REFRESHER COURSE MATERIAL FOR POWER MAINTENANCE

(Based on Railway Board Module)

Issued by E.S.T.C. South Lalaguda, Secunderabad.

REFRESHER COURSE FOR SKILLED ARTISANS

(TECHNICIAN ELECTRICAL POWER MAINTENANCE)

Module No.	***Module Description***	**Days**
ELEC-1.1	Basic Knowledge about tools, safety, First aid, material handling& storage, proper up keep of work area.	1
ELEC-1.2	General Electrical technology and definitions of electrical terms.	1
ELEC-1.3	Reading of drawing, circuit diagrams.	1
ELEC-1.4	Basic properties of Electrical Materials.	1
ELEC- 1.5 & ELEC- 1.8	Names, sizes, location of major Electrical power supply equipments. (Sub-station, Transformers, Relays, contactors, Batteries, wiring, electric fittings, and Power line crossing, pumps , DG sets).	1
ELEC-1.6 & ELEC-1.9	Maintenance schedules, critical points, settings and tolerance of Major Equipments (Pumps, DG sets, power supply equipments, Maintenance of lifts).	1
ELEC - 1.7 & ELEC - 1.10	Testing, erection and commissioning of pumps, DG sets, power supply equipments, Laying and installations of Cables.	1
ELEC-1.14 & ELEC - 1.16	Power supply maintenance and Plant maintenance.	1
ELEC-1.15 & ELEC - 1.17	Case studies on failures on Power and Plant maintenance.	2
	Total	**12**

ELEC - 1.1

BASIC KNOWLEDGE ABOUT TOOLS, FIRST AID, SAFETY, MATERIAL HANDLING & STORAGE, PROPER UP KEEP OF WORK AREA

MODULE No. ELEC-1.1

Module Description: Basic knowledge about tools, safety, First aid, Material handling and storage, proper up keep of work area.

1. KNOWLEDGE ABOUT TOOLS:

Combination plier, Nose plier, side cutter, screw driver, Electrician's knife, test lamp, soldering iron, spanner, standard wire guage, crimping tools.

2. CARE AND MAINTENANCE OF TOOLS:

1. Do not use a plier as a hammer.
2. A screw driver with a loose handle should not be used.
3. Do not hammer the wooden handle of the screw driver.
4. For test lamp, give a knot of wires under the cap of the holder.
5. Electric iron must be properly connected to earth.
6. Flexible wire should be used in electric iron.
7. Spanner should not be loose on the nut and bolt.
8. Spanner should not be used as hammer.
9. Do not throw wire gauge with other tools in the tool kit. Protect from rust and dust.

3. FIRST AID BOX: Items contained in First aid box are:

- Set of splints. :One Set
- Roller Bandage : 10
- Triangular bandages : 4
- Tourniquet bandages :2
- Cotton Wool:4
- Safety Pins :10
- Adhesive Dressing : 20
- Paracetamol Tab :20
- Antiseptic Cream :1
- Diazepam Tab :10
- Injury Card:1

SAFETY PRECAUTIONS:

Do not forget that electric shocks are generally received by the worker and can be avoided.
Put off main switch immediately incase of a person in contact with a live conductor.
Apply artificial respiration quickly and call the doctor at once.
Connect a switch on live (+ve or phase) conductor only.
Do not use wires and tools having poor insulation.
Do not renew a blown fuse until it is satisfied as to its cause and have rectified the fault
Do not add water to acid while preparing an electrolyte always add acid to water.
Do not bring a naked flame near an accumulator.
Do not throw water on a live conductor or equipment in case of fire.
Use only carbon tetrachloride.
Use fire extinguishers on electrical fire.

Safety rules pertaining to Electrician

- Only qualified persons should do electrical work.
- Keep the workshop floor clean, and tools in good condition.
- Do not work on live circuits; if unavoidable, use rubber gloves, rubber mats, etc.
- Use wooden or PVC insulated handle screwdrivers when working on electrical circuits.
- Do not touch bare conductors.
- When soldering, arrange the hot soldering irons in their stand. Never lay switched 'ON' or heated soldering iron on a bench or table as it may cause a fire to breakout.
- Use only correct capacity fuses in the circuit. If the capacity is less it will blow out when other load is connected. If other capacity is large, it gives no protection and allows excess current to flow and endangers men and machines, resulting in loss of money.
- Replace or remove fuses only after switching off the circuit switches.
- Use extension cords with lamp guards to protect lamps against breakage and to avoid combustible material coming in contact with hot bulbs.
- Use accessories like sockets, plugs and switches and appliances only when they are in good condition and be sure they have the mark of BIS (ISI).
- Never extend electrical circuits by using temporary wiring.
- Stand on a wooden stool, or an insulated ladder while repairing live electrical circuits/appliances or replacing fused bulbs. In all the cases, it is always good to open the main switch and the make the circuit dead.
- Stand on rubber mats while working/operating switch panels, control gears etc.
- Position the ladder, on firm ground.
- While using a ladder, ask the helper to hold the ladder against any possible slipping.
- Always use safety belts while working on poles or high rise points.
- Never place your hands on any moving part of rotating machine and never work around moving shafts or pulleys of motor or generator with loose shirt sleeves or dangling neck ties.
- Only after identifying the procedure of operation, operate any machine or apparatus.
- Run cables or cords through wooden partitions or floor after inserting insulating porcelain tubes.
- Connections in the electrical apparatus should be tight. Loosely connected cables will heat up and end in fire hazards.
- Use always earth connection for all electrical appliances along with 3-pin sockets and plugs.
- While working on dead circuits remove the fuse grips; keep them under safe custody and also display 'Men on line' board on the switchboard.
- Do not meddle with interlocks of machines/switch gears.
- Do not connect earthing to the water pipe lines.
- Do not use water on electrical equipment.
- Discharge static voltage in HV lines/equipment and capacitors before working on them.

FIRE

Fire is the burning of combustible material. Fire is the combination of Material, Temperature and Oxygen. When the above three substances comes into contact in sufficient quantity, combustion takes place followed by flame and smoke which is called Fire.

S. No	Type of Fire	Description	Fire extinguisher to be used
1	A Type	General fire such as solid materials, cotton, wood, etc	Soda ash cartridges, water buckets, chemical foam, Halon gasses etc
2	B Type	Oil fires such as Liquid materials, oil, grease etc.	Chemical foam, Dry powder, carbon dioxide Halon gas
3	C Type	Chemical fires such as fires in gasses	Dry chemical powder, carbon dioxide, Halon gas
4	D Type	Electrical fires such as metallic, electrical etc	Halon gas, Dry chemical powder, carbon dioxide

Electrical fire occurs in coaching stock due to: Short circuit, Over loading of system, Loose joints/connections, Earth leakage, Using of inadequate capacity wires/ cables, Brining naked flames near the battery/cables, Leakage of gases, using over sized fuses.

Preventive measures to be taken to avoid Fire accidents in workshop:

- Use electrical equipments of approved design and from reputed manufacturer.
- They are to be installed properly, by experienced staff who are fully aware of their responsibilities and conversant with the statutory rules like IE rules and regulations for safe working on electric equipments.
- The electrical equipment has to be maintained properly by carryings out periodical inspections and tests to ensure that the equipment is safe.
- The equipment has to be used carefully, taking normal precautions .
- The place of working should be dry and free from inflammable items.
- Proper earthing of the equipments is to be done.
- Loose connections and shortcut methods are to be avoided. Hanging wires and bare wires should not be allowed.

Action to be taken when a fire occurs in a passenger coaches:

- Isolate the coach electrically
- Electrically switch off the load
- Removal of the battery fuse
- Removal of alternator belt
- Extinguish the fire with CTC/CO2 type fire extinguishers

Action to be taken when fire occurs in a HT Sub-Station:

- First isolate the substation.
- Switch off all the equipments.
- Use the fire extinguishers available in substation for extinguishing the fire

- Send the information to the nearest fire station
- Inform to the higher official
- Clear the combustible material if any near the vicinity of the fire

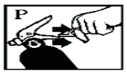
USING A FIRE EXTINGUISHER

Learn about extinguisher operation before you need the extinguisher. They are very simple to use, but practice can prevent a disaster.

Remember: Pull-**A**im-**S**queeze-**S**weep

Extinguisher Operation

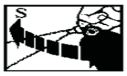
Although extinguishers vary in size, color, and type of extinguishing agent, the vast majority of devices operate basically the same way. Stand six to eight feet from the fire with your back to an unblocked exit. If the fire is small and heavy smoke is NOT present and you have an exit available to you for evacuation purposes, grab the nearest appropriate extinguisher and operate the following P-A-S-S procedure (This technique is published by the National Fire Protection Association (NFPA).



P – Pull the pin located in the extinguisher's handle (twist to break the seal).

A – Aim the nozzle, horn or hose at the base of the fire.

S – Squeeze or press the handle.



S – Sweep from side to side at the base of the fire until it is out.

Extinguisher Tips

- Always place yourself between the exit and the fire so that you can escape if the fire does not go out.
- Familiarize yourself with the location and operating instructions of your extinguishers.

Remember

- Never place yourself or others in jeopardy by attempting to extinguish a fire. If you cannot extinguish a small fire with a portable fire extinguisher, or if the smoke becomes hazardous, leave the area. Close the door to confine and contain the fire. Activate the fire alarm and wait outside for the firefighters to arrive.

ELEC - 1.2

GENERAL ELECTRICAL TECHNOLOGY AND DEFINITIONS OF ELECTRICAL TERMS

MODULE No.ELEC-1.2

Module Description: General Electrical Technology and definitions of electrical Terms.

1. Electricity:
Electricity is a sort of energy, which can neither be seen nor touched, but its presence can be experiences in its applications.

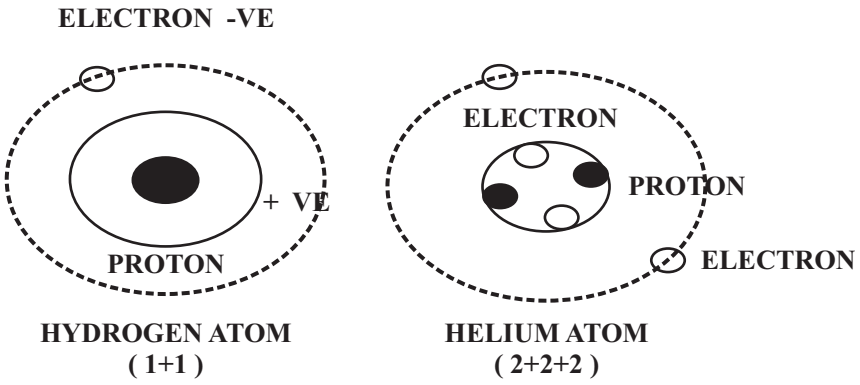
Electricity is of two kinds: 1. Static Electricity 2. Dynamic Electricity.

Static electricity is produced by friction and can not be taken from one place to another.

Dynamic electricity is also known as current electricity and can easily be taken from generating stations to far off places by means of wires and cables.

1. Matter Molecule, Atom and Atomic Structure:

a. **Matter:** A body which has a definite weight and which occupies some space is called the matter. It is found in three states solid, liquid and gas.
b. **Molecules:** Matter can be divided into tiny particles. The smallest particle, which contains all the physical and chemical properties of the matter, is called molecule.
c. **Atom:** Molecules can be further subdivided into atoms. The smallest particle of a matter, which can take part in chemical reactions but can not exist freely, is called an atom. An atom does not contain all the physical and chemical properties of the matter. The atom is composed of electrons, Protons and Neutrons.
d. **Electron:** The smallest part of an atom having negative charge is called 'electron'.
e. **Proton:** The positively charged particle of an atom is called proton.
f. **Neutron:** It has no charge and its mass is nearly equal to the mass of a proton.
g. **Nucleus:** The central part of an atom is called the nucleus. It has proton and neutrons.



1. Specific Resistance of a Conductor:

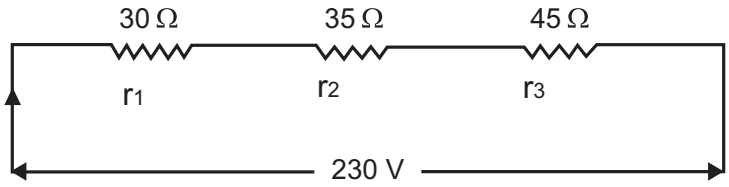
The specific resistance of a material may be defined as the resistance offered to a current if passed between the two opposite faces of the unit cube of the material.

2. Combination of Resistance:

Resistance can be connected in three ways as follows:

A. Series Combinations
B. Parallel combinations
C. Series parallel combination.

A. Series Combination of Resistance: If two or more resistances are connected in such a way that there is only one path for the current to flow, it is known as the series combination of resistance, these resistances are connected end-to-end, and the beginning of the first and the end of the last are taken as two supply terminals as shown in the figure.



Current passing through each resistance in a series circuit remains the same as there is only one path for the current flow.

When the current passes through a series circuit there is a drop of voltage in each resistance which is proportional to their individual resistances.

Example: As shown in the figure

Total resistance $R=r_1+r_2+r_3$

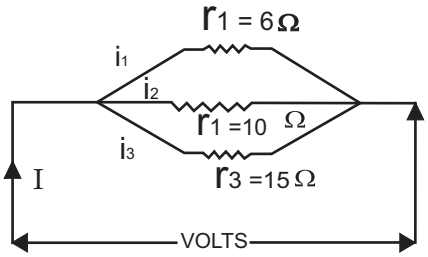
$=30+35+45=110$ ohms.

We know P.D. across circuit = V= 220 volts.

Therefore current flowing through circuit $=I=V / R=220 / 110 = 2A$

As it is a series circuit, the current of 2 amps will flow through each resistance.

B. Parallel Combination of Resistances: If two or more than two resistances are connected in such a way that all the entry ends are joined together at one junction and all the end ends are connected together at one junction and these two junctions are taken as terminal for supply as shown in the fig. below. This arrangement is called as parallel combination of resistance.



In a parallel circuit, the voltage across each resistance is the same as each resistance is connected across the supply mains.

The current flowing through each resistance in a circuit is inversely proportional to the value of the individual resistances as the voltage applied at each resistance is same.
Hence the greater the resistance, the less will be the current flowing through it.

Example: Total resistance (R) = $\frac{\text{Product of total resistances}}{\text{Sum of total resistances}}$

Therefore $1/R = 1/r_1 + 1/r_2 + 1/r_3$

$R = (r_1 \times r_2 \times r_3) / (r_2 \times r_3 + r_3 \times r_1 + r_1 \times r_2)$

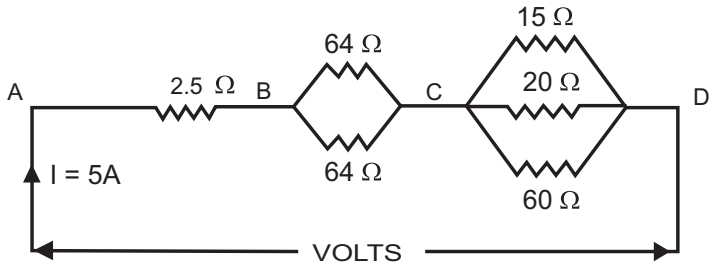
In the fig: We know : $1/R = 1/r_1 + 1/r_2 + 1/r_3$

$1/R = 1/6 + 1/10 + 1/15$

$1/R = (5+3+2) / 30 = 10/30$

$R = 3$ ohms

C. Series-Parallel Combination of Resistances: In this circuit the current divides itself into two branches as shown in figure.



Solution: Equivalent Resistances of section B.C= 64/2=32 ohms.
Equivalent Resistance of section C. D = $(r_1 \times r_2 \times r_3) / (r_2 \times r_3 + r_3 \times r_1 + r_1 \times r_2)$
= (15x20x60) / (300+1200+900) = 7.5 ohms.
Equivalent resistance of A. D = 2.5 + 32 + 7.5 = 42 ohms.
i.e. R = 42 ohms
Voltage across the circuit = I x R = 5 x 42 = 210 volts.

3. **Electric current:** The flow of electrons in one direction along any path or any circuit is called electric current. Its symbol is I and its unit is ampere. (a). The instrument by which the current is measured is called an ampere meter, which is always connected in series with the circuit.

4. **Voltage:** It is the electrical potential (i.e., pressure) between any two live wires or between one live wire and earth. Its symbol is 'V'. The unit of measurement is volt. It is measured by voltmeter, which is always connected in parallel with the load.

5. Resistance: The property of a material / substance which opposes the flow of electric current through it is known as 'resistance'. Its symbol is 'R' and its unit of measurement is "Ohm" represented by Ω (omega). The instrument that measures resistance is known as an 'Ohm' meter.

6. Power: The unit of power is called 'WATT'.
Power (in watts) = V x I.

7. Energy: Energy is the product of power and time.
Energy =W x t. It is generally denoted in 'WATT-HOURS'.

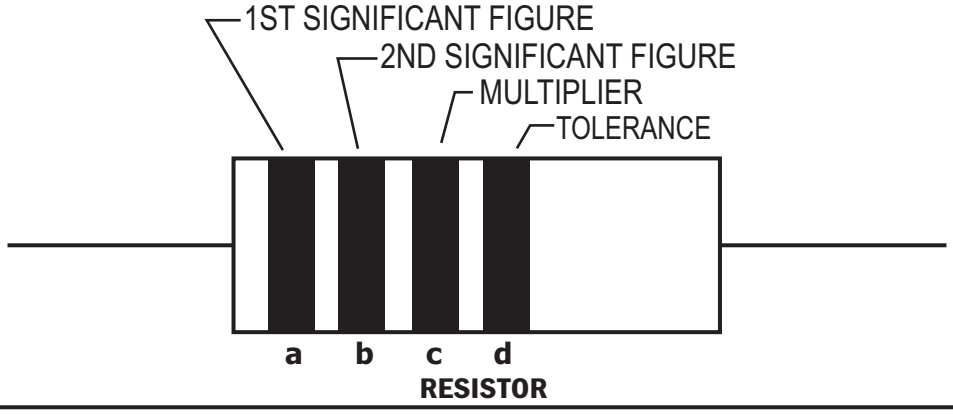
8. Ohm's Law: 'Ohm' established this law, which gives the relation between current, voltage and resistance in a closed electrical circuit. Ohms law states that in a closed circuit the strength of the current flowing through a solid conductor at constant temperature is directly proportional to the voltage across the conductor.
As per the ohm's law,
'V' proportional to 'I' (or) V / I = constant. Or V / I =R.
(Where V= Voltage in Volts, I= Current in amps, R= Resistance in Ohms.)
If one ampere of current is passed through a resistor at an e.m.f. of one volt then the resistance of the resistor will be one Ohm.

$$1\ \text{Ohm} = \frac{1\ \text{Volt}}{1\ \text{Ampere}}$$

The Ohm's law can be expressed in the following three ways:
1. R= V / I Ohms
2. I= V / R Amperes
3. V= I x R Volts.

Table 1-1A, Resistor Color Code

Color	1 st Significant Figure	2nd Significant Figure	Multiplier	Tolerance
Black	0	0	1	
Brown	1	1	10	
Red	2	2	100	
Orange	3	3	1000	
Yellow	4	4	10,000	
Green	5	5	100,000	
Blue	6	6	1,000,000	
Violet	7	7	10,000,000	
Gray	8	8	—	
White	9	9	—	
Gold	—		0.1	5%
Silver	—		0.01	10%
No Color	—			20%



When resistors have a value of less than 10 ohms, the third band is a decimal multiplier. The two colors used are : gold = X0.1 and silver = X0.01.

GENERAL ELECTRICAL TERMINOLOGY

1. AMPERE (Amp): The unit of measure of current flow through a conductor or circuit.

2. AMPERE-HOUR (AH): A unit of measure for battery capacity, obtained by multiplying the current flow (in Amperes), by the time (in Hours) of discharge. A battery which delivery 5 amperes for 20 hours, delivers 5 amperes times 20 hours, OR 100 Ampere-Hours.

3. CAPACITY: The ability of a fully charges battery to deliver a specified quantity of electricity at a given rate (Ampere) over a definite period of time. Capacity is normally measured in Ampere-hours (Ah).

4. CIRCUIT: An electric circuit is the path of an electric current. A closed circuit has a complete path. An open circuit has a broken or disconnected path.

4.1 CIRCUIT (SERIES): A circuit which has only one path for the current to flow. Batteries arranged in series are connected with the negative of the first to positive of the second; negative of the second to positve of the third & so on. If two 12-volt batteries are connected in series the circuit voltage is equal to the sum of the two battery voltages or 24 V.

4.2 CIRCUIT (PARALLEL): A circuit which provides more than one path for current to flow. A parallel arrangement of batteries (usually of like voltage and capacity) would have all positive terminals connected to a conductor and all negative terminals connected to another conductor.

4.3 SHORT CIRCUIT: A shortening of electrical path, usually within a battery/cell, which results in a greater than normal rate of discharge and/or a reduction in cell voltage under load.

5. CURRENT: The rate of flow of electricity. The movement of electrons along a conductor. It is comparable to the flow of stream of water. A unit of measurement is the Ampere.

6. VOLT: The unit of measure for electrical pressure.

6.1 OPEN CIRCUIT VOLTAGE OF BATTERY: The voltage of battery when it is not delivering or receiving power. It is 2.02 or 2.05 Volts for a fully charged cell.

6.2 VOLTAGE DROP: The net difference in electrical pressure (Voltage) when measured across a resistance or impedance.

7. RESISTENCE: The opposite force offered by a wire or substance to the free flow of an electric current.

8. CORROSION: An accumulation of solid sulphates of iron, copper or other metals, usually in the terminal area, contributing to poor electrical contact between cables and battery terminals.

9. SECONDARY BATTERY: Battery which can be recharged by passing direct current through it in a direction opposite to that of discharge.

10. CYCLE: In a battery, a discharge and a recharge is called one cycle.

10.1 DISCHARGE: When a battery is delivering power, it is said to be discharging.

10.2 ELECTROLYTE: In a lead acid battery the Electrolyte is Sulphuric Acid diluted with water. the chemical reaction of cell is as follows:

$PbO_2 + Pb + 2\ H_2SO_4$ ---------- $2PbSO_4 + 2H_2O$

10.3 SPECIFIC GRAVITY : The strength or percentage of the Sulphuric Acid in the electrolyte is measured by the specific gravity of the electrolyte., i.e. the weight of the electrolyte as compared to the weight of an equal volume of pure water.

ELEC - 1.3

READING OF DRAWINGS & CIRCUIT DIAGRAMS

GENERAL SYMBOLS USED IN ELECTRICAL CIRCUITS

5 GENERAL SYMBOLS USED IN ELECTRICAL CIRCUIT

The list of general symbols is given in Table 1.2.

TABLE 1.2 GENERAL SYMBOLS

1	Particulars	2	Symbol 3
1.	Direct current		⎓
2.	Positive		+
3.	Negative		−
4.	Alternating current		~
5.	Single phase		1ϕ OR 1~
6.	Three phase		3ϕ OR 3~
7.	Phase sequence		RYB
8.	Neutral		± OR N OR O
9.	Crossed wires		OR
10.	Connected wires		OR
11.	Earth		
12.	Fuse (rewirable)		OR
13.	Cartridge fuse		
14.	Porcelain connector single way		
15.	Neutral link		
16.	Single pole switch		OR
17.	Two-way switch		OR
18.	Push button switch		
19.	Intermediate switch		OR
20.	Lamp		
21.	Lamp in series		
22.	Lamp in parallel or lamp load		
23.	Fan		
24.	Fan regulator		OFF ON
25.	Two-pin wall socket		
26.	Three-pin wall socket		
27.	Two-plate ceiling rose		
28.	Three-plate ceiling rose		
29.	Electric bell		OR
30.	Electric buzzer		
31.	Double-pole switch		
32.	Triple-pole switch		
33.	Knife blade, double-pole, double-throw switch		
34.	Knife blade triple-pole, double-throw switch		
35.	Double-pole, iron clad main switch with fuses		LOAD LINE
36.	Triple-pole, iron clad main switch with fuses		LOAD LINE

(contd.)

contd.)

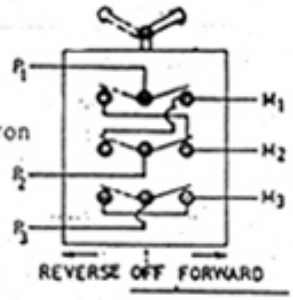
immersed single-pole switch

l immersed double-pole switch

ll immersed
ple-pole switch

eversing switch
Double pole)

eversing switch iron
ad (Triple pole)



Fixed resistance

Variable resistance

OR

Coil
(inductive coil or reactor)

Variable inductive coil

Choke coil

Fixed condenser

Variable condenser

Cell

Battery

Ampere meter (*i*) ac
(*ii*) dc, (*iii*) ac/dc

52. Volt meter (*i*) ac, (*ii*) dc, (*iii*) ac/dc

53. Watt meter

54. Ohm meter

55. Multi-meter

56. Phase indicator meter

57. Power factor meter

58. Frequency meter

59. Galvanometer

60. Synchroscope

61. Single-phase energy meter

62. Series generator (or motor)

63. Shunt generator (or motor)

64. Compound generator (or motor)

65. Single-phase alternator

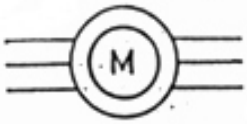
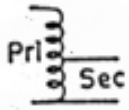
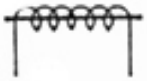
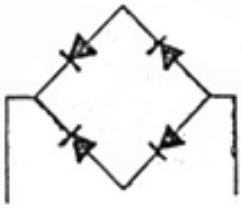
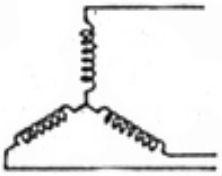
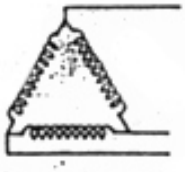
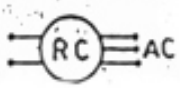
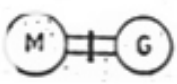
66. Three-phase alternator

67. Single-phase motor

(contd.)

18 Basic Electrical Engineering

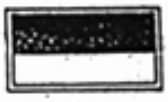
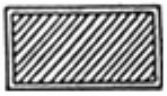
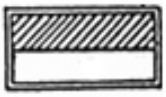
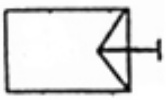
Table 1.2 (contd.)

68.	Three-phase sq. cage induction motor	
69.	Three-phase slipring motor	
70.	Transformer	
71.	Auto-transformer	
72.	Potential transformer	
73.	Current transformer	
74.	Half-wave metal rectifier	
75.	Full-wave metal rectifier	
76.	Star connection	
77.	Delta connection	
78.	Rotary convertor	
79.	Motor generator set—mechanically coupled	

1.6 I.S.I. CONVENTIONAL SYMBOLS FOR ELECTRICAL INSTALLATION.

The I.S.I. electrical symbols are given in Table 1.3.

TABLE 1.3 I.S.I. ELECTRICAL SYMBOLS

	Particulars	Symbol
1.	Main fuse board without switches and lighting	
2.	Main fuse board with switch and lighting	
3.	Main fuse board without switches (power)	
4.	Main fuse board with switches (power)	
5.	Distribution fuse board without switches (lighting)	
6.	Distribution fuse board with switches (lighting)	
7.	Distribution fuse board without switches (power)	
8.	Distribution fuse board with switches (power)	
9.	Main switch (light)	
10.	Main switch (power)	
11.	Changeover switch	
12.	Meter	

ELEC - 1.4
BASIC PROPERTIES OF ELECTRICAL MATERIALS

MODULE NO. ELEC-1.4

Module Description: Basic properties of Electrical Materials.

