism :-

A pump can be driven by a electric motor or an engine. Some of the power taken by the driving mechanism will be consumed by itself and the remaining power is available at the shaft, which is called Brake Horse Power (BHP) .

$$\text{So the efficiency of the driving mechanism (\%)} = \frac{\text{BHP} \times 100}{\text{HP}}$$

(B) Efficiency of the pump :-

It is the power delivered by the pump in the form of WHP divided by the power input to the shaft of the pump by the driver i /c the power loss due to coupling.

$$\text{So it can be written as } \frac{\text{WHP} \times 100}{\text{-----}}$$

BHP

(C) Piping Efficiency:-

We know that when water is flowing through the pipes there will be friction loss. Whatever would have been the total pump head in ideal condition, due to friction loss in piping, the head of discharge will be less. So the net work done is the product of the quantity of the water discharged and actual distance through which it is lifted. So work done per unit time is the product of water discharged per unit time and total static head. Water horse power is the output of the pump which is the sum of power loss due to friction and net work done or it is the product of total pump head and the quantity of water discharged in the unit time.

(D) Pump Set Efficiency (%): -

It is the ratio of the output of the pump to the input to the driver, or

(E) Total System Efficiency (%): -

It is the ratio of net work done per unit time and power input to the driver

It is the product of all efficiencies described above

Cavitation

Cavitation is a damaging condition that erodes pump impellers, shortening their operating lives and accelerating the wear rate of bearings and seals in the process. Cavitation occurs when the fluid's static pressure at a given flow rate falls below the fluid's vapor pressure at a certain temperature. In centrifugal pumps, the acceleration of fluid into the impeller causes the fluid pressure to drop. If this pressure drop is sufficient, the liquid vaporizes, forming tiny bubbles that are unstable and prone to violent collapse. The

most important effects of sustained cavitation are reductions in pump performance and erosion of the pump impeller. Cavitation degrades pump performance because the vapor in the pump restricts flow and lowers the generated head.

Net Positive Suction Head

To prevent cavitation, centrifugal pumps must operate with a certain amount of pressure at the inlet. This pressure is defined as the *net positive suction head* (NPSH). There are two principal references to NPSH:

- (1) the available system pressure (NPSHA) at the inlet, which is a function of the system and the flow rate, and
- (2) the required pressure (NPSHR), which is a function of the pump and the flow rate. NPSHR is typically included on pump performance curves. If the NPSHA is sufficiently above the NPSHR, then the pump should not cavitate.

For satisfactory operation, the NPSHA margin over NPSHR must be provided by the system. A common rule in system design is to ensure that NPSHA is 25% higher than NPSHR for all expected flow rates.

Fire Detection System

Introduction:

The industries or telecom installation with high concentration of cables and electronics switching equipment within relatively small areas constitute a high risk of heat and fire. To prevent the extremely expensive electronics from fire damage, fire prevention is one of the prime importance in the industries.

Definition:

Fire resistance is a property of a building to withstand, resist flame penetration and resistance to temperature rise on the unexposed side/face.

An automatic fire detection and alarm system may consists of the following:

- Fire detectors
- Sounders
- Control Panels
- Additional Accessories.

The installed systems must detect an outbreak of fire without manual intervention and alert the occupants of the building through a siren (Audio/Visual).

The fire protection is scaled in terms of FAR (Floor Area Ratio).

Fire protection

Fire protection measures in a building can be classified in two parts:

→ PASSIVE FIRE PROTECTION

Passive fire protection measures are those which are adopted at the planning stage of building or facility such as:

1. Provision of adequate fire resistance of the structure.
2. Provision of proper FAR, open spaces, supply etc.
3. Provision of adequate access sufficient and readily available water to for fire brigade,

→ ACTIVE FIRE PROTECTION MEASURES

Active fire protection measures are those which operate (manual/Automatic) in the event of outbreak of fire such as

1. Provision of suitable and adequate Fire detection system with audio visual alarm.
2. Wet riser & fire Extinguisher.

PASSIVE FIRE PROTECTION MEASURES

Telephone exchange buildings have been classified as E4 business buildings in the Code India". As such building Materials suitable retardant ability as mentioned therein shall only be provided.

The features of passive fire protection:

1. The panels of partitions shall be of fire retarding Material having metallic frame. The thickness of glass in glazed partitions shall be of min 5.5 mm.
2. All furniture in technical rooms shall be of steel. **Plastic or wooden furniture should not be used.**
3. Jute matting shall not be permitted for floor covering in telephone exchange.
4. **Compulsory open spaces around the building (i.e.4.5 meter) shall be provided and shall not be used for parking. The minimum radius at the tunings shall not be less than 9 meter. The width of entry shall not be less than 5 meter (clear).**
5. Openings in wall and floors shall be sealed by compressed asbestos fiber mixed with cement or vermiculite concrete or any other filler material having a fire resistance of 2 hrs.
6. The electronic switch room, OMC shall be separated from other areas by walls having a minimum fire resistance of **2 hrs.**
7. Entry doors of lifts, lobby, corridors, staircase lobby, should have at least 1 Hour fire resistance.
8. Escape routes shall be marked clearly with red arrows and should be free from all obstructions.
9. Provision of Emergency lights in corridors, staircase lobbies, etc. as well as in rooms.
10. Provision of inter communication or any other suitable communication system in lift car connected with reception/control room.