1. CONDUCTOR: A substance which offers low resistance to the flow of electric current is called a conductor. Almost all pure metals are good conductors of electricity.

Examples of conductors are: Silver, Copper, Aluminium, Brass, Zinc, Nickle,Eureka, Nichrome, Tungsten and Mercury.

PROPERTIES OF A GOOD CONDUCTOR:

1. It should be low cost.
2. It should be easily available in the market.
3. It should have sufficient tensile strength.
4. Its joint should easily be made and soldered.
5. It should have sufficient mechanism strength.
6. It should not be much effected by charging atmospheric conditions.
7. It should have high conductivity and low specific resistance to keep the dielectrically less as low as possible.
8. It should have flexibility.

CLASSIFICATION OF CONDUCTORS:

Conductors can be classified as:

1. Bare conductors 2. Insulated conductors

1. Conductors which are not covered with insulation are known as bare conductors. They are used in overhead lines for transmission and distribution.
2. Insulated conductors are those, which are covered with insulation. They are used for indoor wiring and under ground system.

USES OF CONDUCTORS:

1. **SILVER:** In sensitive measuring instruments tiny capacitors, C>B> points etc.,
2. **COPPER:** In electric wires and cables, winding wire, transformer choke, motor, generators etc.,
3. **BRASS:** In electrical accessories.
4. **ALUMINIUM**: In electrical wires and cables, winding wire, capacitors, shielding etc.,
5. **IRON:** In telephone wires chassis and body of equipments.
6. **LEAD:** In underground cables, solder and lead acid cells etc.,
7. **TIN:** In solder and anti-corrosive plating on various metals. Fuse wires. It has low melting point and not effected by oxidation.
8. **ZINC:** Used in making containers of dry cells, galvanizing iron sheets, wires etc.,
9. **EUREKHA:** Used in resistors, fan regulators, starters etc.,
10. **NICHROME:** Used in heating appliance like electric press, heater, furnance, toaster etc.,
11. **TUNGSTON:** It has high melting point. It is used for making filaments of electric lamps, fluorescent tubes, radio valves etc.,
12. **CARBON:** It has high specific resistance. It is used for making carbon resistances, brushes of electrical machines, electrodes etc.,

13. **MERCURY:** It is a liquid conductor. It is used in mercury vapour lamps, mercury floating switches, mercury arc rectifiers and Ferranti-ampere hour meters etc.,
14. **ELECTROLYTE:** It is also a liquid conductor. They are used in primary and secondary cells etc.,

II. INSULATORS : The substances that cannot pass current through them under normal conditions are termed as insulators. The resistance of an insulator is usually high.
COMMON INSULATORS: Dry air, Asbestos, Bakelite, glass, mica, paper, slate, porcelain, cotton, rubber, plastic, varnish, and mineral oil, dry wood, ebonite etc.

PROPERTIES OF GOOD INSULATORS:
a. It should have high specific resistance.
b. It should have high dielectric strength.
c. It should have an ability to bear high temperature.
d. It should be moisture and waterproof.
e. It should have permanent nature.

COMMON INSULATORS AND THEIR USES:
1. **BAKELITE:** Used in switches, holders, sockets etc.
2. **PORCELAIN**: Used in pipes, fuse cut-outs, neutral links etc.
3. **MICA**: Used in heating elements, windings.
4. **RUBBER**: Used in hand gloves, rubber mating etc.
5. **FIBER**: Used in Formers of Transformer windings.
6. **VARNISH**: Used to insulate a winding.
7. **GLASS**: Used in insulators of over head wiring.
8. **WOOD**: Used in boards, round blocks, casing-caping, battens etc.
9. **LEATHEROID PAPER**: Used in motor winding.
10. **COTTON TAPE**: Used for covering a winding.
11. **PVC**: Used for covering of wires.
12. **OIL**: Used in Oil circuit breakers and transformers.

III **SEMICONDUCTORS:** A semiconductor is a substance whose conductivity lies in between conductors and insulators.
Examples of semiconductors are Germanium and Silicon.
These two elements are essentially required for the manufacture of transistors, diodes, IC's and Chips etc.

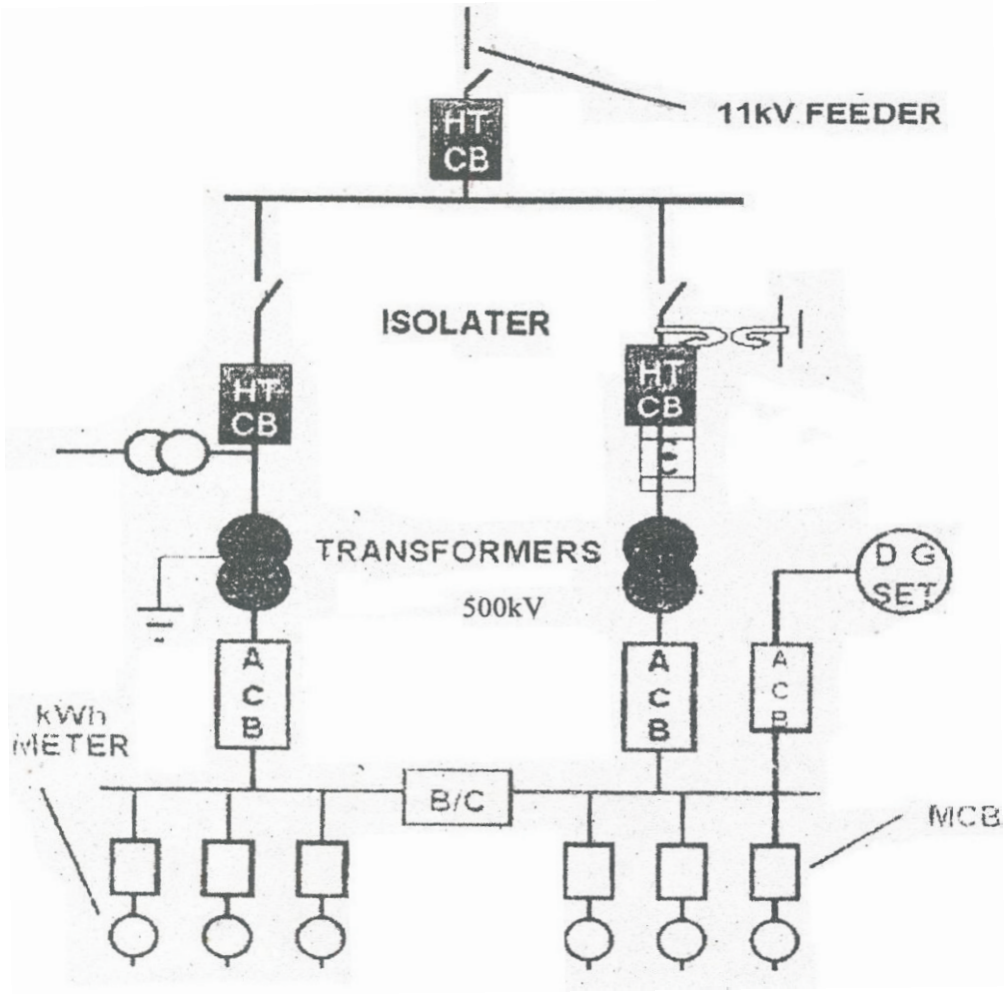
ELEC- 1.5
&
ELEC- 1.8

NAMES, SIZES, LOCATION OF MAJOR ELECTRICAL POWER SUPPLY EQUIPMENTS.

(TRANSFORMERS, RELAYS, CONTACTORS, BATTERIES, WIRING, ELECTRIC FITTINGS, AND POWER LINE CROSSING, PUMPS, DG SETS).

Sub-station

A Distribution Sub-station is a sub-station from which electric supply is distributed to the different users. In a substation there are numbers of incoming and outgoing circuits each having its isolator, circuit breaker, transformers etc. connected to the system. These equipment are mostly static type. Safety and protection of equipment as well as working personnel is also a considerable factor. Lightening arresters, earthing of equipment and fencing is done for this purpose. Maintenance of a sub-station is essential to ensure un-interrupted electric supply duly carrying the periodic schedule maintenance, regular inspections, testing and rectification of defects.



Single Line Diagram of 33/11 kV/440 V Sub-station

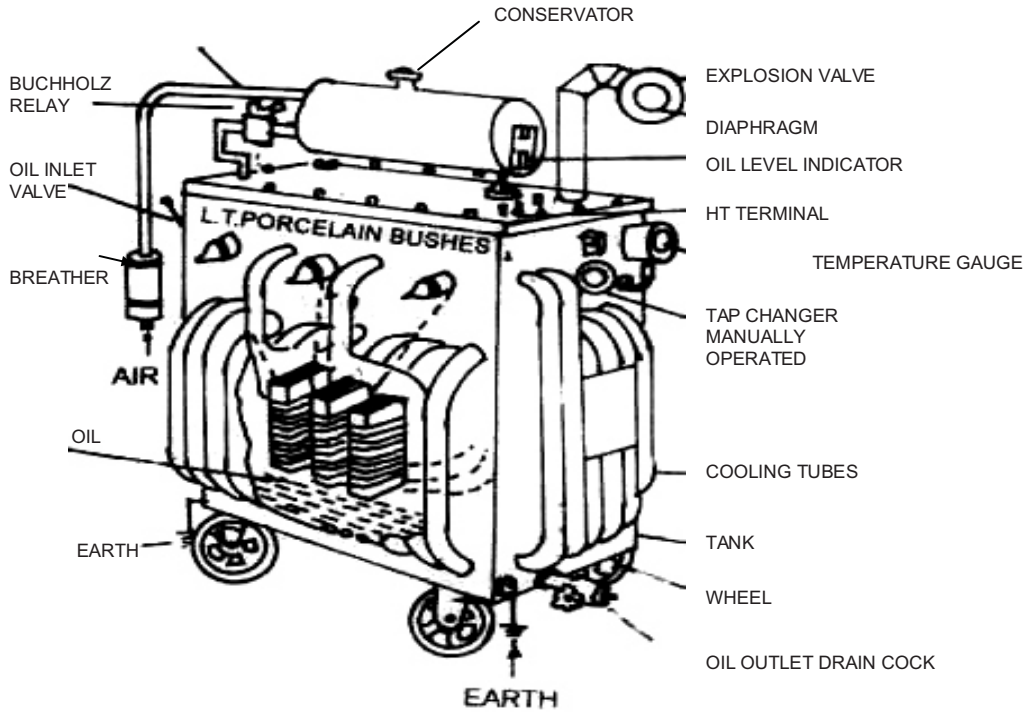
Upkeepment of records of each inspection is essential. If any replacement is carried out or adjustment of certain setting is done then these must be entered in a logbook. A rigid system of maintenance of each equipment will ensures long life, trouble free service and reduction in unnecessary interruptions. All work on major electrical installations must be carried out under permit to work system.
The "permit to work" is to be issued through permit card only by an authorized person. As the name suggests it authorizes the maintenance supervisor and his team to carry out work. Furthermore, this card will indicate unambiguously the points at which it is safe to work, the time interval when it is to be done, steps to be taken to ensure safety such as earthing, display of danger notices etc. at the nearest live point. It should have the signature of the authorized person. After the work is completed the permit card should be cancelled and it should be taken back. Danger notices should be put up or removed by the responsible supervisor who will take the charge of keys equipment, rooms, etc.

EQUIPMENT IN DISTRIBUTION SUB-STATION

The following equipment are installed in Electrical General Services Sub-station:
1. Distribution Transformer
2. Circuit breaker
3. Lightning Arrester
4. Air Break (AB) switches/ Isolator
5. Insulator
6. Bus-bar
7. Capacitor Bank
8. Earthing
9. Fencing
10. Distribution panel board

Distribution Transformer

The distribution transformer is a main and largest equipment of Electrical General Service Sub-station. It is basically a static electrical device which steps down the primary voltage of 33kV or 11 kV to secondary distribution voltage of 415-440 volts between phases and 215 volts between phase and neutral through delta-star windings by electromagnetic induction without change in frequency.
Transformer consists of the following parts and components:
· Primary winding
· Secondary winding
· Transformer tank
· Conservator
· Cooling tubes
· Breather
· Buchholz Relay
· Explosion vent
· Tap changer
· Oil inlet valve
· Oil outlet valve
· Oil level indicator
· L.T. terminals
· H.T. terminals
· Temperature guage



3 Phase, 500 kVA, 11/0.433 kV Natural Air Oil Cooled Distribution Transformer

Working of Important Components:

· **<u>Conservator</u> – Equipped with transformer of rating 500 kVA & above**

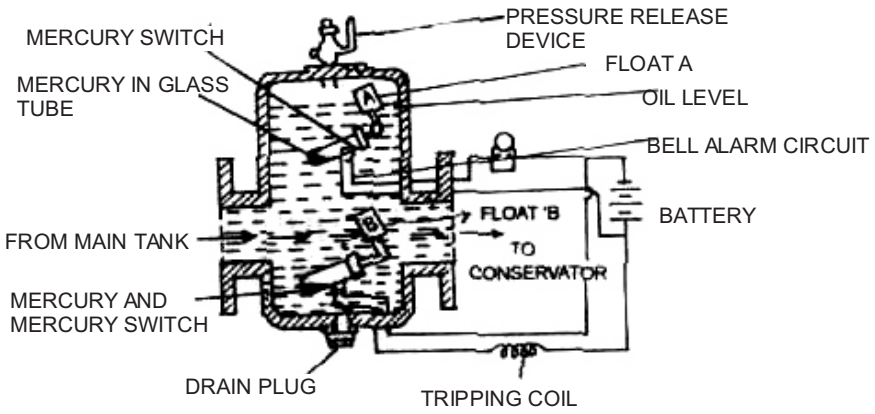
It is a drum containing transformer oil and mounted at the top of the transformer and connected to the main tank by a pipe. As the volume of oil of transformer tank expands and contracts according to heat produced, this expansion and contraction of oil causes the level of the oil in conservator to rise and fall. The aim of conservator is to
- maintain the oil level in tank
- provide space for the expanded oil.

· **<u>Breather</u>**

It is attached to conservator tank and contains silica gel, which prevents the moist air from entering into the tank during contraction of oil. When oil is hot there is expansion and gas passes to atmosphere through it. When oil is cooled, it contracts and the air enters in it. It prevents transformer oil from moisture contamination.

Buchholz Relay

It is protective relay of transformer. This device signals the fault as soon as it occurs and cuts the transformer out of the circuit immediately. This is gas operated protective relay. It is installed in between the pipe connecting the tank and the conservator. This relay works on the formation of excessive oil vapors or gas inside the transformer tank due to internal fault of transformer. It consists of two operating floats A and B. These are operated by two mercury switches separately provided for each float. The float A is for bell alarm and float B is for operating the tripping circuit.



Buchholz Relay

Whenever there is a minor fault or low level of oil, the bell alarm operated by float 'A' and whenever there is severe fault in the transformer, float 'B' operated due to excessive gases. It trips the circuit breaker and transformer is put out of circuit.

· **Explosion Vent**

A major fault inside the transformer causes instantaneous vaporization of oil, leading to extremely rapid buildup of gaseous pressure. If this pressure is not released with in few milliseconds, the transformer tank can rupture, spilling oil over a wide area. An explosion vent provides instantaneous releasing of such dangerous pressure and protects the transformer.

· **Oil level Indicator**

It has markings on transparent sheet for maximum & minimum levels.

· **Inlet Valve**

It provides passage to pour the transformer oil in the tank during purification or in case of shortage found in the tank.

· **Outlet Valve**

It provides passage to drain the oil during overhauling or as and when required oil sample for testing.

· **Cooling Tubes**

These tubes provide better and effective cooling of transformer oil by increasing the surface area of tank to the atmosphere.

· **Tap changer**

The tape changer is used to regulate the output voltage manually according to line voltage. The tapes of transformer can be changed by the tape changer manually. It is provided on HV side so that the voltage on LV side feeding to the load can be maintained. Normally tap selection range is ± 15 % in steps of 2.5 %.

Circuit Breaker

The circuit breaker is an equipment which automatically cut off power supply of the system when any fault or short circuit occurs in the system. It detect and isolate faults within a fraction of a second thereby minimizing the damage at the point where the fault has occurred. The circuit breakers are specially designed to interrupt the very high fault currents, which may be ten or more times the normal operating currents.

There are many types of circuit breakers, e.g. Oil, minimum oil, Air blast, Vacuum, SF6, etc. being used at sub-stations. This list is generally in order of their development and increasing fault rupturing capacity, reliability and maintainability. In distribution substation, generally oil circuit breakers and air circuit breakers are used.

Lightning Arrester

Lightning arrester is a most important protective device of distribution sub-station to protect valuable equipment as well as working personnel. It arrests and discharges over voltage to earth during lightning strokes. These are installed between line and earth near equipment.
Representative values of a lightning stroke: - Voltage - 2×10^8 volts.
- Current - 2×10^4 Amps
- Duration - 10^{-5} seconds.
- Power - 8×10^5 kW

Air Break (AB) Switch/ Isolator

Air break switches are used to isolate equipment for maintenance and also for transfer of load from one bus to another. Lay-out of sub-station depends upon type of Air break switches.

Insulator

The main function of an insulator is to insulate live conductor or equipment at different voltages with reference to the ground structures as well as provide mechanical support. Provision of adequate insulation in a substation is of primary importance from the point of view of reliability of supply and safety of personnel.

Bus Bar Arrangement

The bus bar is a conductor used to connect two and more equipment located side-byside when the currents are very high. These are usually rectangular, sometimes tubular, bare copper bars supported on insulators.

Capacitor Bank

It is a series parallel combination of capacitors required to improve power factor of the system. They act as reactive power generators, and provide the needed reactive power to accomplish active power of circuit. This reduces the amount of reactive power, and thus total power (kVA) or the demand. The bank should be provided as near as possible to load.

Earthing

Provision of an effective, durable and a dependable earthing in a substation and switching stations is very important for the safety of operating personnel as well as electrical devices.

Fencing Arrangement

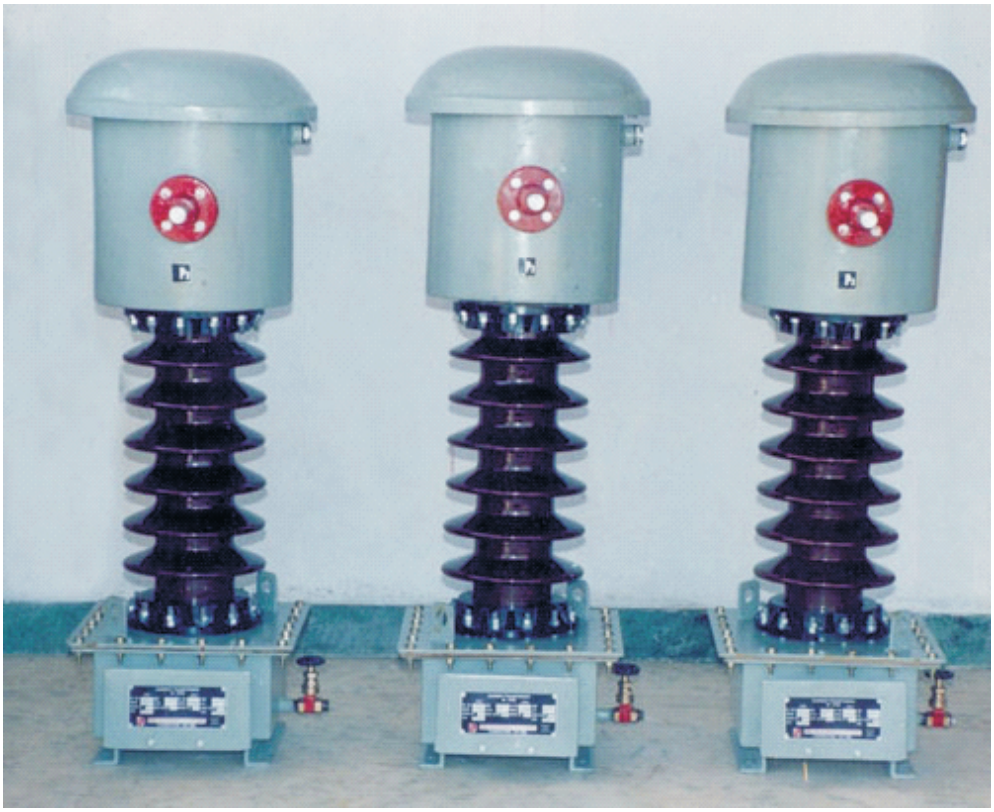
Fencing is provided at outdoor sub-station yard for restricting entry of unauthorized person and livestock. It must be earthed/ grounded separately. Height of fencing normally should not be less than 1.8 metres. Fencing should be painted once in a year by suitable paint.

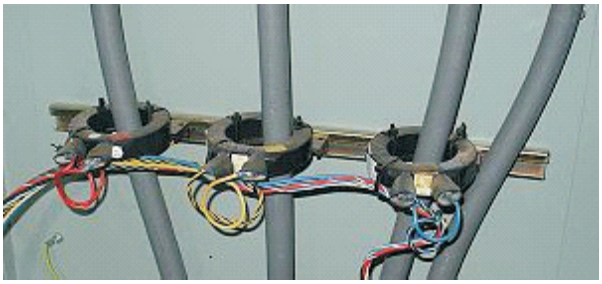
Distribution Panel Board

Distribution panel board consists of MCCBs, control equipment, meters and relays are housed in the control room. The panel frame shall be connected to the earth grid by an earthing conductor. A rubber mat of prescribed size and quality shall lay in front of panel.

Instrument Transformers:

A **current transformer** (**CT**) is used for measurement of electric currents. Current transformers, together with **voltage transformers** (**VT**) (**potential transformers** (**PT**)), are known as **instrument transformers**. When current in a circuit is too high to directly apply to measuring instruments, a current transformer produces a reduced current accurately proportional to the current in the circuit, which can be conveniently connected to measuring and recording instruments.





Unless a burden (i.e. meters, relays, etc.) is connected to the CT, current transformers should always be shorted across the secondary terminals. The reason is very high voltages will be induced at the terminals.

POWER FACTOR

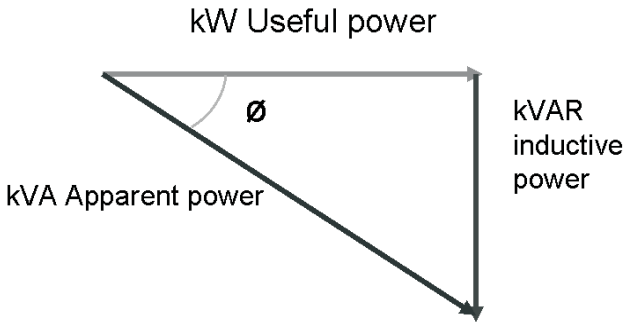
The majority of ac electrical machines and equipment draw from the supply an apparent power (kV A) which exceeds the required useful power (kW). This is due to the reactive power (kVAR) necessary for alternating magnetic field.

The ratio of useful power (kW) to apparent power (kVA) is termed the power factor of the load. The reactive power is indispensable and constitutes an additional demand on the system.

The power factor indicates the portion of the current in the system performing useful work. A power factor of unity (100 percent) denotes 100 percent utilization of the total current for useful work whereas a power factor of 0.70 shows that only 70 percent of the current is performing useful work.

Principal Causes of Lower Power Factor

The following electrical equipment and apparatus have a lower factor:



a) Induction motors of all types particularly when they are under loaded.
b) Power transformers and voltage regulators
c) Arc welders
d) Induction furnaces and heating coils.
e) Choke coils and magnetic systems.
f) Fluorescent and discharge lamps, neon signs etc.

The principal cause of a low power factor is due to the reactive power flowing in the circuit. The reactive power depends on the inductance and capacitance of the apparatus.

Effect of Power Factor to Consumer

The disadvantages of low power factor are as follows:

a) Overloading of cables and transformers
b) Decreased line voltage at point of application.
c) Inefficient operation of plant, and

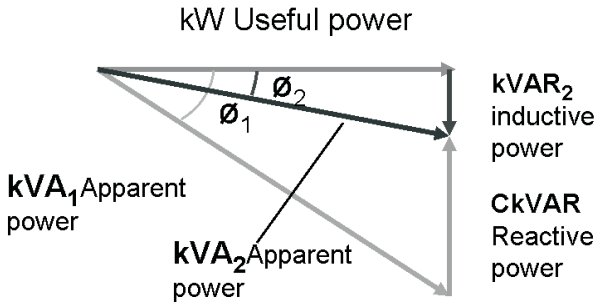
Penal power rates.

The advantages of high power factor are as follows:

a) Reduction in the current.
b) Reduction in power cost.
c) Reduced losses in the transformers and cables.
d) Lower loading of transformers, switchgears, cables, etc.
e) Increased capability of the power system
f) Improvement in voltage in voltage conditions and apparatus performance, and
g) Reduction in voltage dips caused by welding and similar equipment.

Power Factor Calculation

- In initial condition
- kVAR1 = kW x tan ø1
- In improved condition
- kVAR2 = kW x tan ø2
- Now,
  CkVAR = kVAR1- kVAR2



<u>CkVAR= kW (tan ø1- tan ø2)</u>

Economics of Power Factor Improvement

Static capacitors, also called static condensers, when installed at or near the point of consumption, provide necessary capacitive reactive power relieve distribution system before the point of its installation from carrying the inductive reactive power to that extent.

The use of the static capacitors is an economical way of improving power factor on account of their comparatively low cost, ease of installation. less maintenance, low losses and the advantage of extension by addition of requisite units to meet the load growth. Installation of capacitors also improves the voltage regulation and reduces amperes loading and energy losses in the supply apparatus and lines.

The minimum permissible power factor prescribed in the conditions of supply of Electricity Boards or Licensees and the reduction in charges offered in supply tariffs for further improvement of power factor shall along with other considerations such as reduction of losses etc. determine the kVAR capacity of the capacitors to be installed.

USE OF CAPACITORS

The successful operation of power factor improvement depends very largely on the positioning of the capacitor on the system. Ideal conditions are achieved when the highest power factor is maintained under all load conditions.

Individual Compensation - Wherever possible the capacitor should be connected directly across the terminals of the low power factor appliance or equipment.

Group Compensation - In industries where a large number of small motors or other appliances and machines are installed and whose operation is periodical it is economical to dispense with individual installation of capacitors. A bank of capacitors may be installed to connect them to the distribution centre of main bus-bars of the group of machines.

Central Compensation - Capacitors may also be installed at a central point that is at the incoming supply or service position. In order to overcome problems of drawing leading currents on light loads, these capacitors may be operated manually or automatically as required. The automatic control is preferred as it eliminates human errors.

Operation may be arranged by means of AUTOMATIC POWER FACTOR CORRECTER and maintains the correct amount of kV AR in the circuit.

The method of connecting power factor capacitors to supply line and motors is given in Fig. 1 and 2.

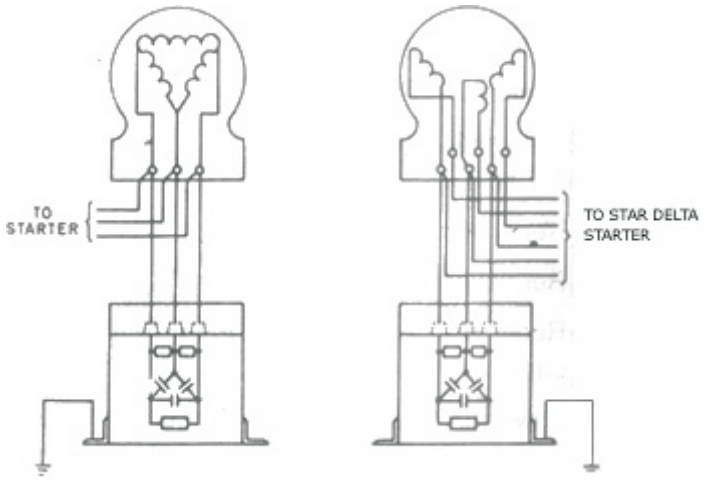


FIG. I METHODS OF CONNECTING CAPACITORS FOR IMPROVEMENT OF POWER FACTOR TO MOTORS

Diesel Generators

The DG set is a compact and robust machine in which mechanical energy is converted into electrical energy.

Diesel Engine is divided into two major sections:

1. Diesel Engine
2. Alternator

DIESEL ENGINE:

The Diesel Engine consists following main parts.

Piston

Piston cylinder has two jobs:
To compress the air.
To release the pressure of the gases while they are burning.

Cylinder Head

A cylinder head closes the top end of the cylinder. It makes a confined space for compress air and the gases.

Valves/ Ports

To admit the air & to discharge the exhaust gases.

Connecting Rod

To transmit force in either direction between the piston and the crank on the crankshaft.

Main Bearing

Support the crank shaft and permit it to rotate

Supporting Structure

It holds the cylinder, crankshaft and main bearing in firm relation to each other. This structure is made up of two parts, the frame and the bed plate.

Fuel Injection Pump

It forces the oil into cylinder and fuel injection nozzle breaks up the oil into fine spray.

Crankshaft

To operate the fuel injection pump and the valve.

Fly Wheel

To store the surplus energy of the power stroke & to return that energy when the piston is being pushed upward on the compression stroke.

WORKING OF DIESEL ENGINE

It uses diesel oil and works on diesel cycle. In this system the air is compressed inside the cylinder and then diesel is injected which burns itself due to high temperature of compressed air. The diesel is injected through injector in the chamber.

This is also called four stroke diesel cycle compression ignition engines. It consists of four strokes, as follows:

- Suction stroke
- Compression stroke
- Power stroke
- Exhaust stroke

ALTERNATOR:

The main parts of alternator are **Rotor and Stator**.

WORKING OF ALTERNATOR

An alternator works on the Faraday's law of electromagnetic induction. It is coupled with the diesel engine and the kinetic energy of engine is transmitted to alternator and converted into electrical energy through the alternators. This electrical energy is then fed to the load.

USES OF D.G. SET ON RAILWAYS

Accident Relief Trains

Portable sets are used on accident relief trains. These sets are used for lighting of accident sites. Portable light fittings with stands and interconnecting cable wounded on reels are erected wherever required along with these portable sets.

Power cars for End-On-Generation

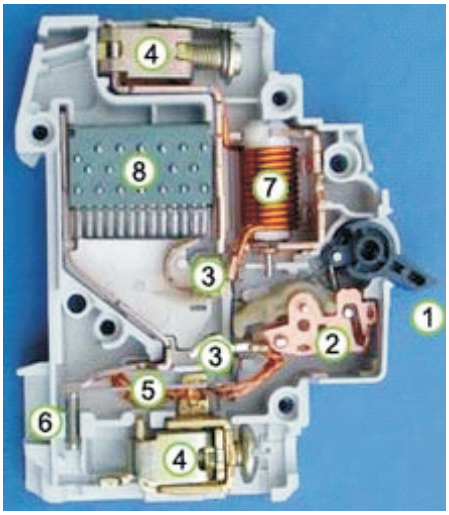
For end on generation there are 2 power cars one at each end with about 2X 500 KVA capacity DG set. Provision of DG set eliminates the need to charge the batteries of the train and to improve self reliability.

CIRCUIT BREAKERS

CUT SECTION VIEW OF CIRCUIT BREAKER

A cutaway view of the molded case circuit breaker is shown. A circuit can be connected or disconnected using a circuit breaker by manually moving the operating handle to the ON or OFF position. All breakers, with the exception of very small ones, have a linkage between the operating handle and contacts that allows a quick make (quick break contact action) regardless of how fast the operating handle is moved. The handle is also designed so that it cannot be held shut on a short circuit or overload condition. If the circuit breaker opens under one of these conditions, the handle will go to the trip-free position. The trip-free position is midway between the ON and OFF positions and cannot be re-shut until the handle is pushed to the OFF position and reset. A circuit breaker will automatically trip when the current through it exceeds a pre-determined value. In lower current ratings, automatic tripping of the circuit breaker is accomplished by use of thermal tripping devices. Thermal trip elements consist of a bimetallic element that can be calibrated so that the heat from normal current through it does not cause it to deflect. An abnormally high current, which could be caused by a short circuit or overload condition, will cause the element to deflect and trip the linkage that holds the circuit breaker shut. The circuit breaker will then be opened by spring action. This bimetallic element, which is responsive to the heat produced by current flowing through it, has an inverse-time characteristic.

Miniature circuit Breakers



MAIN PARTS OF MCB

1. Actuator lever - used to manually trip and reset the circuit breaker. Also indicates the status of the circuit breaker (On or Off/tripped). Most breakers are designed so they can still trip even if the lever is held or locked in the "on" position. This is sometimes referred to as "free trip" or "positive trip" operation.
2. Actuator mechanism - forces the contacts together or apart.
3. Contacts - Allow current when touching and break the current when moved apart.
4. Terminals
5. Bimetallic strip.
6. Calibration screw - allows the manufacturer to precisely adjust the trip current of the device after assembly.

Cables

Cables are used for transmission of electrical power. They are mostly used for low voltage distribution in thickly populated area, in substations from transformers to main distribution panels and from main distribution panels to different distribution panels. Low voltage cables are also used in industries, workshops and maintenance shops/ sheds. Medium & high voltage transmission cables are also used for crossing the roads, railway lines and in densely populated areas in big cities.

Cables as compared to overhead lines have the following advantages:

i. The cable transmission and distribution are not subjected to supply interruptions caused by lightening or thunderstorms, birds and other severe weather conditions.
ii. It reduces accidents caused by the breaking of the conductors.
iii. Its use does not spoil the beauty of place, cities. But if a fault occurs due to any reason, it is not easily located.

MAIN PARTS OF CABLES

Conductor, insulation and protection are the main three parts of the cables.

Conductor

Conductor is a material that provides low resistance to the flow of electrical current. Electrical grade high conductivity annealed copper or annealed aluminium conductors are used in cables. Generally all power cables have aluminium as the conductor material. Aluminium of high purity, (99.5% pure electrical grade) which is highly anticorrosive and highly conductive is used as conductor in cables. Annealing softens the aluminium, reduces tensile strength and increase conductivity.

Insulation

Insulation material means a material having good dielectric properties, which is used to separate or isolate the conducting electrical parts. Insulation to be used for cables must have following properties.

· It should have a high specific resistance and dielectric strength.
· It should be tough and flexible.
· It should not be hygroscopic i.e. it should not absorb moisture from air or surroundings.
· It should be capable of standing high temperatures without much deterioration.
· It should be non-inflammable, fire retardant.
· It should not be attacked by acids or alkalies.
· It should be capable of withstanding high rupturing voltages.

Protection

Following protecting layers are provided for protection of the cable.

a. Inner Sheath

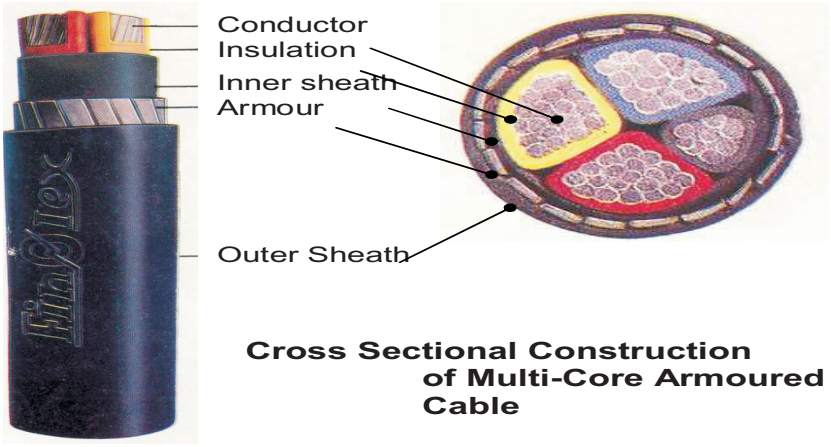
For protection from moisture and aggressive elements, sheath is provided over the insulation. For oil impregnated paper insulated cables, lead sheath or impregnated jute tapes with layers of bitumen compound are used. For polymeric material insulated cables, extruded PVC sheath or wrapping of plastic tapes are used.

b. Armouring

Armouring is provided to avoid mechanical injury to the cable. Depending upon the application, the cable may be armoured or unarmoured. The armouring is applied over the core insulation or inner sheath for single core cables and over the inner sheath for the multicore cables. Armour is a metallic wrapping over the cable insulation. For single core cables, non magnetic materials are used as armour, for example, flat aluminium wire. In multicore cables, common armour is provided for all the laid up cores and the armour material may be galvanized round steel wire or flat steel strip.

c. Outer Sheath

Single core and multicore cables are provided with an extruded PVC outer sheath. The colour of the outer sheath is generally black.



Cross Sectional Construction of Multi-Core Armoured Cable

CLASSIFICATION OF ELECTRICAL CABLES

Electrical cables may be classified according to their application as follows:

i. Wiring cables

These cables are used for internal wiring of the buildings and other protected installations and have two components viz. conductor and insulation. PVC as insulation material and annealed copper (solid or stranded) as conductor are commonly used for wiring cables. Voltage grade of these cables is upto 1100 Volts.

ii. Control cables

These are designed for control purposes or measuring circuits for carrying signals of direct current upto 220 Volts and alternating currents up to 440 volts. These cables are available with armour and without armour. In these cables PVC, XLPE, EPR, Neoprene etc. are used as insulation. Control cables are available in 0.5/0.75/1.00/1.5/2.5 mm^2 size copper conductor (solid/stranded) from 2 cores to 61 cores.

iii. Power Cables

Electrical power cables are used for distribution and transmission of electrical energy. These cables either single core or multicore are particularly useful in power stations, substations, house service connections, street lighting, etc. They can be installed indoors or outdoors, in air, in cable ducts or under ground.

iv. Special Application Cables

Cables are also classified based on special applications such as –
i. Fire performance and heat resistant cables.
ii. Pilot cables.
iii. Instrumentation cables.
iv. Submarine cables & ship board cables.
v. Airport lighting cables.
vi. Mining cables.
vii. Cables for lifts and hoisting gears.
viii. Welding cables.
ix. Cables for hazardous areas such as petrochemical industries etc.

CLASSIFICATION OF POWER CABLES

Electrical power cables are generally classified according to their designed (rated) voltages or the type of insulation used.

Classification as Per Designed Voltage

Electrical power cables are generally classified according to their designed (rated) voltages as given below:
i. Low voltage cables – up to and including 1100 volts.
ii. Medium voltage cables –from 3.3 kV up to and including 33 kV.
iii. High voltage cables – above 33 kV and up to and including 132 kV
iv. Extra high voltage cables – above 132 kV and up to and including 700 kV.

Advantages of XLPE Cables

i. Higher current carrying capacity Current carrying capacity of XLPE cables of the same size is approximately 20 to 30% higher than that of PVC due to higher operating temperature.
ii. Resistant to heat With cross-linked molecules structure, XLPE cables are excellently ozone resistant and provide outstanding stability and are resistant to heat.
iii. XLPE cables have lower dielectric loss, lower permitivity as compared to PVC cables.
iv. Due to lower specific gravity, XLPE cables are comparatively lighter in weight than PVC cables, therefore, ease in handling, laying and installation. The cable requires less supporting due to low weight.
v. XLPE cable has higher mechanical properties and more robust as compared to PVC cables due to thermosetting process.

METHODS OF CABLE LAYING & INSTALLATION

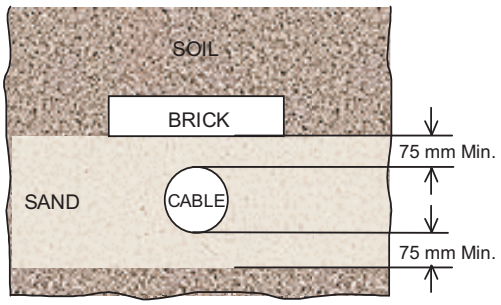
The conventional methods of cable laying and installation are:
· Laying direct in ground.
· Drawing in ducts.
· Laying on racks in air.
· Laying on racks inside a cable tunnel.
· Laying along buildings or structures.

Laying Direct in Ground

This method involves digging a trench in the ground and laying cables on a bedding of minimum 75mm riddled soil or sand at the bottom of the trench, and covering it with additional riddled soil or sand of minimum 75mm and protecting it by means of bricks, tiles or slabs.

Depth

The desired minimum depth of laying from ground surface to the top of the cable should be as following :
· Cables, 3.3 KV to 11 kV Voltage rating : 0.9m
· Cables, 22 kV, 33 kV Voltage rating : 1.05 m
· Low voltage and control cables = 0.75 m
· Cables at road crossings : 1.00 m
· Cables at railway level crossings : 1.00 m
(Measured from bottom of sleepers to the top of pipe)



Cable Trench Layout

Earthing and Bonding of Cables

· The metal sheath, metal screen (if any) and armour of any cable should be efficiently earthed at both ends.
· All metal pipes or conduits in which the cables have been installed should be efficiently bonded and earthed.
· Where cables not having metallic sheath are used, embedding additional earth electrodes and connecting the same with steel armour of cable becomes necessary.
·

MAINTENANCE OF END TERMINATIONS

· Visual inspection of all the cable end termination should be carried out regularly for any over heating flashing mark, insulation damage etc.
· Cable end terminations should be checked for tightness with a suitable torque wrinch/spanner periodically.
· Check the cable support clamps, glands for proper position and intactness.

RECOMMENDATIONS FOR STORAGE AND TRANSPORTATION OF CABLES

· No drums should be stored one above the other.
· Drums should be stored preferably on a plain ground without having any projected hard stones above the ground surface.
· The drums should be stored preferably in the shed.
· Drums should be kept in a such a way that bottom cable end does not get damaged.
· Both the ends of the cable should be sealed with plastic caps.

ELECTRICAL WIRING

Wiring is a method of drawing or laying wires or cables and connecting accessories and fittings for the purpose of distributing electrical power to various points or equipment from the mains.

According to requirement and suitability, wiring can be classified into indoor wing and outdoor wing. Another method of classification of wiring is concealed wiring, and open or exposed wiring. According to method of connection adopted in wiring system wiring can also be classified into T system of connection and Loop back system of connection.

In the loop back system the connection leads are taken from the controlling devices which are incoming terminals to the next point.

Generally for wiring of residential buildings and office buildings loop back systems of connections are adopted.

S. No.	System of Wiring	Advantages	Dis-advantages
1	Cleat system	Installation and Dismantling is easy and quick. Inspection work is easy Installation is cheap.	It is a temporary system. Wires are exposed and are subject to mechanical injury. Insulation may deteriorate after some time as the wires are exposed to atmosphere.
2	Casing and caping	It is easy to install and rewiring is economical and cheap in cost. Inspection is easy short circuiting chances are less.	There is a risk of fire cannot be used in damp places. Not good looking.
3	CTS system	Easy to install and labor charges are less. It is cheaper its appearance is nice. It life is fairly longer.	It cannot be used in situations where exposed to sun or rain. There is a risk of fire
4	Lead Sheathed	It can be used in places exposed to sun or rain. It can be used in damp conditions. Better earthing and long life.	Costly as compared to CTS system. If earthing is not proper there is a danger of electric shocks.
5	Conduit system	No damage due to fire. Has a very long life. No mechanical injury to the wiring.	Costly as compared to other systems. If not earthed properly, there is a likelihood of an electric shock.
6	Concealed wiring	Appearance is good.	Replacement of wires is not easy.

GENERAL RULES FOR WIRING:

1. The switch board should not be erected above gas stoves or sinks or within 2.5m of any washing unit in washing room.
2. Adequate illumination should be provided for all working spaces above the switch board when installed indoors.

3. For small installations connected to a single phase 240 V supply, wooden boards must be used as main boards or sub-boards.
4. Every circuit or apparatus should be provided with separate switches.
5. All the motor starters and switches should be accessible to the operator.
6. The circuit should be designed with a provision for 20% increase in load due to future modifications.
7. When the wiring in an installation has been completed it should be tested before giving the supply and any leakage in the wiring should not exceed 1/5000 of the maximum current of the load.
8. In any building, light wiring and power wiring should be kept separate.
9. All distribution boards in the circuit should be installed at a height of not more than 2 m above the floor level.
10. In three phase, four wire installations, the load should be equally divided on all the phases.
11. Ceiling roses should not be used in a circuit where the voltage exceeds 250 V.
12. Ordinary socket outlets may be fixed at any place, at a height above 20 cm from the floor level.
13. Each 15 A socket outlet for the use of domestic appliances should be of the controlled type and should have its own individual fuse.
14. In an earthed system of supply, a socket outlet with plug should be of three pin type with the third terminal connected to the earth.
15. All lamps, unless otherwise required should be suitably protected and hung at a height of not less than 2.5 m above the floor level.
16. The control of a ceiling fan should be through its own regulator as well as through a switch in series.
17. Unless otherwise specified, the clearance between the bottom point of the ceiling fan and the floor should not be less than 2.4m. The minimum clearance between the ceiling and the blades of the fan should not be less than 300 mm.
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EARTHING

Provision of adequate earthing in a substation and switching stations are very important for the safety of operating personnel as well a electrical devices

PURPOSE OF SUBSTATION EARTHING SYSTEM

The object of an earthing system in a substation is to provide under and around the substation a surface that shall be at a uniform potential and near zero or absolute earth potential as possible. The provision of such a surface of uniform potential under and around the substation ensure that no human being in the substation subject in shock of injury on the occurrence of a short circuit or development of other abnormal conditions in the equipment installed in the yard.

The primary requirements of a good earthing system in a substation are:

a. It is stabilize circuit potentials with respect to ground and limit the overall potential rise.
b. It is protect life and property from over voltage.
c. It is provide low impedance path to fault currents to ensure prompt and consistent operation of protective devices during ground faults.
d. It is keep the maximum voltage gradient along the surface inside and around the substation within safe limits during ground fault.

MAXIMUM PERMISSIBLE RESISTANCE OF EARTHING SYSTEM

Large power station : 0.5 ohms.
Major sub-station : 1.0 ohms.
Small sub-station : 2.0 ohms.
In all other cases : 8.0 ohms.
The earth continuity inside an installation : 1.0 ohms.

PROPER LOCATION FOR PROVISION OF EARTH

The location of earth electrode should be chosen in one of the following types of soil in the order of preference given on next page
· Wet marshy ground.
· Clay, loamy soil and arable land
· Clay and loam mixed with varying proportions of sand, gravel and stones.
· Damp and wet sand, peat.
Dry sand, gravel chalk limestone, granite, very stone ground and all locations where virgin rock is very close to the surface should be avoided.

Pipe Electrode

It should be made of 'B' class G.I pipe. The internal diameter should not be smaller than 38 mm and it should be 100 mm fore cast Iron pipe. The length of the pipe electrode should not less than 2.5 m. It should be embedded vertically. Where hard rock is encountered it can be inclined to vertical. The inclination shall not more than 30^0 from the vertical.
To reduce the depth of burial of an electrode without increasing the resistance, a number of pipes shall be connected together in parallel. The resistance in this case is practically proportional to the reciprocal of the number of electrodes used so long as each is situated outside the resistance area of the other. The distance between two electrodes in such a case shall preferably be not less than twice the length of electrode as shown in figure.

EARTHING OF VARIOUS EQUIPMENT IN THE SUB-STATION

Isolators and switches

A flexible earth conductor is provided between the handle and earthing conductor attached to the mounting bracket and the handle of switches is connected to earthing mat by means of two separate distinct connections made with MS flat. One connection is made with the nearest longitudinal conductor, while the other is made to the nearest transverse
conductor of the mat.

ILLUMINATION

Essentials of good lighting

Good lighting should be glare free, adequate and uniform. When all the points are catered, the lighting becomes harmonious, good and productive. At the same time, the maintenance cost, running expenses etc. should be thoroughly gone into before finalizing the lamps & luminaries to obtain economical illumination

The factors to be taken care of while planning a lighting scheme are:

* Illumination level.
* Absence of glare.
* Contrast.
* Shadows.
* Colour rendering.
* Maintenance factor.
* Energy effectiveness.

Illumination level

The requirement of illumination varies with the purpose. The visibility of objects depends upon the magnitude of the light falling over them and the light reflected by them. The visibility further depends upon the following factors.

PURPOSE

The requirement of illumination varies with the purpose e.g. a badminton hall requires much higher level of illumination as compared to a cinema hall. Same consideration applies to a reading room versus a bed room.

ENERGY EFFECTIVENESS

Luminous efficiency, life of lamp, ease of maintenance have to be considered in a planned lighting system to get optimum returns. Various options are now available to design energy effective system.

Fluorescent tubes, HPSV lamps, Metal Halide Lamps and various CFL and New advancement like of LED and T5 tubes are being extensively used for better lighting effect and economy, limiting the use of incandescent lamps to relatively few selected locations.

Integration of day-light and artificial lighting system should be considered while planning for buildings, and sheds,

Electronic ballasts for fluorescent tubes have also come up & manufacturers claim reduction of 20-25% savings in energy consumption.

REGULATIONS FOR POWER LINE CROSSINGS

This regulations apply to electrical overhead lines and/or underground cables crossing Railway Tracks.

1. An overhead line crossing shall normally be at right angles to the railway track. In special cases, a deviation upto 30^o may be permitted. More than30^o deviation requires a approval from the electrical Inspector of the Railway.
2. The steel structures shall normally be galvanized in accordance with IS. 2629-1966.
3. The minimum distance of the structures (supporting the crossing span) from the centre of the nearest railway track shall be equal to the height of the structure in meters above normal ground level plus 6 meters . In special circumstances, the Electrical Inspector may permit a lesser distance being adopted subject to any conditions he deems fit to impose.
4. The crossing span shall be restricted to 300m or to 80% of the normal span for which the structures are designed which ever is less.
5. The factor of safety of all structures, conductors, guards, guys and ground wires used in the crossing shall be as stipulated in the Indian Electricity Rules 1956 (as amended in November 1984)
6. An overhead line crossing over Railway Track already shall be located at the middle of overhead equipment span supported by two adjacent structures/Traction masts. The distance between any of the crossing conductors and the nearest traction mast or structure under the most adverse conditions shall not be less than 6m.
7. No overhead line crossing shall be located over a Booster Transformer. Traction switching station, Traction substation or a track cabin location in the electrified area.
8. The working of a Railway crane under an overhead line crossing shall normally be avoided.
9. The minimum height above rail level of the lowest portion of any conductor of a crossing, including guard wire, under the conditions of maximum sag shall be as follows

S. No.	VOLTAGE	VERTICAL CLEARANCE
1.	UPTO and including 11KV	Normally by cable
2.	Above 11KV and up to 66KV	14.10Ms
3.	Above 66KV and up to 132KV	14.60
4.	Above 132KV and up to 220KV	15.40M
5.	Above 220KV and up to 400KV	17.90M
6.	Above 400KV and up to 500KV	19.30M
7.	Above 500KV and up to 800KV	23.40M

TYPES OF LAMPS

Filament Lamp

These are incandescent lamps, while the rest are mostly discharge lamps. This contains a filament in a vacuum-evacuated, sealed-glass bulb with a little inert gas (to reduce oxidation). Light is produced when current is passed through the high-resistance filament. Now the usage of filament lamp is restricted due to environmental pollution.

Fluorescent Lamps

The fluorescent lamp is the discharge type and consists of two electrodes within a tube, mostly vacuum-evacuated but filled with a little mercury vapor and an inert gas. The inside surface of the tube is coated with phosphor. The gas (vapor) is ionized by applying a voltage across the two electrodes. Initially a high voltage is applied across the electrodes to break the media and create an arc. The electrode supplies electrons necessary to maintain the arc (light). Different types of phosphors give different colour outputs. There are two types of fluorescent lamps: the cold cathode and the preheated cathode. The cold-cathode lamp is operated on mains voltage through a step-up transformer to generate the high voltage necessary for the operation (similar to neon lamps). Like neon lamps these are used in signage/advertising displays.

The preheated cathode type lamps are more common. The electrodes are made of tungsten and coated with an emitting material. The initial higher voltage for starting the arc is created by opening a magnetic circuit by a device called a Starter. When the circuit is closed, the bi-metallic switch within the starter opens by heat from the coil. This opens the magnetic circuit of the choke, resulting in high transient voltage (300-600V), which is sufficient to create an arc between the two electrodes. The heated (hot) cathode maintains the flow of electrons. The voltage drop across the sustained arc is much lower than the mains voltage. The “choke” or ballast restricts the current to prevent the discharge from running wild and exploding.

The fluorescent lamps are available in 18W(600 mm long), 36W (1200mm long0 and 58 W (1500 mm long). The T8 or 26mm fluorescent lamps are available in 83 K (warm white, slightly yellow in colour) similar to an incandescent source and 84 K (cool white, white in colour). The T5 or 15 mm tubes are also readily available. They are slightly more efficient as they have to be run on electronic ballasts. Modern tri- phosphor lamps having three phosphors are now available. They are more efficient and can provide much better colour rendition. Fluorescent lamps are widely used for functional lighting.

Mercury Vapor Lamp

This is a high intensity discharge (HID) type and consists of tungsten electrodes inside a tube filled with mercury vapor and argon gas. The electric discharge vaporizes the mercury

Metal Halide Lamps

These, too, are high intensity discharge(HID) lamps and are the halogen version of the mercury high pressure lamp. They require a high-voltage igniter to start them. Many of the smaller wattages can only be run on electronic control gear. They have the following applications:

- Lamps up to 70W are used as down lights in areas where the height is 5 m or more
- Lamps 150-1000 W are used in low bay, medium bay and high bay Luminaries.

They are also used in Luminaries for area/ façade lighting and street lighting though above 250W is uncommon for street lighting.

High- pressure sodium vapour Lamp (HPS)

This is a high intensity discharge(HID) lamp. The construction is similar to the mercury vapor lamp but instead of argon and mercury vapor, neon gas and sodium are used. The sodium vaporizes due to the high temperature generated (300^{oC}). The initial colour is red due to neon, but after 5-10 min the sodium emits its golden white colour. Sodium vapor lamps have the following applications:

- Low bay, medium bay and high bay Luminaries in areas where colour rendition is not important.
- Luminaries for area/façade lighting and street lighting.

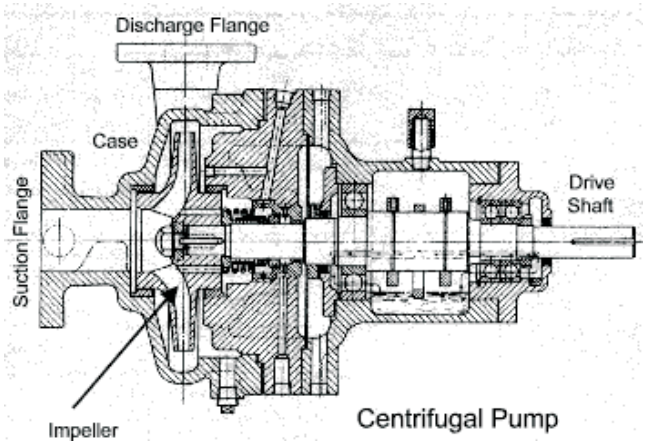
These lamps are one of the most efficient and longest lamp life light sources available.