11. No articles cotton wastes etc. should be stored the back of switch boards.
12. Temporary wiring or extension circuits shall not ordinarily permitted. Extension circuits/temporary wiring shall be installed under the supervision of officer in charge of Electrical maintenance.
13. Cable trenches inside substation shall be filled with pebbles or sand, and covered with reinforced concrete slabs or steel plates.
14. It is absolutely essential to ensure that fuse wire of connect rating only, are used in distribution system,
15. Wherever fire lifts are installed, the words "FIRE LIFT" should be conspicuously displayed.

AUTOMATIC FIRE DETECTION SYSTEM

Every building above 15m and all exchanges which are 1K and above shall be provided with an automatic fire detection system in addition to manual fire alarm system.

The detectors shall be of rate of rise type and smoke type. Wherever smoke detectors provided, a mixture of Photoelectric and Ionization type will be used.

A control indication panel to which detection be installed in the fire circuits in all the zones are connected, floor of control room or in the main entrance lobby on the ground the fire the building. Light indications on the panels shall be able the fire to identify at the fire site.

The alarm system shall provide both alert system and evacuation alarm with different distinctive tones.

The alarm system shall have a battery backup so that in case of mains failure, the backup batteries take over and feed the power to the system.

A telephone shall be provided in the equipment room to all Telecom buildings for direct communication with the fire brigade. One of the extensions of the tele line shall also be available at the ground floor or at the reception. The fire telephone shall be tested daily.

FIRE FIGHTING SYSTEM

Sufficient number of fire Extinguishers (portable type) shall be brought or kept in shelves or mounted on wheels at conspicuous places (but not too close to the equipment). The operating instructions shall be clearly printed on the body of extinguishers.

Sufficient quantity of the fire extinguishers shall be stored.

Two water buckets and two sand buckets shall be provided at each floor.

All firefighting appliances shall be maintained in working condition.

For more details the latest "Fire protection manual" of the department can be referred.

To understand firefighting systems, one has to have an in-depth knowledge of fire itself and its types.

The National Fire Protection Association (NFPA) have standardized fire into four types.

→ CLASS A

Fire in ordinary combustible materials(Wood, cloth, paper, etc.) Extinguished using water or foam.

→CLASS-B

Fire in inflammable liquids, gasses etc. Extinguished using foam, CO2, dry powder.

→ CLASS C

Fire in live electrical equipment. Extinguished using CO2 and Halon.

→ CLASS D

Fire in reactive metals (Magnesium, Sodium, Potassium, etc.) Extinguished using special dry chemical powder.

Wet Riser System

A charged vertical water main inside a building connected to a water main or an automatic stationary pump and fitted with internal hydrants, landing valves and hose reels for tapping water at various floors.

→DOWN COMER

A wet riser fed from an overhead tank installed on the terrace of the building.

→DRY RISER

A vertical water main inside a building, not normally connected to a water main or an automatic stationary pump, with an inlet at street level, through which water can be pumped by fire service pumps to hydrants outlets or hose reels at various floors.

→JOCKEY PUMP

A pump of small capacity which is set to come into operation, automatically with drop in static pressure in the system and to automatically stop when the preset value of pressure is obtained again.

→FIRE PUMP

An electric /diesel pump at static water tank to charge the wet riser system.

→STANDBY PUMP

A pump of same capacity as fire pump, driven by a diesel engine or connected to another alternate source of electric supply.

→LANDING VALVE

An assembly comprising valve(s) and outlet (s) connection from a riser system.

→HOSE REEL

Firefighting equipment, consisting of length or tubing fitted with a shutoff nozzle and connected to a reel with a permanent connection to a pressurized water supply.

→AIR RELEASE VALVE

A device by which the trapped air inside a riser main is expelled by water as the system is being charged.

→PRESSURE SWITCH

A switch connected on delivery line fire pump at preset pressure so designed to automatically start the fire or jockey pump, as the case may be, as the pressure in the system falls below the preset value.

All high rise buildings shall be provided with riser system as per local fire laws, in case there fire buildings above 15m in height shall be protected by a wet riser system. A wet riser is an arrangement for firefighting within the building by means of vertical rising mains not less than 100m.m. internal dia. With hydrant outlets and hose reels on each floor landing connected to a water tank with a water pump and an overhead tank. The size and No. of internal vertical & mains depends upon the height of building and floor area. A fire brigade inlet at ground level fitted with a non-return valve is also provided for charging the rising main with a fire brigade Pump in case of failure of fire Pump, Fire brigade inlet connection is also provided for the underground static water storage tank.

→COVERAGE OF WET RISER

For buildings above 15 meter in height, one wet riser for every 1000 sq. meter or part therefore of floor area shall be provided. The riser shall be fully charged with a minimum Pressure of 3kg/square cm. at the top most landing at all times and shall be automatic in operation. The hydrant shall be so located that it is not farther than 30 meter from any point in the area covered.