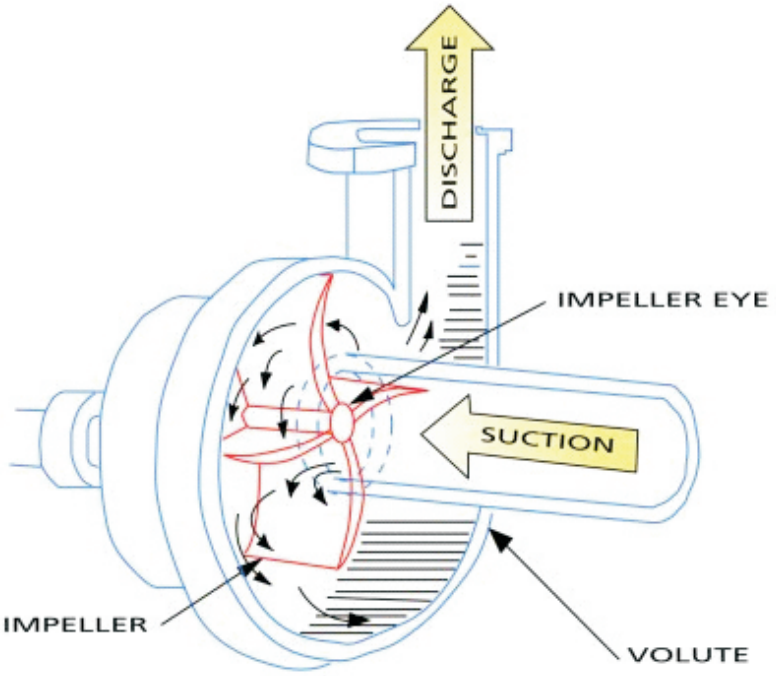
Pumps

In general the following types of pumps are employed in railways.

Centrifugal pumps
Submersible pumps
Turbine pumps
Jet pumps
Mono submersible pumps

CENTRIFUGAL PUMP





1. **PRIMING :-**

Filling the pump with water is called Priming. The pump should not start without being primed. Priming is done filling the pump casing and suction pipe completely with water, thus ensuring that all the air contained in the pump and suction pipe is made to escape. The filling of water can be done manually through the funnel. While filling water, the air-release valve is Kept-open to permit the air to escape from the pump section. Spilling of water through the air release valve is an indication that priming has been completed. The pump is started after closing the valve. The mannual priming is required to be done rarely , when either the foot valve is not functioning properly or there is an air pocket in the suction pipe.

2. **LOW SPEED OF THE ROTATION OF PUMP :-**

The speed of motor driving the pump may be low because of low voltage. Hence it is necessary to check the voltage. Some times the motor may have an open phase which causes it to run at a speed lower than its rated speed. In case of an engine driven pump the fuel supply and governer should be checked.

3. **DISCHARGE HEAD:-**

This represents the height through which the delivered water has to be lifted on the discharge side of the pump. It indicates the difference in level or height between the datum (or centre line of the pump)and the delivery spout of the discharge pipe if water discharge into an overhead service tank or the level of water in that tank at a given instant, if the delivery pipe is connected to the bottom of the tank. The principal reasons of too high discharge head is partially closed sluice valve on the delivery side and blocking of the suction or delivery pipe with solid entrained in water. If the discharge head is kept less than the designed value, it will result in overloading of the pump and motor.

4. DIRECTION OF ROTATION :-

The pump must be run in the direction indicated by an arrow on the casing which is always toward the discharge nozzel. Rotation, right-hand or left hand, is determined by facing the pump from the drive end. It is noted that the impeller rotates in a direction away from the vane curvature.

5. SUCTION HEAD:-

Suction head represents the difference in level between the centre line of the pump (also called datum or datum line) and the water level in the source. It indicates the vertical height through which the water has to be lifted or sucked on the suction side of the pump. The suction lift may be too high due to the clogging of the pump inlet with mud, gravel or some other obstruction. The other reason could be a broken disk or a clogged strainer of the foot valve. In case the pump is being started for the first time, the actual suction lift could be execessive. In such a case the pump is to be lowered so that the total suction lift is with in 6.5 meter (preferably within 4.5m to ensure efficient operation)

5.1 VAPOUR LOCK IN SUCTION LINE :-

Vapour pockets may develop in the pump suction line due to excessive suction head and inadequate submergence of the foot valve. The possible remedies include lowering the pump and increasing the submergence of the foot valve below the pumping water level.

6. IMPELLER:-

Impeller is the rotary element of the pump. It is a wheel or discmounted on the shaft and provided with a number of vanes are arranged in a circular array around an inlet opening at the centre. The impeller is secured on a shaft mounted on suitable bearings. The design of the impeller greatly influences the efficiency and operating characteristics of centrifugal pump.

6.1 PLUGGING OF IMPELLER :-

In case of cavity wells, solids in the water may get a accumulated in the impeller. This may block the pump either completely or partially. Under such situation, the pump casing should be opened and all the parts of the impeller cleaned periodically.

6.2 IMPELLER EYE TOO SMALL :-

The capacity of a pump is a function of diameter of the impeller eye. Therefore, incorrect choice of a pump or moving it from one base to the other may result in this trouble. The only remedy in such a case replacement of the pump with a properly selected one.

7. AIR LEAKAGE :-

Air leakage may take place either in the stuffing box or in the suction pipe. The stuffing box should leak a small amount of water during pump operation. First of all, one should check for the desired leakage by making suitable adjustments. If this adjustments fails to give the desired results, the pump should be stopped and the gland packing checked for damage. A damaged gland packing should be replaced by a new one. The leakage from the stuffing box is again checked. If even after replacement of the gland packing, the defect is not removed, the suction line will have to be checked for air leakage. The flanges and screwed joints are tightened first. In case the leakage is not traceable the same can be located by using a flame or a lighted match stick. The flame if held close to the pipe and flanges, will be drawn towards any leak.

8. FOOT VALVE :-

Foot valve is an integral component of a centrifugal pump. It is fixed at the bottom of the suction pipe. It keeps the centrifugal pump primed and restricts the entry of foreign matter, specially floating debris and aquatic plants into the suction pipe. The valve is a one way flap piece made of leather or rubber and hinged to the valve body. When the pump is not working the valve rests on a well machine base plate and prevents the return flow of water to the well or other source. Thus water is retained in the pump casing and suction pipe. The total area of the opening in the strainer of the footvalve should be about 2.5 times the cross sectional area of the suction pipe. Any reduction in the open area results in heavy friction losses and reduced pump discharge. Similarly, the flap valve in the valve body should open fully.

9. SLUICE VALVE :-

If sluice valve is provided, it is kept closed at the time of starting. This will allow the motor to be started without load. When the pump reaches its full speed, the sluice valve is opened gradually until the desired quantity of water is delivered. Care is taken not to run the pump for a long period with the sluice valve closed, as this may over heat the pump.

10. BEARING:-

(a) Grease lubrication:-

For grease lubricated ball bearing, only a small amount of lubricant is required and lubrication intervals are generally long. How long a bearing can run without grease being added or replaced, depends upon the grease properties, the size and design of the bearing and housing, the speed and other operating conditions. For pumps operating under severe service, perhaps greasing is required every three months and for normal service 1 year to be on the safe side, the addition of grease should be determined from experience.

(b) Oil lubrication :-

For oil-lubricated ball bearings mineral oil of the best quality should be used. Bearing housing with oil-bath lubrication or with an oil sump which is to be filled to a given level, ordinarily are equipped with oil gauges. Oil is added when the oil level due to loss, has dropped below the established low limit. In general, the oil level should never reach higher than centre of the lowest rolling element when the bearing is not rotating.

(c) Heating of bearing :-

Heating of bearing invariably means too much grease. Careful inspection to determine the trouble should be made before more grease is added.

(d) Cleaning of bearing:-

Great care should be exercised to keep the bearing housing immaculately clean, and only clean grease should be used. Under no circumstances should grease which has been used before be applied. Foreign solids or liquids invading the housing can completely ruin the bearings in a short time. It is important to use clean instruments and clothes when cleaning housing. The housing should be flushed clean, using gasoline or a high grade of water free kerosene.

11. WEARING RINGS :-

Wearing ring clearances should be checked from time to time. When the wearing ring clearance is increased, a loss in capacity and head is caused . If the clearance is approximately twice the original, or if the loss in capacity and head does not meet requirements, it is time to replace the rings.

12. STUFFING BOX AND SHAFT PACKINGS :-

Stuffing box should be carefully cleaned and the packing placed in them. Generally a leakage of 15-30 drops of liquid per minute from the stuffing box is excessive or the packing is worn, the entire packing in the box will have to be replaced. Replacing just a ring or two will not result in an effective sealing. The

shaft and shaft sleeve surface are properly cleaned before inserting the packing rings. There should not be any burrs or scores on the working surface. If the shaft sleeve is badly worn or scored, it is replaced.

The radial clearance between the shaft and the stuffing box is measured for determining the size of a new gland packing to be provided.

Be sure that sufficient packing is placed at the back of the water seal cage. If the water is to be pumped is dirty or gritty, sealing water should be piped to the stuffing box from clean outside source of supply in order to prevent damage to the packing and shaft. In placing the packing each packing ring should be cut to the proper length so that end comes together but do not overlap. The succeding rings of packing should be placed in the stuffing box having packing joints staggered. The packing should not be pressed too tight as it may result in burning the packing and cutting the shaft. If the stuffing is not properly packed, friction in stuffing box prevents turning the rotor by hand. On starting the pump it is advised to have the packing slightly loose without causing an air leak, and if it seems to leak, instead of putting too much pressure initially tightened up the gland gradually. The packing should be occassionally changed.

13. <u>Pump Foundation</u> :-

The foundation should be sufficiently substantial to absorb any vibration and to form a permanent rigid support for the base plate. This is important for maintaining the alignment of a direct connected unit. A concrete fondation on a solid base is advisable . Foundation bolts of the proper size should be embedded in the concrete located by a drawing or emplate. Apipe sleeve of about two and one half diameter larger than the bolts should be used to allow movement for the final position of the foundation bolts.

15. PUMP ALIGNMENT :-

The alignment of the shaft is one of the important considerations. Realignment of pump is necessary after complete unit has been levelled on the foundation and again after the grout has been set and foundation both has been tightened. The alignment must be checked after the unit is piped up and rechecked periodically.

Type of misalignment

(a) Angular misalignment:-

Shaft with axis concentric but not parallel.

(b) Parallel misalignment:-

Shaft with axis parallel but not conentric.

The two halves of the coupling should be at least 4 mm apart so that they cannot touch each other when the driver shaft is rotated. Necessary tools for approximately checking are a straight edge and an out side caliper.

A check for parallel alignment is made by placing a straight edge across both coupling periphery at the top, bottom and both the sides. The unit will be in parallel alignment when the straight edge rests evenly on the coupling periphery at all positions Care must be taken to have the straight edge parallel to the axis of the shafts.

A check for angular misalignment is made by using an out side caliper across the width of the coupling faces at various points.

Submersible pumps

The submersible pump consists essentially of the following component parts

(i) Motor:- The motor is located below the pump suction close to the bottom of the well. As its diameter has necessarily to be small, it a disproportionately long compared to its diameter. Although the motor is the familiar 3-phase squirrel cage induction type, it is of special construction and has many interesting features. The motor operates at the highest possible speed of about 2940 rpm for 50 c/s supply. It is of the wet type, i.e., water is permitted to enter into the unit and circulate between the rotor and stator. The windings in the stator unit are hermetically sealed, by providing a thin water proof tissue paper between core laminations which effectively prevents entry of water. The bearings are also water lubricated. The bottom most bearing of the motor is Mitchell water lubricated thrust bearing employing graphitic carbon pressure pads.

(ii) Power supply: This is given by a flexible tough rubber sheathed 3-core cable clamped on to the delivery pipe at suitable intervals. The cable is supplied in one whole length, with the bottom end hermetically sealed into the motor body. The stator winding leads are led out of the body through connecting pins, which are insulated and sealed against entry of water by using adhesives like araldite. The cable ends terminate on sockets which engage with the pins. The cable is held tightly in position by a special water proof rubber gland. If the cable should get damaged or cut, it can be readily re-jointed and vulcanized. The motor unit is arranged for being easily detached from the pump body.

(iii) Impellers: The specific speed is between 800 and 2000. The impellers may be of cast iron, but preferably of gun metal. A high lift pump has a large number of stages up to 20 or more, since its diameter is small and head per stage is low. Suitably shaped diffuser vanes are provided.

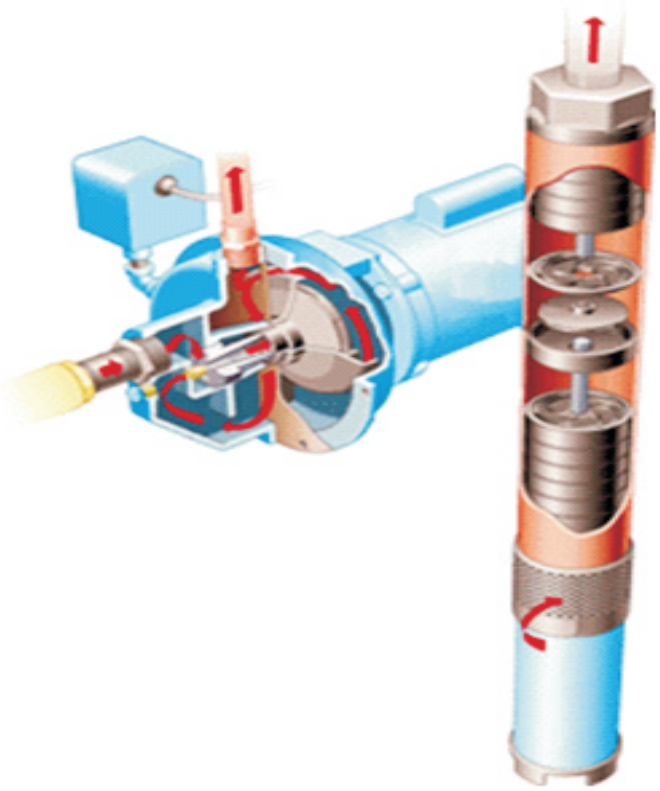


Diagram of submersible pump

Turbine pump

A turbine pump, also called regenerative pump, differs from the centrifugal pump, in that the water is admitted, not at the centre of the impellers, but through an outside opening on the casing. The impeller has a series of blades (fins or buckets) fixed on its outer rim which revolve inside an annular space within the case in the clockwise direction. Water enters at the outer edge of the impeller, and is propelled forward round the pump case through the annular channel, which is much larger than the width of the blades. As the water is carried along, it moves spirally from one blade to the following one until one revolution when it is diverted by a deflector plate to the discharge opening.

(i) A turbine pump can deliver at a pressure greater than what can be delivered by a purely centrifugal pump. Secondly it is self-priming, once it is filled with water, i.e. any air entering it subsequently through the suction is carried along with the water and delivered through the delivery pipe, whereas in a centrifugal pump entry of air into the suction would make it inoperative.

JET PUMP

A jet pump is one in which a small quantity of water under pressure is used to assist a centrifugal pump in pumping water with suction heads exceeding 24 ft., which is normally beyond a centrifugal pumps capacity; it reduces suction head and helps starting. The basic principle of this pump is that when a liquid under pressure is released in front of the mouth of an orifice, a partial vacuum is created in the immediate vicinity of the jet and the surrounding water is sucked into the orifice, very similar to the action of an ordinary paint spray gun, in which the liquid paint in the paint receptacle is sucked up and discharged as finely atomized spray, sue to the action of the compressed air. To get maximum efficiency, a venture tube is provided in front of the jet. This has a special streamlined shape towards the jet and a cone shaped outlet.

This system requires a centrifugal or other pump at the ground level. From its delivery side a pressure pipe is taken down to the bottom of the well, well secured to the suction pipeline and connected to the jet nozzle assembly. The water in the well is sucked by the jet, through the strainer and foot valve, and forced up the suction tube into the pump.

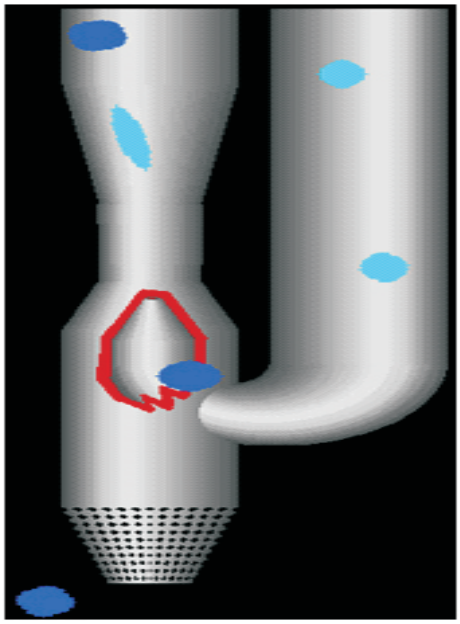


Diagram of jet pump

Mono submersible pump

These pumps can be directly placed in open wells and submerged in water. They have the following advantages;

1. Easy installation and vibration free quick start without suction trouble
2. No maintenance
3. Requires only one size of pipe
4. No foundation or pump house required
5. No risk of pilferage

SELECTION OF CAPACITY OF THE MOTOR

To determine the horse power of the electric motor or engine used in driving a pump, It Is necessary to know the efficiency of the pump, type of drive, type of power unit head under which the pump operates and the losses In the pumping system. The BHP of the motor as well as the Input HP of a pump set can be assessed with the application of following formulae.

Water Horse Power (WHP)

It is to theoretical power required for pumping. It is expressed as

$$\frac{\text{Discharge in GPM X 10 x total head (ft)}}{33000 \times 60}$$

MOTORS

A motor is an electrical machine which converts **Electrical energy** into **Mechanical energy**.

Classification of Motors

The motors are mainly classified as dc motors and ac 1-phase and 3-phase motors.

DC MOTORS

1. DC SHUNT MOTOR
2. DC SERIES MOTOR
3. DC COMPOUND MOTOR
   (a) DIFFERENTIAL COMPOUND MOTOR
   (b) CUMULATIVE COMPOUND MOTOR

AC SINGLE PHASE MOTORS;

1. SPLIT PHASE INDUCTION MOTORS
   (a) SPLIT PHASE INDUCTION MOTORS
   (b) CAPACITOR MOTORS
   (c) CAPACITOR START INDUCTION MOTORS
   (d) CAPACITOR START CAPACITOR RUN MOTORS.
2. REPULSION MOTORS;
   (a) PLAIN REPULSION MOTORS
   (b) REPULSION START INDUCTION MOTORS
   (c) REPULSION INDUCTION MOTORS.
3. SHADED POLE INDUCTION MOTORS
4. UNIVERSAL MOTOR OR AC SERIES MOTOR.

AC THREE PHASE MOTORS;

1. ASYNCHRONOUS MOTORS (INDUCTION MOTORS)
   (a) SQUIRREL CAGE INDUCTION MOTORS
   (b) DOUBLE SQUIRREL CAGE INDUCTION MOTORS
   (c) SLIPRING INDUCTION MOTORS
2. SYNCHRONOUS MOTORS

Basic construction of Induction Motor

The AC induction motor comprises 2 electromagnetic parts:

- Stationary part called the stator
- Rotating part called the rotor, supported at each end on bearings

The stator and the rotor are each made up of:

- An electric circuit, usually made of insulated copper or aluminum, to carry current
- A magnetic circuit, usually made from laminated steel, to carry magnetic flux

The stator

The stator is the outer stationary part of the motor, which consists of:

- **The outer cylindrical frame of the motor**, which is made either of welded sheet steel, cast iron or cast aluminum alloy. This may include feet or a flange for mounting.

- **The magnetic path**, which comprises a set of slotted steel laminations pressed into the cylindrical space inside the outer frame. The magnetic path is laminated to reduce eddy currents, lower losses and lower heating.

- **A set of insulated electrical windings**, which are placed inside the slots of the laminated magnetic path. The cross-sectional area of these windings must be large enough for the power rating of the motor. For a 3-phase motor, 3 sets of windings are required, one for each phase.

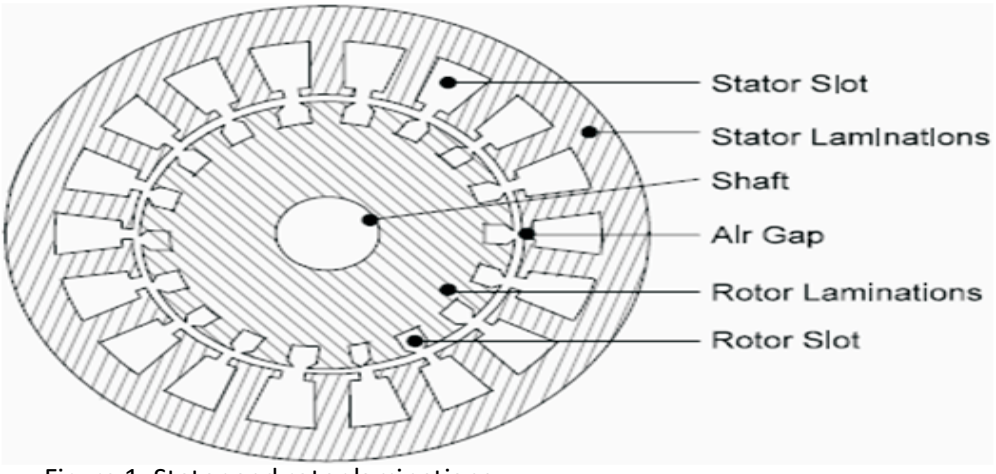


Figure 1: Stator and rotor laminations

The rotor

This is the rotating part of the motor. As with the stator above, the rotor consists of a set of slotted steel laminations pressed together in the form of a cylindrical magnetic path and the electrical circuit. The electrical circuit of the rotor can be either:

- **Wound rotor type**, which comprises 3 sets of insulated windings with connections brought out to 3 sliprings mounted on the shaft. The external connections to the rotating part are made via brushes onto the sliprings. Consequently, this type of motor is often referred to as a slipring motor.

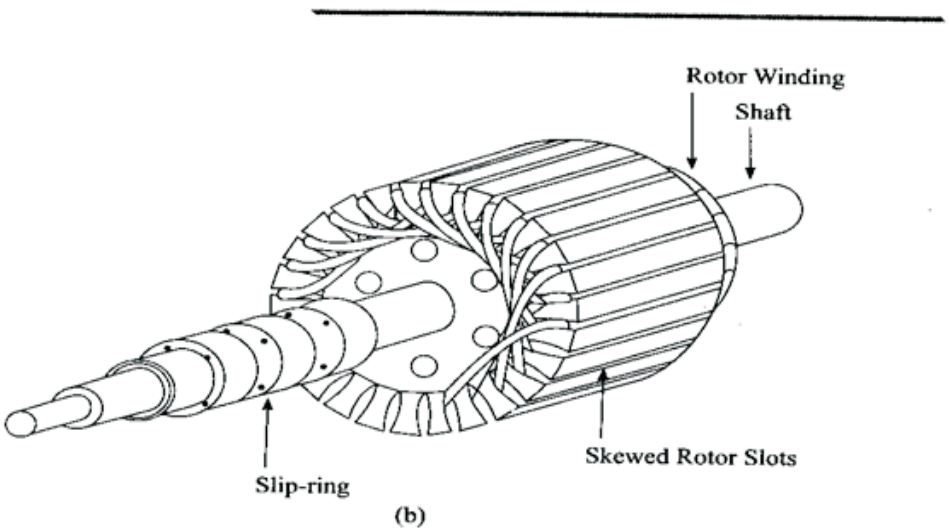


Fig. 4.4 *(a) Simplified diagrammatic representation (in sectional front view) of a slip-ring type induction motor (b) Rotor of a slip-ring type induction motor*

- **Squirrel cage rotor type**, which comprises a set of copper or aluminum bars installed into the slots, which are connected to an end-ring at each end of the rotor. The construction of these rotor windings resembles a 'squirrel cage'. Aluminum rotor bars are usually die-cast into the rotor slots, which results in a very rugged construction. Even though the aluminum rotor bars are in direct contact with the steel laminations, practically all the rotor current flows through the aluminum bars and not in the laminations.

The other parts

The other parts, which are required to complete the induction motor are:

- Two end-flanges to support the two bearings, one at the drive-end (DE) and the other at the non drive-end (NDE)
- Two bearings to support the rotating shaft, at DE and NDE
- Steel shaft for transmitting the torque to the load
- Cooling fan located at the NDE to provide forced cooling for the stator and rotor
- Terminal box on top or either side to receive the external electrical connections

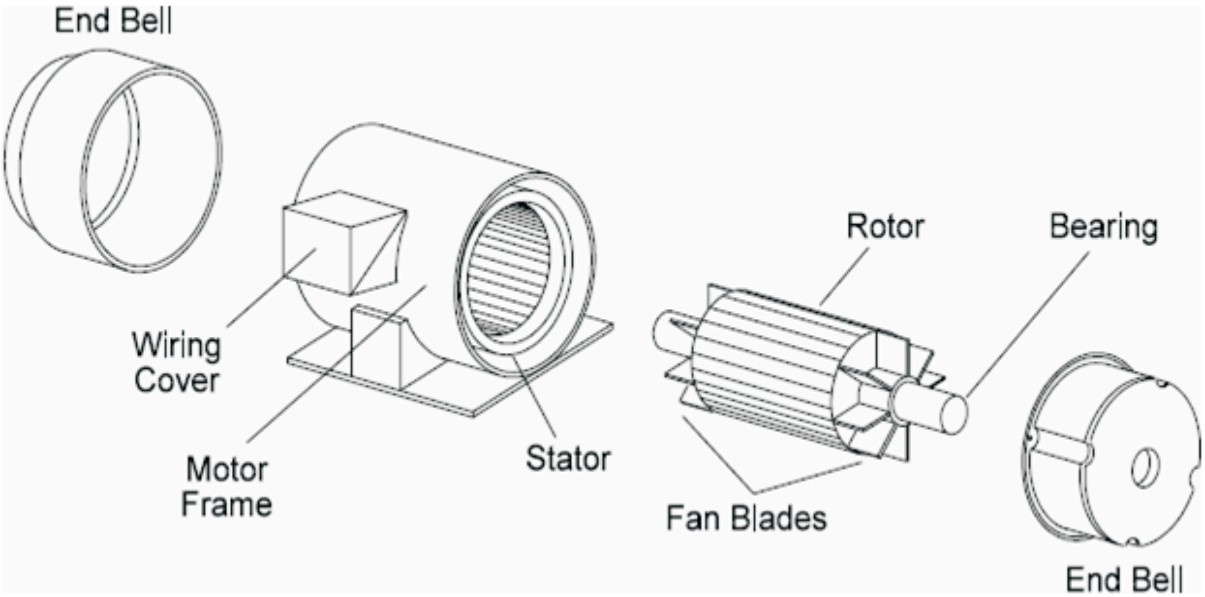
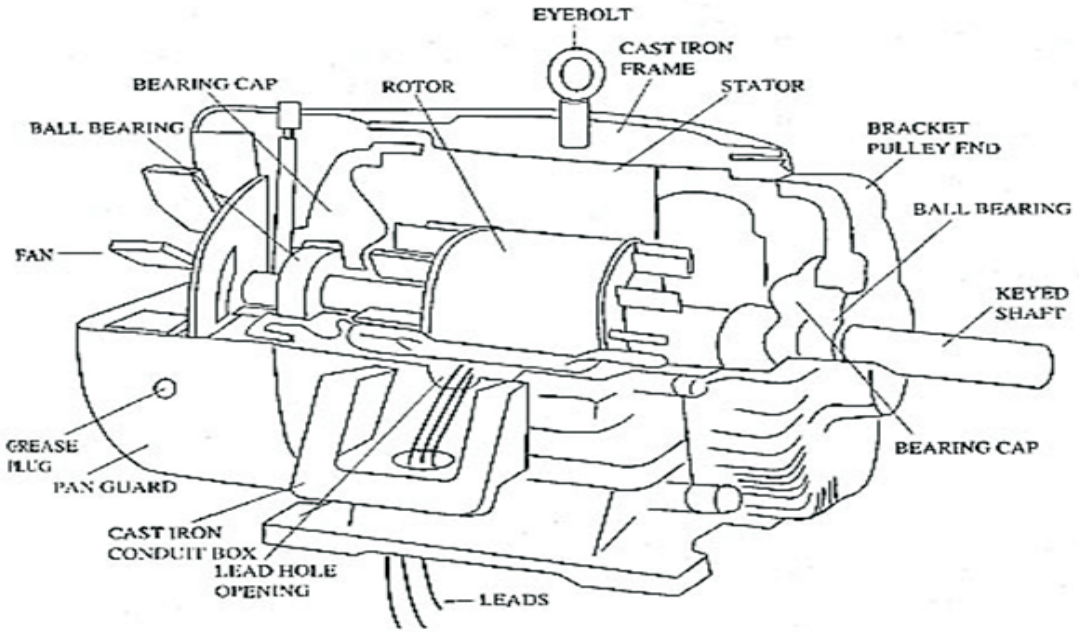
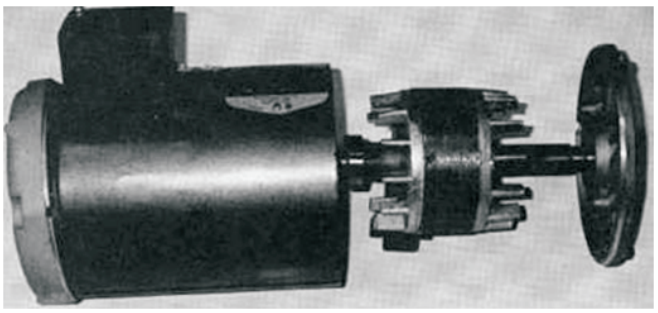
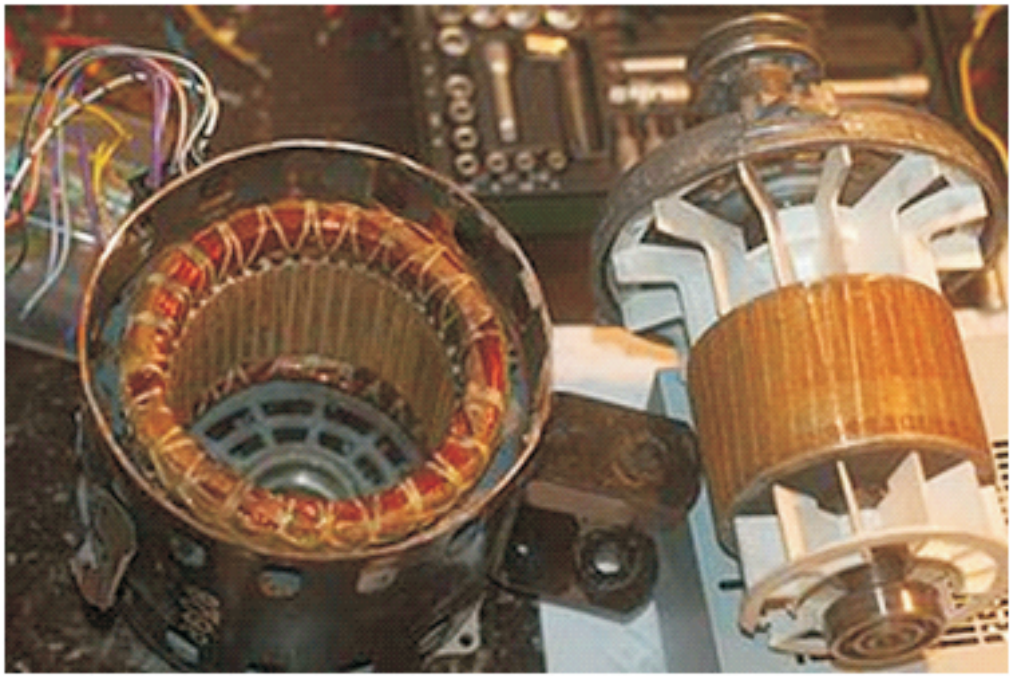


Figure 2: Assembly details of a typical AC induction motor







AC SINGLE PHASE MOTORS

SPLIT PHASE INDUCTION MOTORS:

In this motor, the stator has two windings, placed in space with a phase difference of 90 degrees electrically. One winding is called running winding while second winding is known as starting winding.

A phase difference in the currents in the two windings is produced by either having different R/X ratio of the running and starting winding.

These two currents are approximately 90 degrees out of phase with each other and causes rotating magnetic field. Thus the rotor in the magnetic field starts rotating. Both the windings are in the circuit during normal operation.

In some motors, the starting winding is cut off by a centrifugal switch automatically when the motor attains its normal speed. Such motors are known as “Resistance start induction motors”.

The direction of rotating of all the induction motors can be changed by either changing current through the running winding or starting winding.

DISADVANTAGES;Very low power factor and low starting torque.

APPLICATIONS; Small pumps, grinders, fans, buffing machines etc.,

THREE PHASE INDUCTION MOTORS

These motors are more widely used than any other type of motors.

WORKING PRINCIPLE: In this when a three phase stator winding is supplied by a three phase supply, a rotating magnetic field is set up. This rotating flux cuts the stationary rotor conductors and induces emf in them, which causes the heavy circulating currents to flow due to very small resistance of the rotor. The rotor induced current, accordingly to Lenz's law, flows in such a direction that it opposes the cause which is inducing the current.

In this case, the cause producing the rotor current is the relative speed between the rotating magnetic field of the stator and the stationary rotor. Hence to reduce this relative speed, rotor conductors start to rotate n the same direction in which the field is rotating and tries to catch it up.

SQUIRREL CAGE INDUCTION MOTORS;

A three phase squirrel cage induction motor has two main parts namely stator and rotor.

The stator consists of silicon laminations insulated from each other having slots in its inner surface to carry the windings. The stator is wound for thee phase only and its connections are brought out to terminal box fitted to the side of the frame. The rotor is cylindrically in shape and is built up of number of laminations having slots on its outer surface. Solid copper conductors are inserted in the rotor by soldering or brazing the copper rings. The rotor is then mounted on the shaft and supported on the bearings housed in the side covers of the motor.

ADVANTAGES; They are cheap and are practically constant speed motors

DISADVANTAGES;Low starting torque due to low power factor at starting.

APPLICATIONS; Lathes, water pumps, drilling machines, grinders saw mills, flour mills etc.,

SLIPRING INDUCTION MOTOR;

The stator of a slip ring induction motor is similar to the stator of squirrel cage motor.

The rotor is wound for the same number of poles and phases as that of stator winding. The three ends of the rotor, 3-phase winding coils are connected in star and the other three remaining ends are brought out and connected to the three slip rings mounted on the shaft of the motor. By using carbon brushes, external starting resistance is connected to the slip rings. The external resistances are connected in star.

The starting resistances are included in the rotor circuit to improve the starting torque and to decrease the starting current. As soon as the motor attains its normal speed, the rheostat resistances are cut off gradually from the rotor circuit and finally slip rings are short circuited.

It should be remembered that 3 phase supply is given only to the stator winding similar to that of squirrel cage induction motors.

ADVANTAGES Starting torque is much greater than squirrel cage induction motor.

DISADVANTAGES More costly

APPLICATIONS They are used where high starting torque is required such as in plainers, cranes, rolling mills, lifts etc.,

Motor Starters

Induction motors when direct on Line started take 5 to 7 times their full load current and develop only 1.5 to 2.5 times their full load torque. This initial excessive current causes a large line voltage drop which effects the operation of other electrical equipment. Hence only low power motors say upto 7.5 hp are direct started.

The type of starter used depends on the type of motor being started.

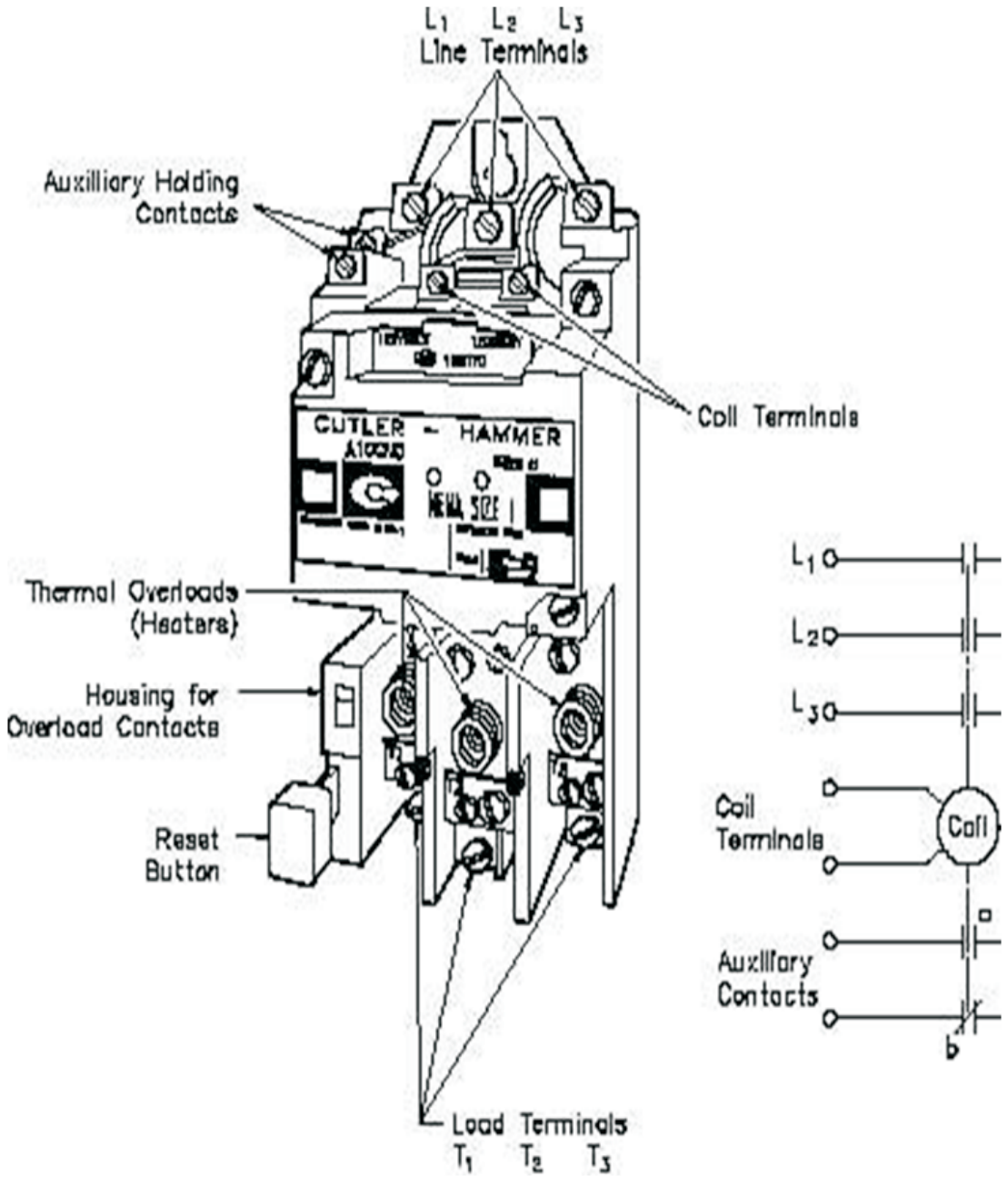
For squirrel cage induction motors the following starters are used .

- Direct on line starter
- Auto transformer starter
- Star delta starter.

For slip ring Induction motors the rotor rheostat type of starter is used.

Direct On Line starter

In this type of starter the full line voltage is directly applied across the motor terminals.
The main components in a DOL starter are
No-volt coil
ON-OFF button
Over load relay.
The no-volt coil rating could be of 440 V or 230V.
The contactor consists of Main and Auxilliary contacts. The main contacts are of Normally open type. The auxiliary contacts could be 2 or 3 with combination of 1NC+1NO or 2 NC+1NO.



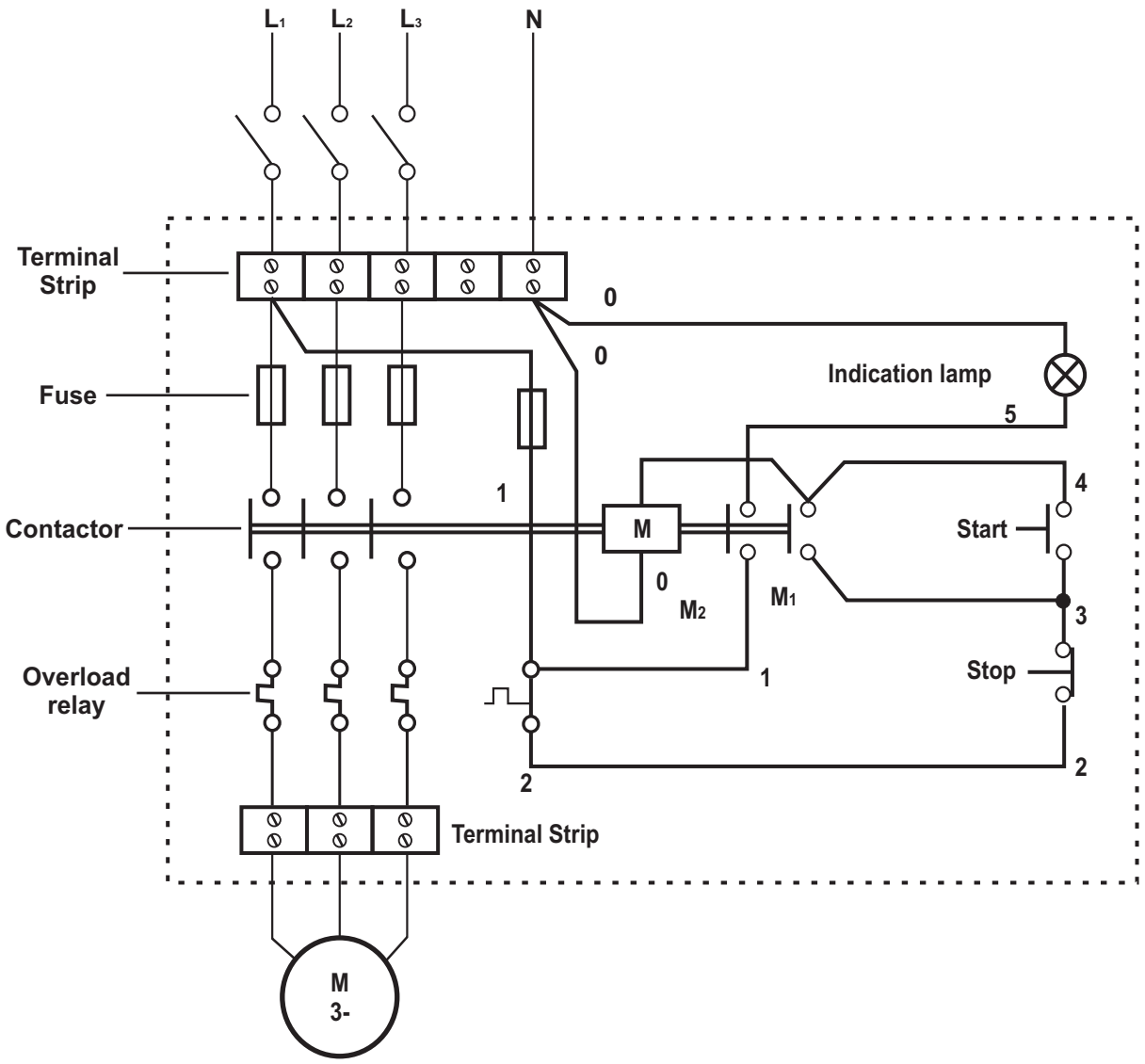


Fig. Wiring diagram for a Direct On line starter

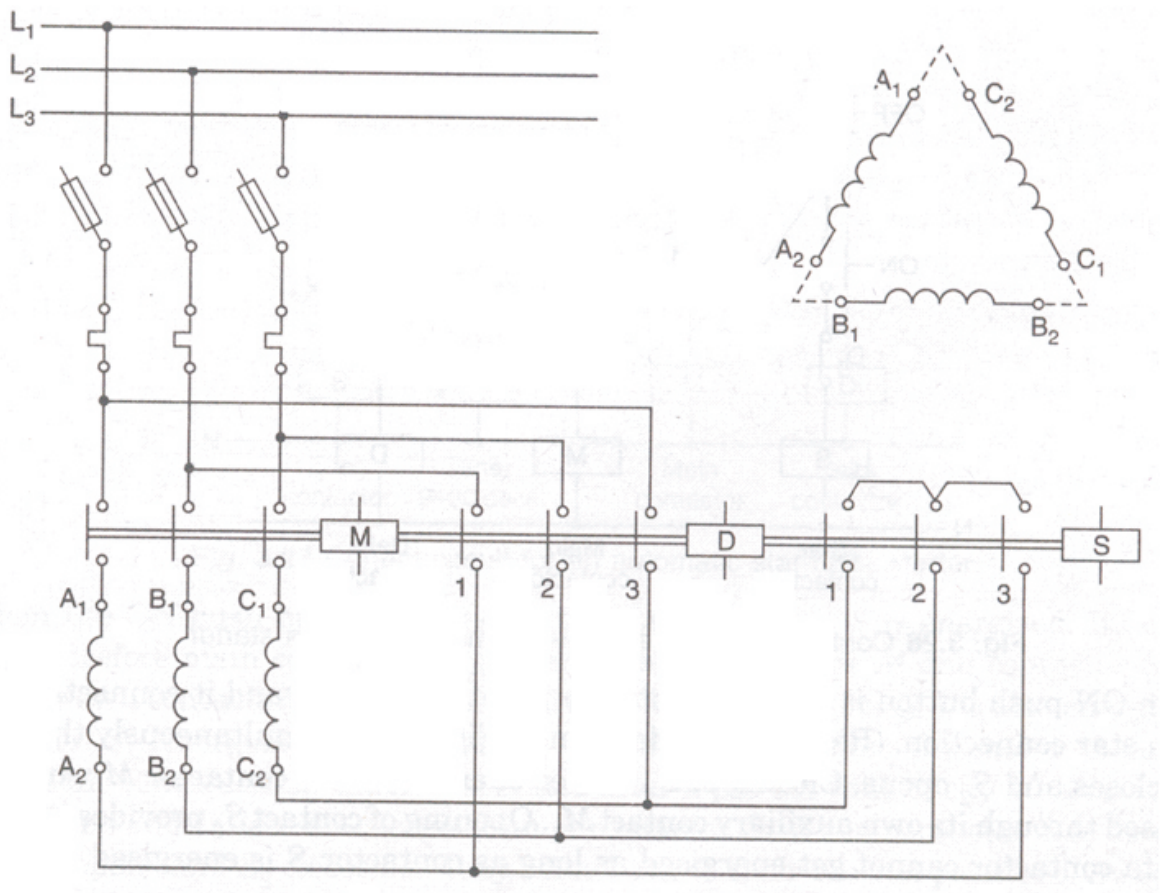
All contact positions in this control diagram are in their normal positions meaning that when the coil M is de-energised. In normal position the supply reaches upto wire number 3 through the normally closed contact of overload relay and STOP push button. When the START push button is pressed, supply reaches terminal 4 at contactor coil and energises the contactor coil. The main contacts of the contactor close and the motor starts running. At the same time auxiliary contacts M1 and M2 also close. Closing of M1 provides a parallel path across the START push button. Now, even if START push button is released, contactor coil remains energized through the closed contact M1. Closed contact M2 energised the indication lamp showing that the motor is ON. Referring back to the wiring diagram it will be observed that the circuit is the same as the schematic diagram but is little difficult to read than the schematic diagram.

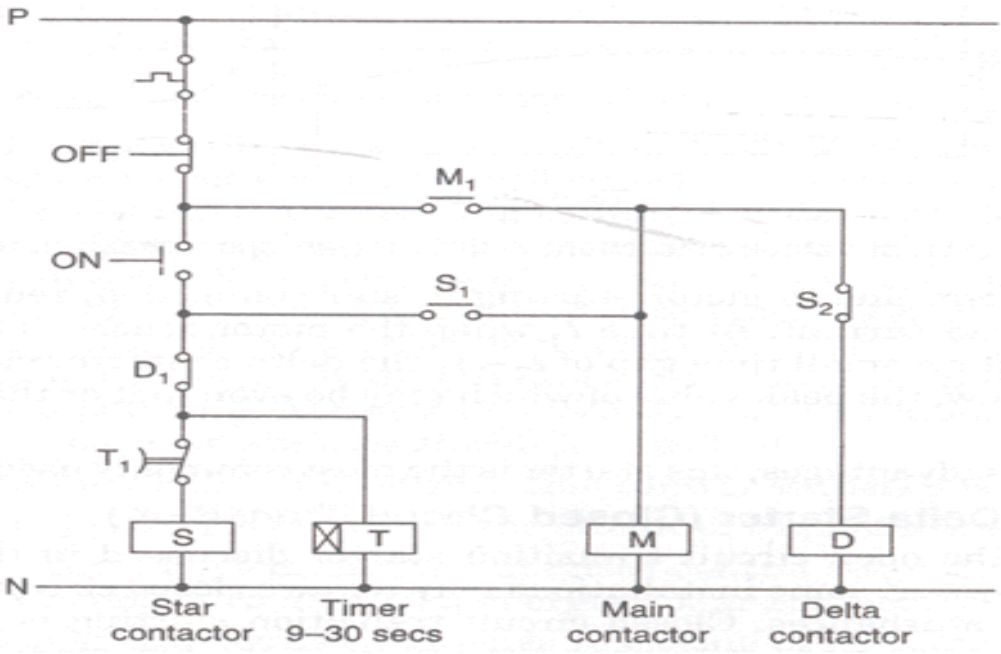
Star –Delta starter

As large capacity Induction motors take high starting current causing voltage fluctuations it is necessary to reduce the starting current by reducing the applied voltage. By use of this type of starter for starting squirrel cage Induction motors, at the time of starting the squirrel cage motor winding is connected in star so that phase voltage is reduced to 0.577 times the line voltage and then when the motor picks up spreed the windings are connected in Delta so that phase voltage equals Line voltage.The motor now runs at normal rated speed.

To connect a star delta switch to a 3 phase squirrel cage motor all the six terminals of the winding should be available.

Before connecting a Star delta starter to a motor, the terminals of the motor are to be correctly identified.





In an automatic star delta starter, the time required to change from star to delta connection is obtained with a time delay relay. A knob on the time delay relay can be adjusted at the desired time setting required for running the motor in star. The time setting is around 10 sec. for lightly loaded motor time setting is a little less, while for fully loaded motors the time setting may be little more than 10secs. The power circuit diagram for an automatic star-delta starter is the same as that shown in the figure. The control circuit is as above.

When the ON push button is pressed the star contactor S is energized. Its contact S1 closes and therefore main contactor M gets energized. Contactor M and contactor S get hold through their own contacts M1 and S1 respectively. A time delay relay T is also energized along with contactor S. energisation of contactor S and then M cause the motor to run in star connection. This continues till timer T operates after a pre-set time of say 10secs, its delayed contact Tech-I opens and causes de-energisation of contactor S. when contactor S is de-energised its contact S1 opens and S2 closes i.e., they come back to their normal positions. As contact M1 is already closed the delta contactor gets energized and the motor runs with its windings in delta connection. As soon as the delta contactor is energized its contact D1 opens which provides interlocking avoiding simultaneous energisation of star-contactor. At the same time it also de-energises timer T. In running condition therefore contactor M and contactor D remain energized while contactor S and timer T remain de-energised.

ELEC-1.6
&
ELEC-1.9

Maintenance schedules, critical points, settings and tolerance of major (pumps, DG sets, Water coolers, Window type A.C. units, CLS panel, Sub-station, Solar water heater system, Lifts, Transformers, Power supply equipments).