Wet Riser System Components

1. ELECTRICAL FIRE PUMP

The electric fire pump shall be suitable for automatic operation complete with necessary electric motor and automatic starting gear, suitable for operation on 415 volts 3 phase 50 Hz. A.C. system. Both the motor and the pump shall be assembled on a common bed plate, fabricated MS, channel type or cast iron type. The pump shall be only directly driven by means of a flexible coupling. Coupling guard shall also be provided.

→ FIRE PUMP

The fire pump shall be horizontal split casing centrifugal type. It shall have to deliver 1800/2400 rpm as specified, developing adequate head so as to ensure a minimum pressure of 3kg/ cm at the highest and farthest outlet. The delivery pressure at pump outlet shall be 7Kg/cm in any case.

The pump casing shall be of cast iron and parts like impeller, shaft sleeve, wearing ring etc. shall be of non-corrosive metal like bronze/brass or metal. The shaft shall be of stainless steel.

The pump shall be effectively sealed to prevent loss of lubricant or entry of dust or water.

→ MOTOR

The motor shall be squirrel cage AC induction type suitable for operation on 415 volts 3 phase 50 Hz system, The motor shall be totally fan cooled type conforming to protection class IP 21 vide IS4691. The class of insulation shall be type B. The synchronous speed shall be 1500/3000 RPM as specified. The motor shall be rated for continuous duty and shall have a horse Power rating necessary to drive the pump at 150 percent of its rated discharge with at least 65% rated head.

→MOTOR STARTER

The motor starter shall be automatic start delta type conforming to IS: 1822-1967 as amended up-to-date. The unit shall include suitable current transformer and ammeter of suitable range on one line to indicate the current. The starter shall not incorporate under voltage, no voltage trip, overload or SPP.

2. DIESEL FIRE PUMP

This is a standby fire pump operated by a diesel engine. The diesel pump set shall be suitable for automatic operation complete with necessary automatic starting gear for starting on wet battery system and shall be completed with all accessories. Both engine and pump shall be assembled on a common bed plate fabricated from mild steel channel type. The pump shall be only direct driven by means of a flexible coupling. Coupling guard shall also be provided. The speed shall be 1500/1800 RPM as specified.

SPECIFICATIONS

→ FIRE PUMP:

Same as electric fire pump.

→ Diesel Engine

The Engine shall be cold starting type without the necessity of preliminary heating of the engine cylinder or combustion chamber. The engine shall be multi cylinder/vertical 4 stroke cycle, water cooled diesel engine, developing suitable H.P. at operating speeds specified to drive the fire pump. The capacity shall be at least 20% greater than the required to drive the pump at its duty point. It shall also be capable of the rated discharge at 65% of rated head. The engine shall run for continuous hours and at least 3000 hours in any period. The engine shall have load capacity for one of 12 hours.

3. PIPING FOR WET RISER SYSTEM

The wet riser system piping shall comprise cast iron or galvanized iron pipe work as specified with and necessary C.I. or G.I fitting and accessories pipe shall be used in location where the pipes are buried under ground. Gl. pipes shall be used in other locations. The wet riser piping system shall remain pressurized at all times during operation and as such the piping work shall be out to with stand the same.

G.I. pipes and accessories and fittings shall be of heavy class conforming to IS1239 part I/1974 and part II/1979 as amended up-to-date, hot dip galvanized to grade-1. The pipe joints shall be flanged with smooth faced flanged.

G.I. pipes shall be of class B to IS 1537-1976 and fittings shall be of heavy to IS 1538-1976. The flanged shall be smooth faced.

4. AIR VESSEL AND RELEASE VALVE

Air vessel on top of each wet riser piping shall be fabricated of at least 10mm thick steel to with stand the pressure, with dished ends and supporting legs. This shall be of 450 mm diameter and 2m high. This shall be complete with necessary flame connection to the wet riser piping and air release valve with necessary piping to meet the functional requirement of the system. The air vessel shall be of continuous welded constructions and galvanized. This shall be tested for twice the working Pressure.

5. RING MAIN AND YARD HYDRANT

In the open compounds a ring main or tree main with suitable no. of yard hydrants shall also be provided so that **one hydrant is available at every 60 meter length of the building**. Each hydrant point shall be provided with a hose Box with 2 Nos 15 meter length hose pipes. The hydrant main shall be buried at a minimum depth of 1 meter, below ground level. Yard hydrant shall be of stand post type conforming to IS: 908. 1975 and stand post for single outlet flame riser and single headed brass/gunmetal valve.

6. HOSE REELS AND HOSE BOXES

Hose reels and hose boxes shall be installed on all floors of the buildings. The hose reels shall be connected to one of the female couplings of twin couplings of landing valves of the installation by means of an adapter. The hose boxes shall be provided with two 15 meter hoses. Length 63mm hose pipes with coupling and one branch pipe nozzle.

Hose pipes shall be rubber linen woven jacketed and 63mm in diameter. They shall conform to type-2 of IS 636-1979 as amended up-to-date. The hose shall be sufficiently flexible and capable of being rolled.