MAINTENANCE OF EQUIPMENT

The schedule maintenance of equipment installed in sub-station is essential to ensure trouble free service and avoiding un-necessary interruptions.
Following safety precautions should be observed during maintenance of transformers:
Ensure all arrangements are safe.
Isolate the transformer from supply and earth the terminals properly.
Check & record the oil level in the tank before unseal the tank and unscrew the nuts and bolts.
Ensure the work place is fire proof; care should be taken to prevent fire.
Put a caution board "NO SMOKING".
The staff should not have anything in his breast pocket and should not wear watch or ring.
Item wise activities involved in various schedules of sub-station **equipped with transformers up to 1000 kVA** are as follows:

DAILY SCHEDULE (If manned)

Items		**Schedule Inspection**	**Action required**
Switch yard			
	All jumpers & other connections	Check visually for flash/ spark marks	Tighten the respective bi-metallic clamp/ connection
Transformer			
	Temperature	Check oil temperature during peak load hours. Check ambient temperature	Either switch off some load or share with other transformer
	Tank	Check for oil leakage	Arrest the leakage
	Dehydrating breather	Check visually colour of active agent	Ensure blue colour of silicagel
Control Panel Room			
	Relays	Check visually target position	Take corrective action
	MCCB/Fuse		
	Load (amp.)	Check against rated figure	Reduce load if higher
	Voltage	Check against rated figure	Take corrective action
	PF meter	Monitor the PF reading	Take corrective action. It should be nearly unity
	General	Ensure general cleanliness of room and panels	
Capacitor Bank			
	All connections	Check visually for flash/ spark marks	Tighten the clamp/ connection

MONTHLY SCHEDULE

Note: In addition to daily maintenance, carry out following works:

Items		Schedule Inspection	Action required
Switch yard			
	Yard	Growth of unwanted shrubs, garbage etc.	Keep the yard free from shrubs, garbage etc.
	Earth pits	Check neatness and tidiness	Maintain tidiness and do watering
	Earth connections	Check all connection ends at earth pits and metal parts	Ensure solid connection
Transformer			
	Oil level	Check oil level in conservator	If low, top up with dry oil.
	Connections	Open terminal box cover and check connections visually for flash/spark marks	Take corrective action
	Dehydrating breather	Check air passages. Check colour of active agent	Clear passages, if required. Reactivate silicagel if found pink
	Cleaning	Entire transformer body	Clean entire transformer including bushings
	Buchholz Relay	Check gas in the chamber	Take corrective action
Control Panel Room			
	Load (amp.)	Check load balancing	If found unbalance, distribute the load equally on all phases
	MCCB/Fuse	Check current ratings	Provide proper size of MCCB/ Fuse according to load condition

QUARTERLY SCHEDULE

Note: In addition to monthly maintenance, carry out following works:

Items		Schedule Inspection	Action required
Switch yard			
	Support Insulators	Examine for cracks, rust and flash/ spark marks	Clean and replace if required
	Lightning arresters	Check line and earth connection	Clean and ensure rigid connection
	AB switch/ Isolator	Check for proper operation Check line and earth connection	Clean and lubricate Ensure rigid connection
	Jumpers	Check all jumpers	Tighten, if required

Items		Schedule Inspection	Action required
Transformer			
	Bushing	Examine for cracks, rust and flash/ spark marks Check for oil seepage	Clean and replace if required Arrest leakage
Control Panel Room			
	Load (amp.)	Check load balancing	If found unbalance, distribute the load equally on all phases
	MCCB/Fuse	Check condition for overheating	Replace, if required
	LT Bus bars	Check visually for overheating, flash/ spark marks	Take corrective action

HALF YEARLY SCHEDULE

Note: hi addition to quarterly maintenance, carry out following works:

Items		Schedule Inspection	Action required
Transformer			
	Oil	Check BDV	If BDV < 30 kV/cm, do filtration to restore quality of oil.
	Cable box, gasketed joints and gauges	Inspect for leakage and cracks	Take corrective action
Control Panel Room			
	Load (amp.)	Check load balancing	If found unbalance, distribute the load equally on all three phases
	Oil circuit breakers	Check oil level in the tanks. Test the oil, if shows signs of moisture, carbonization or dirt. Check all valves for oil leakage. Check the condition of all gaskets provided to prevent entrance of water and leakage of oil.	Maintain at the proper height. Filter or replace if necessary. Arrest leakage Ensure they are healthy.
	ACB	Check entire unit	Clean with lint free cloth
		Check contacts	Clean fixed and moving contacts
		Operation Check tripping of relay	Clean and lubricate operating mechanism Re-set if required

YEARLY SCHEDULE

Note: In addition to half yearly maintenance, carry out following works:

Items		Schedule Inspection	Action required
Switch yard			
	Concreting/ coping of the supports	Check the condition of the concreting/ coping of the supports of the structures. The supports fixing to earth become weal and during the time of heavy rains, cyclone or flooding, the structure may fall, leading to a major breakdown.	If there are cracks or the coping of concreting is coming off, preventive action may be taken to concrete or coping.
	Gravel/crushe drock	Check leveling, oil stain and dust accumulation	Spray water to remove oil stain and accumulated dust. Maintain leveling to avoid formation of water pools.
	Earth resistance	Measure the earth resistance of individual equipment earth pit, preferably during summer	If it is beyond permissible limits, take corrective action
	Earth connection of metal parts	Check the earth connection of metal parts to ensure that the metal parts are properly connected to the earth so that any earth fault of the metal parts is cleared quickly and efficiently. If not, accidents may happen.	Take corrective action
	AB switches	Check operation.	Lubricate and ensure proper operation
		Check the line and earth connection of AB switches.	Ensure they are connected properly
	HT lightning arresters	Measure IR value Line-Earth	If low, replace it.
		Check the line and earth connection of HT lightning arresters	Ensure they are connected properly
	Connections from and to bus-bars	Check the connections	Tighten the connections properly from the bus bars and bars to the lines.
	Insulators	Clean and check all insulators for any crack or damage, flash/ spark marks.	Change, if cracks or damages are developing

Transformer			
	Winding	Measure IR value HV-Earth HV-LV LV-Earth	If low, investigate and take corrective action
Items		**Schedule** Inspection	**Action required**
	Oil	Check BDV	If BDV < 30 kV/cm, do filtration to restore quality of oil.
		Check for incipient faults	Perform dissolve gas analysis (DGA) as per anncxure - B
	Buchholz relay, alarms and their circuits etc.	Check floats, alarm contacts, their operation, fuses etc. Check relay accuracy, etc.	Clean components and replace contacts and fuses if necessary. Change the setting, if necessary.
	Earth resistance	Check values of earth resistance	If high, investigate and take corrective action
	Body	Check for peelings/ rusting/ damage	Repaint, as required
	Cable box	Check the sealing arrangement for filling holes	Ensure sealing arrangement for filling holes

5 YEARLY SCHEDULE

Note: In addition to yearly maintenance, carry out following works:

Items		**Schedule Inspection**	**Action required**
Switch yard			
	Gravel/crushed rock	Check condition, up layer and size	Remove rounded pieces and muck by screening. Maintain up layer of 100 mm by additional quantity of size 40mm
Transformer			
	Conservator	Inspect inside for sludge etc.	Clean or flush inside with oil
	Core and windings	Overall inspection including lifting of core and coils	Wash with clean dry oil.
	Rollers	Examine carefully during overhauling	Grease them properly
	Circuit breaker	Examine carefully during overhauling	Overhaul every circuit breaker completely

TIPS FOR IMPROVING MAINTENANCE

Transformer

The principal object of transformer maintenance is to maintain the insulation in good condition. Moisture, dust and excessive heat are the main reasons of insulation deterioration and avoidance of these will keep insulation in good condition.

· Oil

o Leakage of excessive oil to be investigated and repaired as early as possible.
o Maintain the record of oil used and always prefer the same make of oil for topping up or replacement. The oil of different makes may be separated into layers. The mixture of oil have greater tendency to form acidity or sludge.
o Never use the released oil even if the same make.
o Never mix the transformer oil to the oil of switchgear equipment.
o Only the dielectric strength does not indicate the healthy condition of oil. Therefore in addition to chemical tests other tests such as acidity test, test for polar contaminants, sludge also to be carried out.
o If the acidity exceeds limits, open the cover to ascertain the condition of interior of tank, core and windings. Take suitable action if sludge or corrosion is evident.
o DGA : Dissolve Gas Analysis to assess the internal condition of the transformer.

· Transformer Body

o Ensure correct pressure for tightening the nut and bolt at joints. Replace the gaskets as and when opened the gasketed joints.
o Measure the insulation resistance without disturbing thing.
o Properly clean the tank cover before opening it.
o Remove all nuts and bolts etc. and keep them properly, before removing the cover.
o Dismount bushings, if mounted on top. Remove the cover carefully if core and windings are separate. If core and windings are suspended from tank cover, provide eye bolts on the cover for lifting along with core and winding. Care should be taken to ensure vertical removal of the core. After lifting the core, recount and tally the spanners and tools used.
o The spanner should be cleaned and to be held by cotton strap or string tied round the waist or wrist of the staff opening tank cover.

· Core and Windings

o Lifting the core and coils
Remove the fixing devices if core and coils are suspended, from each end near the top.
Unload the connections of bushings and remove the bushings from tank walls.
Remove mechanical connection to the tap changing switch handle, if any.
Remove any earthing strips between the core clamps and tank.
Lift the core and coils vertically by slinging it from lifting lugs provided on core. Make sure that the sling does not foul against connections, tapping switch etc.
Allow the core and coils to drain oil into tank for some time.
Now lower them on beams placed in a metal tray filled with saw dust or sand.

o Inspection

Ensure that everything is intact correctly.
Leads are not pulled out off their places.
Ensure tightness of nuts and bolts.
Clean the sludge by transformer oil and ensure that ducts are not blocked.
Clamp the windings firmly without any movement. Adjust the vertical tie bars to tighten loose windings or spacers. Properly tight the special coil adjustment bolt, if provided.
Check the proper operation of tap changing switch. Tight all connections.
Conduct insulation resistance test and take the corrective action.
Remove sludge deposition at the bottom of tank.

· **Bushing**

o Clean the bushing porcelain and examine for cracks and chips. Replace if required.
o If the bushing is below oil level, lower the oil until it is below the bushing hole.
o If only the porcelain is to be changed it may not be necessary to undo the internal bushing connection, for, in some cases the bushing stems are joined by an insulated bar to prevent them from turning when the nuts are undone. All the nuts at the top of the bushing should be removed and the old porcelain lifted straight up over the central stem, which remain in place. Slide the new porcelain down over the stem and tighten the nuts. Too much strain on the porcelain should not be applied when tightening the connections. Change only one porcelain at a time. If the insulated bar between the bushing stems is not provided, the internal connections should be undone and the whole bushing removed before the porcelain is changed and then replace the porcelain.
o When a complete bushing is to be changed the internal connection to the bushing should be undone. If the replacement bushing has a socket at the bottom end, the old bushing should be unclamped and withdrawn from the tank. Now unplug the flexible lead from the old bushing and plugged into the new one, which is then lowered into the hole in the tank and re-clamped firmly but not too tightly.

· **External Connection**

o The bluish tinge characteristic of metal indicates overheating. Either it become loose or dirty or the size of conductor is not suitable for carrying current.
o A small copper loop to bridge the top cover of the transformer and the tank may also be provided to avoid earth fault current passing through the fastening bolts when there is a lighting surge, high voltage surge or failure of bushings.

Conservator and Magnetic Oil Gauge

o The oil level indicator should always be kept clean.
o Replace the broken transparent material of level indicator immediately.
o Examine the mechanism of oil gauge functioning properly during cleaning of conservator.

· **Breather**

There are generally two types of breathers used on a transformer:
a. Plain breather
b. Silica gel breather

The end of the plain breather should be kept clean and the ventilation holes free of dust. If an oil seal has been provided, the oil should be wiped out. Silica gel dehydrating breathers are fitted with a sight glass so that the colour of the crystals may be seen. The colour changes from blue to pink as the crystals absorb moisture. When the crystals get saturated with moisture they become predominantly pink and should therefore be reactivated. The
body of the breather should be removed by undoing the nuts. If the crystals have been kept in an inner container, the container should be removed, but if they are not, the crystals should be removed into a shallow tray. The crystals should be backed at a temperature of about 200°C until the whole mass is restored blue colour. Clean the breather and place the dry and blue crystals. Renew the oil in the sealing cup at the bottom.

· **Buchholtz Relay**

o During operation if gas is found to be collecting and giving alarm, the gas should
be tested and analyzed to find out the nature of fault. Sometimes, it is noticed that the gas collecting is only air. The reasons for this may be that the oil is releasing any absorbed air due to change in temperature or due to leakage on the suction side of pump. The absorbed air is released in initial stages only when no vacuum is applied during filling of oil. The internal faults can be identified to a great extent by a chemical analysis of gas
o Routine operation and mechanical inspection/tests should be carried out at one and two yearly intervals respectively.
o The operation is tested by injecting air into the relay through the lower petcock of a double float relay for the 45° petcock of a single float relay. After inspection, any air which has accumulated in the upper gas chamber must be released by the upper petcock, by filling the chamber with oil.
o To carry out mechanical inspection, the oil level must be brought below the level of relay. Both floats should be able to rise and fall freely. Relay should give alarm/trip due to the oil level falling below the Buchholtz level. The mercury switches should be tightly clamped. If the glass of a mercury switch is cracked, it must be replaced.

· **Explosion Vent**

o Frequently inspect diaphragm of the vent and replace if required.
o An investigation should be carried out to determine the nature and cause of the fault before replacing the broken diaphragm.

· **Gaskets**

o Check the tightness of all bolts fastening gasketed joints. To avoid uneven pressure, the bolts should be tightened evenly round the joints. Leaking gaskets should be replaced as soon as the circumstances permit.

· **Pipe Work**

o Inspect the pipe work for leakage due to slack unions, mis-alignment.
o Align the pipe and remade the joint.

· **Temperature Indicators**

o At each yearly maintenance inspection, the level of oil in the pockets holding thermometer bulbs should be checked and the oil replenished, if required. The capillary tubing should be fastened down again if it has become loose. Dial glasses should be kept clear and if broken,

replaced as soon as possible to prevent damage to the instrument. Temperature indicators should be calibrated with standard thermometer immersed in hot oil bath if found to be reading incorrectly.

· Spares

o It is a healthy practice to have essential spares like one member of each type of bushings, one spare limb winding, one thermometer, one cooling fan, etc, for each group of similar transformer.

Circuit Breakers

Circuit breakers usually need more frequent and more prolonged maintenance. In general, for maintenance of CB the instructions of manufacturer should be followed. A few salient points on maintenance of CB are given below:

Under normal operating conditions during regular inspections following checks should be done:

· The contacts should be checked for proper alignment.

· The oil level should be checked and maintained.

· The oil condition should be tested, if dielectric strength is lower than specified, oil should be filtered. While taking oil samples normal precautions should be followed. If water is found an investigation of the cause should done and a remedial action should be taken.

· All insulating parts should be thoroughly cleaned to remove all traces of carbon which may remain after the oil has been drained from the tank.

· Check the functioning of the breaker through devices which will have to function on fault or overload.

· Check indicating devices such as mechanical ON and OFF indication, as an incorrect indication may at some times lead to a fatal accident.

· Check auxiliary switches for cleanliness and correct contact making.

· If a CB operate under fault conditions to interrupt a fault, then maintenance after such occurrences should be carried out giving special attention to the following items:

o Current carrying parts: All contacts including isolator contacts should be examined, dressed or replaced if necessary.

o Insulation should be cleaned to remove carbon deposits. Examination to be made of cracks, tracking or other damages.

o Arc control devices should be checked and dismantled, if any carbon or metallic deposits are found, these should be removed.

o All joints and seal should be examined for tightness.

o Oil should be checked in case of oil circuit breaker.

o The general inspection for any mechanical damage or distortion of the structure and mechanism should be made. The switch gear should be closed and tripped by each of the methods provided.

Air Break Switch/ Isolators

Isolators mounted upside down, or with their insulators horizontal often present access problem. During maintenance insulators are cleaned with lintless cloth slightly soaked in gasoline. The conditions of all contacts are checked and on detecting any trace of burning, defective contacts are cleaned or replaced with new ones. Old grease is washed from the insulation rubbing the part with kerosene and a thin layer of fresh grease is applied. Loose bolts and nuts are tightened at all points. The operating mechanism of isolator is checked by closing and opening each isolator several times with the line deenergized. When adjusting the mechanical part of 3 phase isolators, the switch blades are checked for simultaneous closing isolator blades are checked for ease of engagement with fixed contact jaws.

Isolator contacts must make a close fit in order to avoid excessive heating when closed. This is checked by feeler gauge of 0.05mm (10mm wide). Contact springs are checked both in compressed and free state. Contact surface are coated with acid free petroleum jelly containing minute quantity of graphite.

MAINTENANCE PROFORMA 2.8.1 Daily Maintenance Proforma

STATION:
LOCATION:
DATE:

Items		**Work to be done**	**Work done/ Remark if any**	
Switch yard				
	All jumpers & other connections	Check visually for flash/ spark marks		
Transformer			**TR-1**	**TR-2**
	Temperature	Check oil temperature during peak load hours. Check ambient temperature		
	Tank	Check for oil leakage		
	Dehydrating breather	Check visually colour of active agent		
Control Panel Room				
	Relays	Check visually target position		
	MCCB/Fuse	Check for overheating		
	Load (amp.)	Check against rated figure		
	Voltage	Check against rated figure		
	PF meter	Monitor the PF reading		
Capacitor Bank				
	All connections	Check visually for flash/ spark marks		

Signature of supervisor

Signature of in-charge

Signature of operator/ technician

Station: Location: Date:

Note: In addition to daily maintenance, carry out following works:

Items		Work **to** be **done**	Work done/ Remark if **any**	
Switch yard				
	Earth pits	Cleaning		
		Watering		
	Earth connections	Check all connections both at earth pits and metal parts		
	Yard	Growth of unwanted shrubs, garbage etc. Keep the yard free from shrubs, garbage etc.		
Transformer			TR-1	TR-2
	Buchholz Relay	Check gas collection		
	Oil level	Check oil level in conservator		
	Connections	Open terminal box cover and check connections visually for flash/ spark marks		
	Dehydrating breather	Check air passages		
		Check colour of silica gel		
	Cleaning	Clean entire transformer externally		
Control Panel Room				
	Load (amp.)	Check load balancing. If found unbalance, distribute the load equally on all phases		
	MCCB/Fuse	Provide proper size of MCCB/Fuse according to load condition		

Signature of supervisor

Signature of operator/ technician

Signature of in-charge

Quarterly Maintenance Proforma

STATION: **LOCATION:** **DATE:**

Note: In addition to monthly maintenance, carry out following works:

Items		**Work to be done**	**Work done/ Remark if any**	
Switch yard				
	Support Insulators	Clean and examine for cracks		
	Lightning arresters	Clean and check line and earth connection		
	AB switch	Clean and lubricate for proper operation		
		Check line and earth connection		
	Jumpers	Check and tighten all jumpers		
	HT bus bars	Examine and tighten bus-bar expansion joints etc.		
Transformer			**TR-1**	**TR-2**
	Bushing	Clean and examine for cracks		
		Check for oil seepage		
Control Panel Room				
	LT Bus bars	Clean and check visually for overheating, flash/ spark marks. Tighten all connections.		

Signature of supervisor

Signature of operator/ technician

Signature of in-charge

Half Yearly Maintenance Proforma

STATION: LOCATION:

Note: In addition to quarterly maintenance, carry out following works:

DATE:

Items		**Work to be done**	**Work done/ Remark if any**				
Transformer			**TR-1**			**TR-2**	
	Oil	Check BDV, ifBDVOO kV/cm, do filtration to restore quality of oil.					
	Cable box, gasketed joints and gauges	Inspect for leakage and cracks					
Control Panel Room							
	Oil circuit breakers		OCB1	OCB2	OCB3	OCB4	OCB5
		Check oil level in the tanks.					
		Test the oil, if shows signs of moisture, carbonization or dirt. Filter or replace if necessary.					
		Check all valves for oil leakage.					
		Check the condition of all gaskets provided to prevent entrance of water and leakage of oil.					
	ACB		ACB 1	ACB 2	ACB 3	ACB 4	ACB 5
		Clean with lint free cloth					
		Clean fixed and moving contacts					
		Clean and lubricate operating mechanism					

Signature of supervisor

Signature of operator/ technician

Signature of in-charge

Yearly Maintenance Proforraa

STATION: LOCATION:

Note: In addition to half yearly maintenance, carry out following works:

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DATE:

Items		**Work to be done**	**Work done/ Remark if any**	
Switch yard				
	Concreting/ coping of the supports	Take preventive action, if there are cracks or the coping of concreting is coming off.		
	Gravcl/crus hed rock	Check leveling, oil stain and dust accumulation. Spray water to remove oil stain and accumulated dust. Maintain leveling to avoid formation of water pools.		
	Earth resistance	Measure the earth resistance of individual equipment earth pit ¦ Major sub-station : 1.0 ohms ¦ Small sub-station : 2.0 ohms		
	Earth connection of metal parts	Check the earth connection of metal parts is properly connected to the earth.		
	AB switches	Check the line and earth connections		
		Lubricate and check proper operation		
	HT lightning arresters Bus-bars	Measure IR value between HV terminal and earth, if low, replace it.		
		Check the line and earth connection Tighten the connections properly from the bus bars and bars to the lines		
	Insulators	Clean and check all insulators for any crack or damage. Change if required		
Transformer			**TR-1**	**TR-2**
	Winding	Measure IR value between HV-Earth 1 HV-LV |- Min. 2M ohm/ kV LV-Earth J If low, take corrective action		
	Oil	Check BDV, if < 30 kV/cm, do filtration to restore quality of oil.		
		Perform dissolve gas analysis (DGA) as per annexure - B to check for incipient faults		

Items		Work to be done	Work done/ Remark if any	
	Buchholz relay	Clean and check components of floats, alarm contacts and their operation. Replace if necessary		
		Check accuracy of relay. Change the setting, if necessary.		
	Earth resistance	Check earth resistance of neutral and body. If high, take corrective action		
	Body	Check for peelings/ rusting/ damage. Repaint, as required		

Signature of supervisor

Signature of operator/ technician

Signature of in-charge

5 Yearly Maintenance Proforma

STATION: LOCATION:

Note: In addition to yearly maintenance, carry out following works:

DATE:

Items		**Work to be done**	**Work done/ Remark if any**	
Switch yard				
	Gravel/crushed rock	Check condition, up layer and size. Remove rounded pieces and muck by screening. Maintain up layer of 100 mm by additional quantity of size 40mm		
Transformer			**TR-1**	**TR-2**
	Core and windings	Overall inspection including lifting of core and coils. Wash with clean dry **oil.**		
	Rollers	Examine carefully during overhauling and grease them properly		
Control Panel				
	Circuit breaker	Overhaul every circuit breaker		

Signature of supervisor

Signature of in-chargc

Signature of operator/ technician

1. SWITCH ROOM

A) **HT SWITCH GEAR PANEL**:

(a) **Quarterly Maintenance**:

1. .
2. **VCB:** Check and clean insulators. Check and lubricate the operating mechanism and its linkages.Check and ensure proper working of Hoist gear mechanism.
3. **Earth connection**: Check earth connection to bus bar and switches.
4. **Over load relay**: Check over load relay for correct setting and proper working.
5. **Earth leakage relay**: Check earth leakage relay and its setting.
6. **Cable boxes**: Check cable boxes for soundness.
7. **Connections**: Check and tighten all connections at Bus bar and switches and ensure no gaps left.
8. **Cable/wire entry points**: check cable/wire entry for grommets at Bus bar and switches and no gap should be left.

B) L.T. SWITCH GEAR PANEL:

(a) **Quarterly Maintenance**:

1. Panel Indications Meters: Check for proper working of panel Indication meters.
2. Bus Bar: Check conditions of bus bar chamber and connection. Check bus bar neutral is earthed rigidly.
3. Fuses: Check the fuses for correct capacity.
4. Switches & switch board: Check earthing of switches & switch board. Check switches are provided with proper gasket and interlocking mechanisms are functional. Check and ensure correct description of load on switch [Paint the gauge of fuse wire/fuse capacity/ name of the feeder on switch.]
5. Energy meter: Check working of energy meter.
6. Capacitors: Check condition of capacitors and capacitor connections.
7. **ACB:** Check the spring loaded Mechanism for its proper charging. Check ensures trip mechanism

8. Switches: Blow out dust and clear thoroughly in side the panel and switches.

(C) SAFETY EQUIPMENTS:

1. Sand bucket with sand:
2. Fire extinguishers.
3. First Aid Box with medicine
4. Artificial respiration chart.
5. Ladders

6. **Men working** caution boards
7. **Danger** caution Boards
8. Safety Helmets.
9. Safety belts.

(D) GENERAL:

1. Substation diagram indicating details of incoming, outgoing feeders, Transformers, OCB/switches should be exhibited.
2. Statistical graph sheets in glass covered frame. a) Energy consumption b) M.D. Recorded c) Power factor d) Energy charged e) Load factor. The graph should be month wise indicating three years figures.
3. The following records/register should be available in switch room. a) Joint monthly readings recording register. b) Power supply interruption register. c) Sub station equipment failure register.
4. Check working of Telephone.
5. Check neatness of Room.
6. Check condition of cable Trenches and trench covers.

II. POWER SUPPLY ARRANGEMENTS

1.OH LINES

Quarterly Maintenance:

1. Posts: Check the alignment for leaning posts. Ensure trimming of infringing tree branches.
2. Cross arms and stay clamps: Check the condition of cross arms, stay clamps and ensure for proper fixing and for proper spacing particularly at cut points and diversion point.
3. Over head lines and guarding wire: Check the overhead lines, guarding wires for sag and ensure tightness, and also ensure guarding and across cross lacings for its proper spacing.
4. Insulators: Check all insulators for cracks and clean thoroughly.
5. Jumpers: Check and cleans all the jumper connection at incoming, out going, tapping point's and at cut point's and ensure tightness. Check the condition of jumpers.
   1. For oxidation and flash marks.
   2.For strands cuts.
6. Earth Connection: Check and clean all the Earth connection and ensure for tightness and continuity, and also ensure all the cut point posts, stays are earthed. Measure and record the individual and combined earth resistance values.
7. Stay Arrangements: Check the studs and stay arrangements and ensure for proper fixing of clamping and for load tension.
8. Conductor: Check it for cut in stands and damage of conductor.
9. Service tapping: Check and ensure proper connections of service tapings. Check and ensure proper Tension in Service Tapings.

2 UG CABLES

Yearly Maintenance:

1. Check the insulation values of cables once in a year.
2. Check under ground cables near the poles/structures for any damages and also the condition of vertical protection pipe.
3. Check for proper earthing of cable armor and cable protection pipe.

III. CLS PANELS

FORTNIGHTLY MAINTENANCE

1. Check availability of all 3 supplies, i.e ATUP, AT DN and Normal supply
2. Select rotary switch into AUTO mode. Switch off any two supplies. Note it for proper switch over to available supply. Repeat for other two supplies also.
3. Check the healthiness of all MCB's i.e., out going as well as in coming supplies. Replace if defective.
4. Check the temperature of incoming and out going MCB's and rotary switch with non contact thermo meter and record their values.
5. Ensure proper tightness of lugs. (Loose connections leads to over heat.)
6. Check proper function of Buzzer. Replace if defective.
7. Measure the voltage and current in all 3 supplies by putting one by one ON and record it in register. If voltage is less than 200V, inform depot incharge
8. Measure voltage and current in S&T circuits and record it in register.
9. Remove COB WEBS if any. Clean inside panel.

IV. SERVICE BUILDINGS & PLATFORMS

DAILY CHECK LIST

1. **DG Sets**: Check the working condition of DG Set. Check the luboil level. Clean the battery. Check the electrolyte level and ensure proper charging. Check the radiator water level.

MONTHLY CHECK LIST

1. PFs : Check the all night and part night systems are functioning on PFs.
2. Fuses: Check the condition of fuses, fuse holders, fuse base, connection in DPIC, TPIC switches.
3. Energy Meters: Check energy meters for working.
4. Electricity Charges: Check platform vendors are regularly paying electricity charges. Check station energy consumption with quota fixed. Check condition of meter Seals. Check Actual load with sanctioned load.
5. Cable terminations at MDBs : Check for 1. Insulation condition at turnouts.2. over heating symptoms 3. Condition of grommets, cable lugs, tightness of connections.
6. Water Coolers: Check working of water coolers. Check the condition of inside of water cooler tanks.
7. Cell Phone Charging Points: Check adequate 3 pin and 2 pin plug points are available in PFs, waiting halls, retiring rooms, crew booking points, running rooms, ASM office, etc for cell phone charging lap top computer, walkie-talkie sets.
8. Lux levels: Check Lux levels in 'A' class stations and 'B' class stations.

QUARTERLY CHECK LIST

1. Switches Gear: Check controlling switches, MDB's plug points and replace wherever necessary.
2. Switch Boards: Check switchboards are fixed properly.
3. Unauthorized Connection: Check and remove unauthorized connections, unused wires/fittings. Attend all loosely hanging wires.
4. Lights: Check the condition of light fittings and lamps. Light fittings should be cleaned and painted if required.

ANNUALY CHECK LIST

1. Fans: Check the condition of ceiling fans, i.e., bolts, etc. Fans with running noise should be attended. Fans should be cleaned and painted if required.
2. Cables: Check cables are taken into Metal clad switches through rubber bushes.
3. Air Cooler: Check the working of Air Coolers, clean Air Cooler, paint if necessary (metal body). Check the condition of fiber pads of Air Coolers and replace if necessary.
4. Looping Boxes: Check the condition of looping boxes of platform lighting and paint the boxes.
5. Lamp Post: Check condition of lamp post, paint if necessary.
6. Safety in Kitchens: Check adequate safety are ensured in kitchens with electrical equipments. Check no electrical fittings are directly above ovens.

V. RESIDENTIAL BUILDINGS & COLONY

MONTHLY CHECK LIST

1. Energy Meters: Check energy meters for working.

ANNUALY CHECK LIST

1. Fans: Check the condition of ceiling fans. Fans with running noise should be attended.. Fans should be cleaned and painted if required.
2. Switches Gear: Check controlling switches, MDB's plug points and replace wherever necessary.
3. Switches Boards: Check switchboards are fixed properly.
4. Cables: Check cables are taken into Metal clad switches through rubber bushes.
5. Lamp Post: Check condition of lamp post, paint if necessary.

VI. MONO BLOCK PUMPS

DAILY MAINTAINANCE:

1. Gland Packing: Leakage through Gland packing.
2. Bearings: Bearing temperature
3. Sound : Whether any under noise or vibration is present
4. Readings: Pressure, Voltage and current reading.

HALF YEARLY MAINTENANCE

1. Free movement of gland of the stuffing box
2. Cleaning and oiling of the gland-bolts.
3. Inspection of packing and repacking if necessary.
4. Alignment of the pump and the drive.
5. Cleaning of oil-lubricated bearings and replenishing fresh oil. If bearings are grease-lubricated, the condition of the grease should be checked and replaced to correct quantity, if necessary.
6. An anti-friction bearing should have its housing so packed with grease, that the void spaces in the bearings and the housing be 1/3 to ½ filled with grease. A fully packed housing will cause the bearing to overheat and will result reduced life of the pump.

YEARLY MAINTENANCE

1. Cleaning and examination of all bearings for flaws developed, if any.
2. Examination of shaft-sleeves for wears or scour.
3. **Checking clearances: i)** Clearances at the wearing rings should be within the limits recommended by the manufacturer. Excessive clearance means a drop in the efficiency of the pump. Ii) I f wear is one side, it means misalignment should be set right. Also the cause for disturbance of the alignment should be investigated.

VII.SUBMERSIBLE PUMP

HALF YEARLY MAINTENANCE

1. Once in 6 months check the main voltage and current drawn by the motor.
2. Follow maintenance schedule for motor and stator and test the protective devices like fuses etc.,
3. Electrical cables, which are from the motor, should be checked and neatly routed up to electrical panel board.
4. Keep clear record of number of hours the pump running.
5. Note that the pumping water is clean or not
6. Check the level of the water inside the well. If not at proper level adjust the motor accordingly.
7. Submersible pumps have been known to operate satisfactorily for 6000 hrs. to 10000 hrs. between overhauls for a period of 2 years at 12 hrs operation per day (8760 hrs.)

VIII. D.G. SET

DAILY MAINTENANCE (A—CHECK)

1. Lubricating Oil: Check the lubrication oil level in engine and govemor and top up if necessary. Check the oil bath level
2. Radiator water: Check radiator water level.
3. Air cleaner oil: Check oil bath cleaner oil level. Check the condition of pre-cleaner dust pan. Check the condition of air cleaner restrictions.
4. Fuel System: Check and record fuel oil. Drain sediment from fuel tank.
5. Battery: Clean the battery. Tight the connection.
6. Switch gear: Check automatic starting switch for its proper functioning.
7. D.G. Set: Check the condition of belt for its proper tension. Observe oil leakages. Observe abnormal sound. Record lub oil pressure. Record Voltage. Record Load Current. Record KWH Meter reading.

HALF YEARLY MAINTENANCE (B—CHECK)

1. Lubrication: Change lube oil. Change lubricating oil filter element/bypass filter element and check for metal particles and oil slugging/oxidation. Record lube oil pressure.
2. Fuel system: Clean main fuel tank breather by using clean solvent. Check hydraulic governor oil. Check the throttle linage.
3. Air system: Check ail piping. Check all air cleaner connections for cracks & tighten all air intake connections. Chance crank case breather element. Remove and clean air compressor delivery house
4. Cooling system: Change water filter element. Check the coolant Ph value, if it is below (8.5 to 10.5) normal range then chromate concentration should be 3500 ppm. Check and adjust the belts. Incase of change of new belts, which will stretch within one hour of use and must be re-adjusted keeping tension of belts within permissible limits.

1. Battery: Check the level of electrolyte and top up if necessary . Check specific gravity of electrolyte, it should be 12000 and measure the battery voltage. Check tightness of connections for any over heating and abnormality. Check condition of Battery body. Check the battery charger and Record charging current. Check condition of inter cell connections for any overheating and abnormality
2. Switch Gear: Check condition of switches/circuit breakers for its proper operation. Check condition of contacts. In case of burn out, replace the contacts.
3. Alternator: Visually examine the terminal box, junction box and insulator etc., and clean them by using dry and clean cloth. Check condition of cooling fan.

YEARLY MAINTENANCE (C—CHECK)

1. Fuel system: Adjust injectors and valves. Check hydraulic governor oil.
2. Air system: Check air piping. Check all air cleaner connections for cracks & tighten all air intake connections.
3. Cooling system: Clean radiator externally. Check fan hub and water pump.
4. Battery: Same as daily and yearly maintenance schedule.
5. Switch gear: Same as daily and yearly maintenance schedule.
6. Alternator: Same as daily and yearly maintenance schedule.

TWO YEARLY MAINTENACE (D—CHECK)

1. Fuel System: Clean and calibrate injectors. Replace fuel pump filter. Check fuel pump calibration.
2. Air system: Clean turbocharger wheel and diffuser. Check turbocharger bearing clearance. Tighten Manifold nuts and screws.
3. Cooling system: Same as daily and yearly maintenance schedule.
4. Battery : : Same as daily and yearly maintenance schedule.
5. Switch gear: Same as daily and yearly maintenance schedule.
6. Alternator: : Same as daily and yearly maintenance schedule.

FOUR YEARLY MAINTENANCE (E—CHECK)

1. In addition to daily, half yearly, yearly & two yearly maintenance, the following schedule to be done .
   a) Key parts like bearing to be checked for wear.
   b) Oil consumption and oil pressure to be measured.

NOTE: Major Over haul to be estimated at three E- checks or 25000hrs of working.

Maintenance of D. G. Sets

Batteries
Clean the batteries with dry cloth.
Tight the connections if required.

Switch Gear
Check automatic starting switch for its proper functioning.

Check any abnormality if visualised.
Check phase indications and working of panel meters.

Alternator
Check any abnormality, if visualised.
Check the air-in and out restrictions.

WEEKLY SCHEDULE

In addition to Daily schedule, carry out the following checking:

Engine

- Check the Lubrication oil level in engine and governor and top up if necessary.
- Check coolant oil for its proper functioning.
- Check the constant heater functioning.
- Check the anti-freeze and concentration of coolant, if any.
- Check the condition of belt for its proper tension.
- Check the condition of pre-cleaner dust fan.
- Check the condition of air cleaner restrictions.
- Check the oil bath filter and level of oil bath.
- Check the vibration and tightness of the bolts.

Batteries

- Check the level of electrolyte and top up if necessary.
- Check specific gravity of electrolyte, it should be 1200 and measure the battery voltage.
- Check tightness of connections for any overheating and abnormality.
- Check condition of body.
- Check charging current and charging system, floating current should be 1 Amp.
- Check condition of inter cell connections for any overheating and abnormality.

Switch Gear and Alternator

Same as Daily schedule.

Do's and Dont's

GENERAL

Do's

- Do keep your engine clear and in adjustment.
- Do ensure proper clearing of air cleaner & fuel filter.
- Do connect the load only when generator voltage regulation is normal.
- Do ensure sufficient fuel before starting.
- Do open the door & windows for proper ventilation.
- Do clean area of any lubricating oil spilled while priming or filling crank case.
- Do correct the troubles while they are simple.
- Do prevent over speeding.
- Do guard against corrosion.
- Do check and control operating temperature.
- Do regulate the engine fuel.

Don'ts

- Don't start the engine without checking of engine fuel and level of lubricating oil.
- Don't start engine without opening fuel caps.
- Don't smoke in the generator room & also don't keep inflammable goods in generator room.
- Don't forget to clean silencer after every three six months possibly.
- Don't mix water into fuel.
- Don't mix different grades of grease.
- Don't pour diesel when engine is running.

IX WINDOW TYPE AIR CONDITIONERS

GENERAL MAINTENACE SCHEDULE OF WINDOW TYPE AIR CONDITIONERS

1. Remove Air Filter, clean with blower and water
2. Clean front grill cover by water and pipe with cloth
3. Clean evaporator and condenser coil brush and use water pressure for cleaning

1. Tighten electrical connections and ensure main supply wires clipped properly and rewire of necessary
2. Check earth continuity
3. Check TCS setting and working of thermostat
4. Voltage
5. Current
6. Grill Temperature
7. Gas leak if any
8. Any unusual noise and other remarks

YEARLY MAINTENANCE SCHEDULE OF WINDOW TYPE CONDITIONERS

1. Remove Air Filter, clean with blower and water
2. Clean the blower fan motor, fan blade and blower wheel. Tighten holding screw and lubricate fan motor bearing with oil.
3. Clean front grill cover by water and pipe with cloth
4. Clean evaporator and condenser coil brush and use water pressure for cleaning
5. Clean the compressor unit and wash by water supply. Tighten electrical connections and ensure main supply wires clipped properly and rewire of necessary.
6. Check start and run capacitor by meter for its value and replace if valves less than 10% of the standard values.
7. Check earth continuity
8. Check TCS setting and working of thermostat
9. Voltage
10. Current
11. Grill Temperature
12. Gas leak if any
13. Any unusual noise and other remarks
14. Paint correct asset No. & POH date on plant.
15. Check relay for its drop out and pick up voltage values
16. Paint outer case if corroded

X. WATER COOLERS

GENERAL MAINTENANCE SCHEDULE OF WATER COOLERS

1. Cleaning of storage tank by soda
2. Check functioning of float valve
3. Clean externally and interior side of the top cover.
4. Clean compressor unit, clean condenser by blower and wash by water spray.
5. Tighten electrical connections and ensure main wire clipped properly.
6. Clean condenser fan motor blade and tightened, lubricate motor with oil and check the electrical connections.
7. Check earth continuity.
8. Check air passed through condenser.
9. Check inlet and outlet water pipe joints and water tap for water leaks and flow of water.
10. Check holding bolts of compressor and tighten it
11. Check functioning of thermostat and its setting
12. Voltage
13. Current .
14. Temperature
15. Any unusual noise and other remarks
16. Stencil the tank cleaned Date
17. Measure the purity of Water with TDS meter.

YEARLY MAINTENANCE SCHEDULE OF WATR COOLERS

1. Cleaning of storage tank by soda
2. Check functioning of float valve
3. Clean externally and interior side of the top cover.
4. Clean compressor unit, clean condenser by blower and wash by water spray.
5. Tighten electrical connections and ensure main wire clipped properly.
6. Clean condenser fan motor blade and tightened, lubricate motor with oil and check the electrical connections.
7. Check earth continuity.
8. Check air passed through condenser.
9. Check inlet and outlet water pipe joints and water tap for water leaks and flow of water.
10. Check holding bolts of compressor and tighten it

XI. SOLAR WATER HEATING SYSTEM

Solar water heating system: Thermo Siphon System(500 LPD to 2,500LPD)

Do's:

a) Ensure that the cold water tank and make up tank is always full and never runs dry.
b) Ensure use of hot water once in a day either in the morning or in the evening.
c) Ensure that the GATE VALVE provided in the cold water line is always open.
d) Clean the glass once in a week.

Don'ts:

a) Don't cover the collectors.
b) Don't erect any structures which can cast shadow on the collectors.
c) Don'ts draw the hot water when the heater is ON.

Maintenance Periodicity:

a) Weekly:
   1. Clean the glass once in a week.
   2. Check and ensure soft water level in make up tank. If required top up with soft water.

b) Quarterly:

1. Drain the tank by opening the drain plug provided at the bottom of the tank.
2. Before draining, close the cold water inlet valve and after drain open the same.
3. Draining should be done only after the usage of hot water.

c) Yearly:

1. Check for erosion of sacrificial anode. Replace if it found eroded or 80% of the material has sacrificed.
2. Before the on set of monsoon, check the pipe and tank insulation for possible leakage.
3. Ensure that the water does not seep into the insulation.
4. Use proper sealant like M-Seal for joining the openings susceptible to water seepage.

Precautions:

1. The collector surface develops very high temperature. To avoid this, the collector should be shaded from the sun by an opaque sheeting before making/repair any internal pipe connection.
2. Do not touch the collector surface/ glazing during sunshine hours as it could lead to BURN INJURY.
3. Do not use the hot water for direct drinking application.
4. Do not touch the tank surface or internal or external piping of the system with bare hands.
5. The solar usage water hardness should be less than 300 PPm.

MAINTENANCE SCHEDULE OF EARTHING:

A. HALF YEARLY SCHEDULE :

S.N.	Items to be inspected	Nature of inspection	Action required ,if inspection shows unsatisfactory condition
1.	Earth strip, joints and connections to structure and rails (Visually)	Check for proper continuity	If found broken or loose, this should be immediately replaced /tightened
2.	Earth clamp bolts & nuts in the earth pit (visually)	Check for proper contact of earth clamp, slackness of bolts & nuts, rust and dirt.	Rust and dirt should be cleaned. Bolt and nuts of this clamp should be tightened.
3.	Sump	Check up general condition including dryness.	If the surrounding area is too dry one or two buckets of water should be poured into the sump every week to keeps the soil surrounding earth pipes permanently moist.

B. YEARLY SCHEDULE:

S. N.	Items to be inspected	Nature of inspection	Action required ,if inspection shows unsatisfactory condition
1.	Earth resistance	Measure the earth resistance and recored.	If the earth resistance is higher immediately steps should be taken to improve the figure to bring it within the permissible limits.
2.	Earth pits	Check up the electrode for proper earth continuity.	Remove the hardened top layer of the earth pit for a depth of 1 meter, mix with coke and loamy soil (non-sandy) and ram the earth. Repair the earth. Repair sides and top cover of the earth pits. Avoid use of salt as far as possible to avoid rusting of earth pipe.

Maintenance schedule of Centrifugal pumps

1. Daily observations

a) Leakage through packing.

b) Bearing temperature

c) Whether any under noise or vibration is present and

d) Pressure, Voltage and current reading.

2. Half yearly attention

a) Free movement of the gland of the stuffing box

b) Cleaning and oiling of the gland bolts.

c) Inspection of packing and repacking , if necessary.

d) Alignment of the pump and the drive.

e) Cleaning of the oil lubricated bearings and replenishing fresh oil. If bearings are grease lubricated, the condition of grease should be checked and replaced to correct quantity, if necessary.

3. Annual attention

Complete overhaul, painting and output test.

Note : Never neglect maintenance just to adhere to arbitrary schedule. On the other hand, do not perform unnecessary maintenance operation because this defects the purpose of the routine preventive programe.

Daily observations

1. Leakage through packing :

Water leak of 40 to 60 drops per minute is required for adequate cooling. If leakage from the stuffing box is excessive or the packing is badly worn, replace all the packings in the box. Never replace just one or two rings, they will not sent effectively. Be certain to use only the grade of packing recommended by the pump builder.

2. Bearing temperature :

In general the temperature of any bearing in a centrifugal pump should not exceed 160 °F. Before allowing a bearing to operate at any temperature above the recommended, check with the pump manufacturer. Much depend on the type of bearing, its lubricant and the duty of the bearing performs in the pump.

If any bearing is running hot, check for the cause. Ball or roller bearings may be over lubricated. Remove some grease and test under load. Hot sleeve bearing may not have enough oil, the oil rings may be stuck or broken, or the lubricant may be too thick for its job. If the oil is thought to be too thick, change it. Run the pump again. If the bearing still runs hot, dis-assemble, wash and inspect the bearing. Replace bearing. Replace worn or damaged parts.

3. Any undue noise or vibration :

If any undue noise or vibration present check for the cause and rectify, see the trouble shooting charts.

4. Pressure, Voltage and current readings

Maintenance activities (overhaul) of the pump

Maintenance of rotating parts

1. Impeller :

a) Removing of the impeller :

Before the impeller can be removed for inspection, scale and burrs must be removed from the shaft with a file. To prevent the damage of the unbolting & removing the case, use a screw driver to loosen the impeller set screw, clean the shaft as the work progress.

If a bronze impeller is a shrink fit on the shaft, slip a metal sleeve over shaft, while the impeller is heated. Start heating of the impeller with a torch from the outside of the shroud, working towards the hub. Remove the impeller while heating it, so its temperature will be equalise. When the impeller is loose pry it off the shaft being carefull to press only against the shroud. Wear asbestos globes when lifting the next impeller or use special lifting claims supplied by the pump manufacturers.

b) Cleaning of impeller :

If the impeller is dirty, clean it carefully before its inspection. Use a soft wire brush or a steam lance to remove thick gummy residues. Scale, cock and other deposits can be removed by chemical cleaning or sand blasting. In either case, precautions must be taken to see that the impeller material is not damaged by the cleaning methods chosen. Petting of the impeller may be caused by condition, which can occur without audible noise.

c) Inspection :

After removing the impeller from a pump inspect its eye, vanes, shrouds, wearing rings, passages, hub and other parts. Wear may occur at the eye, vanes, shrouds and other impeller parts.

d) Impeller Runout :

With pumps having bearings at each end of the shaft, mount the impellers, wearing rings, spacer, and shaft sleeves on the shaft and support the assembly between between centers. Set a dial gauge at zero and take readings at each and at the centre of each shaft sleeve. Also take similar readings at each impeller wearing ring. For most pumps, if the runout is not more than 0.0015 in., the assembly can be considered accurate and the shaft installed as is. If the reading is greater, check for a bent shaft, out of square, dirty, or burred impeller end of a shaft or spacer sleeve.

2. Shaft Sleeves :

These wear when packed too tightly. They may be reconditioned by welding or metalling. Where the wear is extereme, replacement of worn sleeves with a new one is often recommended. Use sleeve puller to remove the old sleeves from the shaft. When the sleeve is rusted to the shaft , use the impeller nut to help loosen the sleeve. In extreme cases hammer and chisel may be needed to split the sleeve before removal. After installing a new shaft sleeve check its concentricity on the shaft.

3. Bearings :

Modern pump are supplied with a ball or roller antifriction bearings. These bearings on pumps and motors, as delivered from the factory, are usually furnished with sufficient lubrication to last for 2 or 3 months of operation. No additional lubrication should be added when first putting the unit in the service. Injury to antifriction bearings is more likely to result from too much lubricant than too little. The real purpose of the lubricant for these bearings is to form a coating on the highly polished surface as a protection against corrosion, rather than for lubrication. An oversupply of lubricant will cause excessive heating due to pumping action o the bearing. Properly lubricated antifriction bearing will require additional lubricant only two or three times a year, depending on the continuity of a service. About once a year, it is desirable that the bearings should be cleaned and flushed out thoroughly with gasoline or kerosene and then filled with fresh lubricant. In addition fresh lubricant, the bearing housing (cover) should be filled about one-forth to one-third.

Pumps fitted with plain bearings are usually supplied without any lubricant. Before starting the pump, clean the bearings thoroughly, as dirt or other foreign matter may have got into the bearing housing during transport or erection. The bearings should then be filled with a neutral mineral oil of about 300 S.S.U. viscosity at 20°C. This oil should be changed when it becomes dirty and the bearings should be cleaned again.

Do's and Dont's for Pumps

DO's

- Keep the friction wear low by using a good grade of packing and adjusting the gland evenly.
- Put the pump near the source of water, is it minimise adjusting the suction lift.
- Platform should be plane & rigid.
- Pump should be proper aligned.
- Bend should be of 90° (right angled).
- Keep the friction wear on shaft low by using a good grade of packing and adjusting the glands evenly.
- Spray the impeller with a rubber, plastic or metallic coating to reduce wear from liquids coating abrasives.
- DO use recommended grade of oil or grease.
- Do provide ample space on all sides of pump so that the pump can be inspected while in operation and cane be serviced conveniently whenever required.
- Keep sufficient space around the foot valve.

Dont's

- Don't use any oil heavier than light motor oil (SAE 10) for bearing cleaning.
- Don't press the packing tightly by over tightening of the gland-nut as this may result in buming of the packing and cutting of the shaft.
- Don't back off the gland nut while the pump is running.
- Don't use the pump without lubricating the bearing with grease or oil as the case may be.
- Don't use the pump outside the recommended.

6. Don't use the pump with liquid other than specified.
7. Don't use the pump with less NOSH than recommended.
8. Don't use the pump with delivery valve fully shut for longer period.
9. Don't use the pump when misaligned.
10. Don't use the pump without lubricant to the stuffing box either external or internal.
11. Don't use the pump unless the periodical checks as suggested.
12. Don't use the pump with under weight on suction and delivery pipe flanges.
13. Don't use the pump when strainer removed from the suction.
14. Never over lubricate the bearing.

SUBMERSIBLE PUMP-Maintenance

HALF YEARLY MAINTENANCE

- Once in 6 months check the main voltage and current drawn by the motor.
- Follow maintenance schedule for motor and stator and test the protective devices like fuses etc.,
- Electrical cables, which are from the motor, should be checked and neatly routed up to electrical panel board.
- Keep clear record of number of hours the pump running.
- Note that the pumping water is clean or not
- Check the level of the water inside the well. If not at proper level adjust the motor accordingly.
- Submersible pumps have been known to operate satisfactorily for 6000 hrs. to 10000 hrs. between overhauls for a period of 2 years at 12 hrs operation per day (8760 hrs.)

MAINTENCANCE SCHEDULE FOR STARTERS

MONTHLY:

1. Check and ensure proper spring tension of moving contacts.
2. Check and adjust the time lag setting of delay relay in case of automatic star delta starter.
3. Check overload relay and adjust the setting according to current drawn by the motor.
4. Check and ensure 'ON' and 'OFF' push buttons for proper operation and for proper working.
5. Record the voltage and Amps intake.
6. Check functioning of single phase progenitor.
7. Clean the starter thoroughly.
8. Check entry of wire leads to the starter body through grommets (rubber bushes).

QUARTERLY:

Check and clean the fixed and moving contacts. Check for proper alignment

ELEC - 1.7
&
ELEC - 1.10

Testing, erection and commissioning of pumps, DG sets, power supply equipments, Laying of Cables.

Major steps prior to commissioning of Transformer:

1. Fitment of accessories.
2. Filling of oil.
3. Drying out.
4. Charging of breather with fresh silica gel.
5. Cleaning of porcelain of bushings with trycloroeth lane and then be dry cloth.
6. Earthing of tank and cover.
7. Neutral earthing as per schematic diagram.
8. Connection protection circuits, alarms circuits, with CTs, PTs.
9. Setting of Relays.

Various Commissioning Tests for Transformers:

1 General observation—complete transformer.
2 Secondary injection tests – of all the protection relays.
3 Primary injection tests.
4 Ratio tests
5 Tripping test on HV side breaker, LV side breaker, winding temperature trips.
6 Calibrate earth resistance.
7 Alarm circuits
8 Fans and pumps
9 Functioning of Bucholz Relay.

Check list before commissioning of Transformer

1. All valves are in correct position ,closed or opened as required.
2. All air pockets are clear.
3. The thermometers pockets are filled with oil.
4. Oil is at the correct level in oil indicator/conservator .
5. Earthing connection is done.
6. Condition of silicagel in breather.
7. Incoming and outgoing terminals are done correctly.
8. External phase clearance between phases as well as phase to earth are checked after cable terminations.
9. Diaphragm of explosion vent is checked.
10. Proper cable support has been provided to reduce indue stress on the transformer terminals.
11. No leakage or seepage of oil occurs from any part of the body, including gasket joints and terminals

Testing , erection and commissioning of Transformer

The following tests are required:-

1. **Winding resistance:-** Accurate measurement of winding resistance can be made with a good Wheatstone or Kelvin Bridge.

2. **Ratio test:-** It is done by a special ratio-testing equipment called ratio meter. This consists of a small portable transformer with a fixed primary, and a secondary winding having a large number of taps at equal intervals connected to two selector switches, one coarse and the other fine, so that any voltage desired could be obtained and read off directly. Ratio test is the first test to be conducted on every transformer. The permissible tolerance is +/-0.5% of the declared ratio. The test to be conducted for every tapping position.
3. **Polarity test:** - The primary and secondary are supposed to have the same polarity when the turns in both the winding go round the core in the same direction and the start and end leads are marked in the same way. In case of a star connected 11 kv/400 volts transformer a low voltage of 440volts can be applied to HT. Connect the terminals A1,B1,C1 of transformer 1 and A2,B2,C2 of transformer 2 to the Ht terminals in an identical manner. The direction of current in the two windings will then be the same. Connect also the secondary terminals a1, b1 ,c1 to the LT busbars. Check for voltage between terminals a1-a2, b1-b2,c1-c2. The three voltages should be zero , so that the transformers have the same polarity and phase rotation. If the terminal markings are incorrect the voltage may be 400volts between one or more pairs. Identify the pairs between which there is no voltage and mark them identically and parallel the transformers.
4. **Phase relationship:** It is important that the winding connections are correctly made as per vector diagram shown on the name plate. The phase sequence will then be automatically correct.
5. **Impedance voltage:** When impedance voltage is applied across one winding of the transformer, it produces normal full load current to flow through the second winding when its terminals are short circuited. It is expressed as a percentage of the applied voltage. For example in an 11 kV/400 v transformer having impedance voltage of 10%, full load current will flow in the 400 V winding if it is short circuited at the terminals. The permissible tolerance of impedance voltage over the guaranteed figures is +/-10%, for a two winding transformer.
6. **Insulation resistance**

   This is best measured by a megger. The megger reading gives a good picture of the amount of moisture absorbed by windings.

Voltage of winding	Minimum insulation resistance in mega ohms	Voltage of megger
400 Volt	2 M Ohm	500volt
11 KV	50 M Ohm	1000volt
33kV	150 M Ohm	2500volt
132 kV	500 M Ohm	2500 volt

7. Dielectric strength for oil

Dielectric breakdown strength of transformer oil is one of the most reliable tests for proving the condition of oil, and therefore meticulous care is essential in conducting the test. Slightest contamination or moisture brings down the breakdown value.

i) The break down values (BDV) given refer to the RMS voltage when tested as per IS:335:1973, using a standard test cell, with two 13 mm dia, polished spheres, and a test gap of 4 mm.
ii) The test should be conducted when the oil is cold and not when Hot.
iii) Rubber is affected by oil, Use plastic tubes for drawing out the sample. Sample bottles should have glass stoppers.
iv) The sample oil should be drawn from the bottom of the transformer tank.
v) The glass bottle should be clean, clear, transparent and dry.
Good transformer oil should have BDV value 40 kV for one minute.

Purification of Transformer Oil

The object of oil purification is to remove all contaminants such as water, carbon deposits, dirt, sludge, dissolved moisture and gases. The most important quality to be preserved is the di-electric strength, which is affected by presence of moisture.
The insulating material used in the winding are hygroscopic in nature and therefore moisture is absorbed through defective breathers, gasket and addition of untreated make up oil. It is essential to remove these impurities in purifying the oil when the di-electric strength goes below the permissible limits.
For purifying the transformer oil, machine conforming to RDSO's specification no.ETI/PSI/103 may be used.

Oil Sampling

General precautions

i. Use always clean, dry and amber glass bottles as per IS: 6855-1973
ii. Take oil sample preferably in dry weather and avoid any external contamination.
iii. Oil sample shall be at least as warm as the ambient air.

Sampling procedure

i. First drain at least one liter oil to eliminate any contaminations which is accumulated in the drain cock.
ii. Rinse the bottles with the oil being sampled.
iii. After taking the sample, ensure that the cock is correctly closed.
iv. Check that the label marking are correct and complete.
v. Store samples in a dark place.
vi. Ensure that the sampling is done by an experienced person.
vii. Ensure that each of sampling bottle is filled up to 95 to 98 percent of its capacity.

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DG SET

PROCEDURE FOR STARTING DG SET

The following procedures are adopted for starting diesel generator set.

* Manual.
* Through battery using.
    * Push button
    * Self start.

MANUAL PROCESS

Normally small DG set are started using handle in the groove which is inside the diesel engine shaft. Initially the handle is rotated manually and when the firing in the engine starts the handle is pulled out. The handle is so designed that it can rotate the engine shaft in only one direction. After the start the handle becomes free & it can be extracted outwards.

THROUGH BATTERY

Using Push Button

This arrangement is used in big diesel generator set, in this method engine is not required to be started by using a handle rather this can be done by pressing a push button.

After pressing the button the battery is connected to the generator which moves the engine shaft resulting in the start of the engine. Through this method DG set can be started comfortably as per the requirement. This arrangement can also be provided in small DG sets. This requires least physical efforts to start DG set. Precaution should be taken to avoid to press of push button continuously for long duration say 1 min. or more.

Self Starting System (A.M.F Panel)

This method is adopted where the supply from the generator is regularly required In this method the arrangement is such that as soon as the AC supply fails the battery is connected to the DG generator automatically & the engine shaft is rotated to start the DG set. This circuit is connected through the relay. In this method the DG set starts working after the power supply failure in minimum time.

CABLES

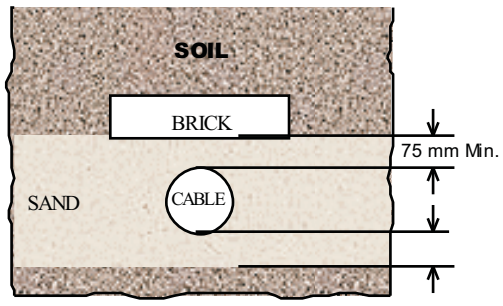
METHODS OF CABLE LAYING & INSTALLATION

The conventional methods of cable laying and installation are:

- Laying direct in ground.
- Drawing in ducts.
- Laying on racks in air.
- Laying on racks inside a cable tunnel.
- Laying along buildings or structures.

3.4.1 Laying Direct in Ground

This method involves digging a trench in the ground and laying cables on a bedding of minimum 75mm riddled soil or sand at the bottom of the trench, and covering it with additional riddled soil or sand of minimum 75mm and protecting it by means of bricks, tiles or slabs.



Cable Trench Layout

Cable Trench:

The desired minimum depth of laying from ground surface to the top of the cable should be as following :

- Cables, 3.3 KV to 11 kV Voltage rating : 0.9m
- Cables, 22 kV, 33 kV Voltage rating : 1.05 m
- Low voltage and control cables = 0.75 m
- Cables at road crossings : 1.00 m
- Cables at railway level crossings : 1.00 m

(Measured from bottom of sleepers to the top of pipe)

Clearances

The desired minimum clearances are as following

- Power cable to power cable – Clearance not necessary. However larger the clearance, better would be current carrying capacity.
- Power cable to control cables : 0.2m
- Power cable to communication cable : 0.3m
- Power cable to gas/ water main : 0.3m

Cable Laid Across Roads, Railway Tracks and Water Pipe Lines.

- Hume pipe/ 'B' grade GI pipe of suitable size shall be used where cable cross roads, railway tracks. Spare ducts for future extensions shall also be provided.
- The duct/ pipe joints shall be covered by collars to prevent settlement in between pipes.
- The diameter of the cable conduit or pipe/duct shall be at least 1.5 times the outer diameter of cable. The ducts/pipes shall be mechanically strong to withstand forces due to heavy traffic when they are laid across the road/ railway tracks.
- The cable entry and exit shall be through bell mouth or padding.
- The bending radii of steel or plastics ducts shall not be less then 1.5m.
- Single core cables shall not be laid individually in steel ducts but instead, all three cables of the same system shall be laid in one duct.

Cable Over Bridges

On bridges, the cables are generally supported on steel cable hooks or clamped on steel supports at regular intervals. It is advisable that cables laid in bridges are provided with sun shields to protect the cable from direct heating by sun's rays.

Earthing and Bonding of Cables

- The metal sheath, metal screen (if any) and armour of any cable should be efficiently earthed at both ends.
- In case of single-core cables of larger sizes, the armour, lead sheath and metal screen, if any, is bonded at times only at one point. Attention is drawn in this case to the presence of standing voltages along armour or lead sheath and to the considerable increase in such voltages when cables carry fault currents. These voltages must be taken into account when considering safety and outer sheath insulation requirement.
- All metal pipes or conduits in which the cables have been installed should be efficiently bonded and earthed.
- Where cables not having metallic sheath are used, embedding additional earth electrodes and connecting the same with steel armour of cable becomes necessary.
- Earthing and bonding should be done in accordance with IS: 3043-1987.

TESTING OF EARTHING

1. Earth tester is used to measuring of earth resistance. There are 2no.s of electrodes which is connected with a wire of 75 feet and 150feet respectively. One of the electrode to be fixed at 75 feet distance other is to be fixed at 150 feet distance apart. These leads to be connected to earth megger by rotating the megger handle. Record the measurement of resistance duly changing the direction of electrodes/probes. The average value gives the net value of resistance
2. During the course of inspection if a value is found high take necessary steps to improve the earth value i.e. adding of water regularly providing parallel one more earth pit.

The following safety precautions to be observed on the electrical installations:

1. Do not connect single pole switch or fuse in a neutral circuit .Always it should be connected in the live or fuse wire.
2. Do not use copper or aluminum wire as fuse wire.
3. Do not touch or tamper with any electrical gear or conductor unless you have made sure that it is dead and earthed.
4. Do not disconnect earthing connections the safety gadgets installed on main apparatus till you are at work.
5. Do not expose your eyes to an electric arc.
6. Do not use paint, enamel and grease on the electrodes.
7. Do not use water pipe line for earthing.

OPERATIONAL CHECKS FOR CENTRIFUGAL PUMPS

1. Checks for the pump before starting.

    a) The shaft rotates freely.

    b) The pump is primed.

    c) If there is any valve in delivery branch, it is open.

    d) The stuffing box (gland) is properly tightened (in case of gland packed pump)

2. Checks during running conditions :

a) The direction of rotation is correct.
b) The pump is running smoothly.
c) See that the prime mover is not overloaded.
d) Leakage through stuffing box is normal i.e. 50 to 60 drops per minute in the gland packing
e) There is no leakage from mechanical seal.
f) The ball bearing do not get excessive hot.
g) Avoid idle running on operation against closed discharge valve for a longer period of time.

Commissioning/Testing of Motors

OPERATION BEFFORE COMMISSIONING:

Before motor is put into regular service, make an initial start as follows:-

a)Tum the shaft of the motor by hand to be sure that it rotates freely.

b)Check motor connections against wiring diagrams.

c) Check voltage, phase, and all load drive parameters against motor name plate.

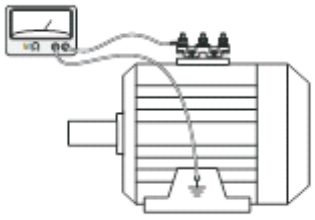
d) The motor must not be operated at speeds beyond the safe mechanical limits.

e) If load is disconnected, run motor at no load long enough to be certain that no unusual conditions develop and check for the direction of rotation. Listen and feel for excessive noise, vibration, clicking or pounding. If present stop motor immediately, investigate the cause and correct before putting motor in service.

f) When checks are satisfactory, operate at a minimum load and look for unusual conditions. Increase load slowly to a maximum. Check motor for satisfactory operation.

g) Electric motors operating under normal conditions become quite warm. Although some places may feel too hot to touch, the unit may be within temperature rise limits. If necessary use a non-contact thermometer for measuring the temperature.

h) Insulation resistance of the stator and rotor windings should be checked before commissioning, both between the windings and between each winding and earth.



Tests to be carried out before commissioning motor.

1)Identification of terminals

2)Test for Insulation Resistance.

(1) Identifying the terminals of a 3-phase induction motor with the help of single lamp method.

1. Connect the terminals as shown in Fig 5a. Connect it to a 240V AC supply and switch on the supply.
2. If the lamp glows, the linked terminals are dissimilar. i.e U_2 U_1. Mark them as U_2 V_1.
3. If the lamp does not glow, the linked terminals are similar (i.e U_2 V_2). (Fig 5b) Mark them as U_2 and V_2.

When current flows through the coils they produce magnetic fields. If dissimilar ends are shorted (linked) they assist each other and voltage induces in the third coil and the lamp glows. If similar ends are linked, the magnetic fields oppose each other and no voltage will be induced in the third coil. Hence the lamp does not glow.

(2)Test a 3-phase induction motor for insulation resistance and earth effectiveness

PROCEDURE

1 : **Measure the insulation resistance value between the windings.**

Before starting the Megger test, see that the supply is off, fuse-carries are removed and the motor is disconnected from the starter.

2. Identify the terminals of the given AC induction motor from the markings.

As a precautionary measure, remove all the links in the terminal plate and check the continuity of each winding. End terminals of the same winding should have continuity.

Maintenance of Motors

To get trouble free service and maximum efficiency a motor needs regular periodical maintenance.

A motor has to be regularly maintained in the following aspects.

Regularly examine the earth connections and motor leads.

Examine periodically the starting equipment.

Blow out clean dry air over the windings of the motor thoroughly .

In case of slipring motors check the slip ring for pitting and brush for wear. Replace badly pitted slip rings and worn out brushes.

Check bearing housing for any abnormal temperature rise.

Check insulation resistance.

Maintain record of each motor

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Power supply maintenance and Plant maintenance

OVERALL INSPECTION OF TRANSFORMERS

Overall inspection of the transformer including lifting of core and coils has to be done once in five years.

UNTANKING OF CORE ALONG WITH WINDING:

1. Before untanking measure the insulation resistance of transformer with a 1000V megger between LT andHT, LT and Earth &HT and Earth. The IR value should be minimum of 200 Mega Ohms.
2. Unload the conservator tank after draining out the oil. Replace the oil sight glass if damaged
3. Open the tank cover bolts.
4. Remove the HT bushing lead nuts, cap, bushing clamp nuts and then remove the HT bushings .
5. Disconnect the HT leads and remove the tank cover .
6. Disconnect the LT flexible leads and then unlock the core fixing clamp.
7. Remove the mechanical connection to the off load tap changing switch handle.
8. Lift the core and coils vertically by slinging it from lifting lugs provided on the core. Take adequate precautions so that the sling does not foul against connections, tapping switch.
9. Allow the core and coils to drain oil into tank and then place the core at a clean dry place or in a metal tray filled with saw dust or sand.
10. Check carefully for damages or breaks in coil at joints and at tap changer.
11. Operate the tap changer and observe for any defects at contact points.
12. Tighten any loose connections, replace any defective material. Check for continuity in HT and LT windings. Check insulation resistance with a 1000V megger. The insulation resistance between HT and LT, LT and earth & HT and earth should be minimum 200Mohms.

TANKING OF CORE

Before tanking heat the core in a oven for drying out the transformer. To take away slackness, tighten the tie rods and core bolts with a torque wrench for reducing gap in the core. Use permali wood pieces for proper fitment of coils. Fasten all leads firmly. Check off load tap changer by operating it. Ensure that there is no damage to the coils. Insulate the terminals with cotton tape.

Before tanking the core ensure that the tank is clean and dry ***and apply anti-tracking varnish of Dr. Beck elmo luft1A***

- Clean the core with a blower. Lower the core into tank duly ensuring that there is no fouling or damage to the coil.
- Fit the LT bushings in the slots duly placing the gasket between the tank body and insulating part of the bushing. Connect the off load tap changer.
- Fit locking clamps to clamp tightly the core to the tank body. Connect the flexible copper braid between LT terminals and LT bushings fitted to the transformer.
- Pour transformer oil.
- Place gaskets properly.
- Place tank cover on the tank after carefully drawing out the HT leads. Place rubber gaskets and bushing clamp on tank wall. Form an eyelet of HT winding and connect it to the HT lead.
- Seat the HT bushings carefully. Place the oil seal, cone washer, brass cap on the terminal lead. Fit the nut on the lead and tighten. Fix the tank cover by tightening the bolts evenly.
- Fit back conservator tank. Pour oil into the conservator tank up to the upper level mark.
- Check the transformer for Insulation resistance before commissioning the transformer.

MAINTENANCE OF CIRCUIT BREAKERS

Out of many items which need inspection and maintenance, the circuit breaker is perhaps the most important. Circuit breakers usually need more frequent and more prolonged maintenance. In general, for maintenance of CB the instructions of manufacturer should be followed.

Under normal operating conditions during regular inspections following checks should be made:

- The contacts should be checked for proper alignment.
- All insulating parts should be thoroughly cleaned to remove all traces of carbon which may remain after the oil has been drained from the tank.
- Check the functioning of the breaker through devices which will have to function on fault or overload.
- Check indicating devices such as mechanical on and off indication, as an incorrect indication may at some times lead to a fatal accident.
- Check auxiliary switches for cleanliness and correct contact making.
- Check all bolts and nuts for tightness.
- Check links of operating mechanism for smooth movement. A small quantity of appropriate lubricant should be applied at joints. Excess of lubricant should be avoided because it may find way in other parts. Remove dust laden lubricating oil before applying new lubricant.
- If a CB operate under fault conditions to interrupt a fault, then maintenance after such occurences should be carried out giving special attention to the following items.
- Current carrying parts: All contacts including isolator contacts should be examined, dressed or replaced if necessary.
- Insulation should be cleaned to remove carbon deposits. Examination to be made of cracks, tracking or other damages.

- Arc control devices should be checked and dismantled, if any carbon or metallic deposits are found, these should be removed.
- All joints and seal should be examined for tightness.
- The general inspection for any mechanical damage or distortion of the structure and mechanism should be made. The switch gear should be closed and tripped by each of the methods provided.

In addition to the periodical maintenance carried out as above, every circuit breaker will be completely overhauled after five year interval

MAINTENANCE OF ISOLATORS/AIR BREAK SWITCH

During maintenance insulators are cleaned with lintless cloth slightly soaked in petrol. The conditions of all contacts is checked and on detecting any trace of burning, defective contacts are cleaned or replaced with new ones. Old grease is washed from the insulation rubbing the part with kerosene and a thin layer of fresh grease is applied. Loose bolts and nuts are tightened at all points. The operating mechanism of isolator is checked by closing and opening each isolator several times with the line de-energised.

When adjusting the mechanical part of 3 phase isolators, the switch blades are checked for simultaneous closing isolator blades are checked for ease of engagement with fixed contact jaws.

Isolator contacts must make a close fit in order to avoid excessive heating when closed. This is checked by feeler gauge of 0.05mm (10mm wide). Contact springs are checked both in compressed and free state. Contact surface are coated with acid free petroleum jelly containing minute quantity of graphite.

Condition of isolator insulation is determined by measuring insulation resistance with mega-meter. The general overhaul of isolating switch should be carried out every 2-3 years.

MAINTENANCE OF CABLES

The maintenance of cable installation includes inspection, routine checking of current loading, maintenance and care of all cables and end terminations.

Repairs of cables generally involve replacement of a section of the defective cable by a length of new cable and insertion of two straight joints. All repairs and new joint in connection with repairs should be made in the same manner as joints on new cables.

In some cases where the insulation has not been damaged severely, or where moisture has not obtained ingress into the insulation, it may only be necessary to install a joint at the point of cable failure.

MAINTENANCE OF END TERMINATIONS

- Visual inspection of all the cable end termination should be carried out regularly for any over heating flashing mark, insulation damage etc.
- Cable end terminations should be checked for tightness with a suitable torque wrinch/spanner periodically.
- Check the cable support clamps, glands for proper position and intactness.

INSPECTION OF EARTHING ARRANGEMENTS

1. All the earthing insulations should be checked before commencing the installation
2. The earth values should be checked during summer in a dry day and the value should be painted on the earth pit duly recording the date of measurement. Simultaneously separate register is also to be maintained.
3. During the inspection of the earth pit check any G.I. nut bolts rusted replace it with new G.I hard ware. Ensure proper tightness.
4. Ensure that the two independent nuts should not be connected in series since failure of one terminal or breakage of conductor will defeat the purpose of providing earth resistance.
5. Ensure that the earthing leads connections should be easily visible. They should not be buried in concrete or cement.

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Case studies on failures on Power and Plant maintenance.

CASE STUDY OF DIESEL GENERATORS

PROBLEMS AND REMEDIAL MEASURES

PROBLEM	POSSIBLE CAUSE	REMEDY
Engine fail to start.	Dirty clogged air cleaner.	Clean it
	Fuel tank may be empty	Refill the fuel tank
	Air may be in injection pump	Bleed
	Pressure valve spring may be broken	Replace if broken
	There may be leakage of fuel in external and internal connection	Check and arrest the leakage.
	Nozzle needle may be jammed.	Clean or replace it.
	Fuel filter may be jammed.	Clean or replace it.
Engine starts but stops after some time	Air cleaner may be clogged	Clean it.
	There may be no fuel.	Refill the fuel.
	There may be air in fuel	Bleed it
	Fuel line may choked	Clean it.
	Fuel filter may be chalked.	Clean it
	Fuel pump may be faulty	Replace it.
	Water may be mixed with fuel.	Change the fuel
Engine not gaining full speed.	Fuel tank may be empty.	Refuel it.
	Governor spring may be broken	Replace it.
	Fuel filter may be chalked or dirty	Clean it.
Engine misses during operation.	Air may be in fuel line.	Bleed it.
	Fuel injection hauls may be chalked	Clean them
	Nozzle may be damaged or dribbled	Replace it.
	Fuel pump may be faulty.	Replace it.
	Water mixed with fuel	Change fuel.
Engine lacks power	Pump may inject insufficient quantity of fuel	Readjust it.
	Nozzle may not be tight	Replace with new nozzle
	Air cleaner may be dirty or clogged.	Clean it
	Poor quality of fuel.	Change it
	Choked fuel line.	Clean it
	Dirty Choked fuel filter.	Clean it
	Water mixed with fuel.	Change it
	Dirty cooling system.	Clean it
Excessive smoke at no load.	Dirty clogged air cleaner	Clean it
	Choked fuel injection haul.	Clean it
	Faulty fuel pump	Change it

Excessive smoke at full load.	Dirty clogged air cleaner	Clean it
	Poor quality of oil	Replace with proper grade of fuel
	Nozzle damaged.	Replace it
	Choked fuel injector haul	Clear it
	Faulty fuel pump	Replace it
	Engine overloaded	Adjust the load.
	Broken/seized/burn out piston rings	Replace them.
Engine gives out blue smoke.	One or more cylinder not working	Check and repair.
	Engine needs overhauling	Send for overhauling
	Worn out liner on piston	Replace it
	Wrong grade of lubricating oil	Replace with proper grade of oil.
	Engine used after a long time	Ensure weekly starting.
Engine gives out white smoke.	Water mixed with fuel	Change fuel
Engine overheats	Faulty fuel pump	Replace it
	High exhaust back pressure	Release the pressure
	Wrong grade of lubricating oil	Use fresh oil with proper grade.
	Clogged oil passage.	Clear the passage.
	Faulty relief setting.	Adjust it.
	Loose fan belt.	Adjust it
	Air leakage through cowling.	Repair it
	Engine oil may be dirty.	Change it
	Engine overloaded .	Adjust the load
	Broken/ worn-out piston rings	Replace them.
	Damaged main or connecting bearings	Replace them.
Excessive vibration	Loose fly wheel	Adjust it
	Battery run down	Charge the battery
Excessive fuel consumption.	Dirty clogged air cleaner	Clean it.
	Poor quality of fuel	Use proper grade of fuel
	External internal fuel leakage	Check it and prevent.
	Faulty fuel pump	Replace it
	Engine overloaded	Adjust the load.
	Broken worn-out piston rings	Replace them.
	Worn-out liner and piston	Replace them
	Damaged main or connecting bearing	Replace them.
	Injector needs adjustment	Adjust it
	Incorrect value of fuel timing	Adjust properly.

Overheating of Alternator	Excessive room temperature or improper ventilation	Machine should be installed in a good ventilated room.
	Misalignment	Check alignment and adjust.
	Faulty foundation	Reconstruct the foundation and properly labour it.
	Overloading of machine	Check the load current.
	Blocking of ventilation.	Clean the inlet and outlet holes.
Overheating of Armature	Overloading	Adjust the load.
	Internal short circuit	Rewind the armature.
	Incorrect value of fuel timing	Adjust properly.
Overheating of Alternator	Excessive room temperature or improper ventilation	Machine should be installed in a good ventilated room.
	Misalignment	Check alignment and adjust.
	Faulty foundation	Reconstruct the foundation and properly labour it.
	Overloading of machine	Check the load current.
	Blocking of ventilation.	Clean the inlet and outlet holes.
Overheating of Armature	Overloading	Adjust the load.
	Internal short circuit	Rewind the armature.

Trouble shooting of centrifugal pumps

No liquid delivered

Lack of prime
Speed of pump driver too low
Discharge head too high
Suction lift too high
Impeller plugged
Wrong direction of rotation,

Pump discharge pressure low

- Gas or air in liquid
- Pump water passages obstructed
- Impeller diameter too small

Pump looses prime after starting

- Incomplete priming
- Too high a suction lift
- Air leaks in the suction pipe or packing glands
- Gas or air in the liquid
- Suction line not filled with liquid
- Air or vapour pockets in the suction line
- Pump speed too high

Bearings wear rapidly

- Misalignment
- Bent shaft.
- Vibration.
- Excessive thrust from a mechanical failure.
- Inside the pump.
- Lack of lubrication.
- Wrong bearing installation procedures.
- Dirt in the bearings.
- Moisture in the oil.
- Excessive cooling of the bearings.

Trouble Shooting of Submersible Pumps

Pump fails to start

- This may be due to blown fuses, short circuiting or heavy load on the pump.

Pump starts but low discharge or no discharge at all.

- The motor is running in the reverse direction.
- The pump is operating against a head greater than its rated capacity.
- The pump suction is blocked by foreign matter, salt deposits or collapse of the bore.
- The pump is air locked no discharge at all.
- The reflux valve above the pump is jammed or the pipe closed by obstruction or by the valve.
- Voltage or frequency is considerably lower than required.

Possible Troubles of Jet Pumps and their causes and Remedies

Trouble	Possible Causes	Suggested Remedy
Pump not delivering water	a. Leaky suction pipe b. Inadequate priming c. Injector nozzle clogged d. Foot valve stuck or strainer clogged e. Water level below foot valve. f. Horizontal piping does not slope up from well to pump g. Pump rotating in wrong direction	a. Make sure all pipe connections are pressure-tight b. Do proper priming by adding water c. Remove the injector and clean nozzle of any obstruction. Make sure piping is absolutely clean before replacing injector. d. Remove, repair and clean. e. Lower injector or foot valve deeper in the well. f. Make sure there is no air trap in the horizontal piping between the well and the pump. g. Check electric connections of the motor
Low pump capacity	a. Water level too low b. Low well capacity c. Injector nozzle clogged d. Foot valve stuck or clogged e. Leaky suction pipe	a. Check water level against performance tables to make sure that it is not out of range of pump or injector used. b. This will result in excessive drawdown in well. Usually corrected by lowering jet further in well. c. Remove injector from well and clean nozzle in case of any obstruction. Make sure pipes are clean before replacing. d. Remove injector from well and clean strainer. Make sure foot valve is not stuck. e. Make sure all pipe joints are pressure-tight so that no air can leak under suction.
Pump starts and stops frequently	a. Leak in pumping system b. Foot valve may be leaking c. Improper connection of service pipes	a. Check all valves and make sure there is no leakage in system. b. Remove foot valve and repair it. c. In case of domestic water supply, on installations where pump is installed at some distance from point of water usage, service line should be connected to water storage tank rather than to pump or on the pipe-line from pump to tank

Trouble shooting of Motors

a. Motor fails to start

Cause	Test	Remedy
Overload relay tripped.	Wait for overload coils to cool. Push the reset button if separately provided. In some starters the stop button has to be pushed to reset the overload relay.	If motor could not be started check the motor circuit for other causes as outlined in this chart.
Failure of power supply.	Test the power supply at the starter incoming terminals.	If the supply is present in the incoming terminals of the starter, check the starter for fault. If not, check the main switch and fuses. Replace the fuses if necessary or restore power supply.
	Measure the voltage at the mains and compare with the name-plate rating.	Restore normal supply or check the cables for undergoing.
Low voltage.	Compare the connection with the original diagram of the motor.	Still if motor does not start, reconnect after disconnecting the connection of the motor.
Wrong connection	Measure the starting torque required by load.	Reduce load, raise tapping on auto transformer, and install a motor of a higher output.
Overload.	Open the motor and check the play of bearings.	Replace if required.
Damaged bearings.	Measure current per phase and they should be equal, if required measure resistance per phase; check insulation resistance between winding and earth.	Repair the fault if possible or rewind stator.
Faulty stator winding.	Check the control circuit and compare it with the circuit diagram.	Reconnect the control circuit according to the manufacturer's circuit diagram.
	Check the terminal connection of the main switch, starter and motor foe discoloring and loose nuts.	Tighten the terminals.
Wrong control connections.	Disconnect the motor from the load.	If the motor starts satisfactorily check the driven machine and rectify the defect.
	Check visually and then with multimeter/megger.	Rectify the defect or wind.

Loose terminal connections at mains or at starter or at motor.	Check the phases and coil groups with the help of an ohmmeter or use internal growler.	Repair the winding or rewind.
	Test with a megger or test lamp.	If the fault is found, repair or rewind.
Driven machine is locked.	Rotate the rotor by hand.	If the rotor is stalled, dismantle the motor and rectify the defect.
Open circuit in stator or rotor.	Check the load and belt tension.	Reduce the load or loosen the tight belts.

b. Motor blows off fuses

Cause	**Test**	**Remedy**
Incorrect size of fuses.	Check the size of the fuse wire (it should be rated 11/2 times its normal current); connect the ammeter in the circuit and test for excess load current.	Replace the fuse wire if necessary; repair the motor if it is due to electrical fault of stator or rotor.
Low voltage	Measure the line voltage.	Remove the cause of low voltage.
Excessively loaded.	Measure the line current and compare it with its rated current.	Rectify the fault; if not possible then rewind the stator.
Faulty stator winding.	Check for open circuit, short circuit or leakage of the stator as explained earlier.	Repair the fault; if not possible then rewind the stator.
Loose connection in starter.	Check for loose or bad connection in the starter because it may cause unbalancing of current.	Rectify the loose connection; loose all the contact points of the starter with sand paper and align the contacts.
Wrong connection.	Check the connection with the original diagram.	Reconnect the motor if it still does not start.

Trouble shooting of DOL starter

Symptoms	Causes	Remedies
Motor does not start when the 'Start' button is pressed. However on pressing the armature of the contactor manually, motor starts and runs.	Open in no-volt coil circuit.	Check the main voltage for lower than acceptable value. Rectify the main voltage. Check the control circuit wiring for loose connection. Check the resistance of the no-volt coil winding. If found incorrect replace the coil.
Motor starts when 'ON' button are pressed. It however stops immediately when 'ON' button is released.	Auxiliary contact in parallel with the start-button is not cooling.	Check the parallel connection from 'ON' button terminals to the auxiliary contact of the contactor. Rectify the defect. Check the auxiliary contact points of the contactor for erosion and pitting. Replace, if found defective.
Failure of contactor due to too much heating of the 'No' volt coil.	Higher incoming supply rating. No-volt coil rating is not high.	Higher supply voltage than normal. Reduce the incoming voltage.
Coil does not get energized even though supply voltage is found across the no-volt coil terminals.	Open-circuited NVC. NVC burnt out.	Check the nylon strip on relay.
Relay coil has been changed. However motor does not start when the start-button is pressed.	Control circuit of relay open.	Check the control circuit for open. Clean the control station contacts.
Humming or chattering noise.	Low voltage. Magnetic face between yoke and armature is not clean. Shading ring on iron core missing.	Overload relay not reset. Feed the rated voltage. Clean the surfaces of yoke and armature. Provide shading ring in the iron core.

TROUBLE SHOOTING OF STAR - DELTA STARTER

1.Starter not getting on?	1.Check up STOP(PB) "NC contact 2.Check up Delta contact 3.Check up "Timer NC" contact 4.Check up star contactor coil
2. Main contactor Not getting On?	1Check star contactor "NO" contact 2. check up main coil.
3. When ON push button is released, star coil releases or main coil releases.	1 Check Main contactor "NO" contact
4. Star contactor continuously ON	1. Check up Timer "NC" contact.
5. Star contactor stop, But does not change to Delta contactor	1. Check up star contactor "NC" contact
6.When changed to "Delta" connection, Motor getting sound	1. Change motor connections at "Delta" contactor out going side.. This is due to same main phase being supplied to one motor phase

P.B. Push Button
N.C. Normally close
N.O. Normally Open.

******* THE END ******