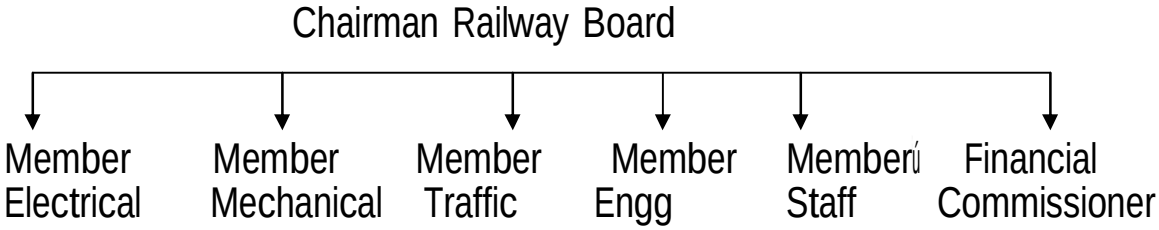
Chapter 01

Lesson No. 01 Foundation

Sub-lesson - 01 Railway Administration.

Indian Railway is the biggest organization in Asia and second biggest in the world. Indian Railway is the biggest commercial organization run by Govt. of India in which approx. 16 lakhs of employees are working. The entire organization is in control of Railway Board. It is headed by Chairman Railway Board. Railway Board fuctions under Railway Ministry. The railway ministry is headed by Hon. cabinet Minister and and there are two Minister of state for Railways.

To improve the efficiency of Indian Railways, it is devided in to 16 different zones. Varios Divisions are working under Zonal Railways.



Various Directorates works under Railway Board for each department.
To assist members there are-

- Additional Member
- Advisor
- Executive Director
- Director
- Joint Director
- Dy.Director
- AEE

The Indian Rly is divided into 17 zones for better efficiency and administrative convenience. The zone is headed by General Manager and

assisted by AGM and SDGM. For every department there is a Principal HOD. e.g. There is Principal CEE for electrical department.

In addition to these zones there are 7 production units and Metro Rail headed by GM also works under Railway Board.

16 Zonal Railways-

Zone	**Head Quarter**
1. Eastern Railway	Kolkata
2. Western Railway	Churchgate, Mumbai
3. Northern Railway	New Delhi
4. Southern Railway	Chennai
5. Central Railway	CST, Mumbai
6. East-central Railway	Hajipur
7. East-central costal Railway	Bhuvaneshwar
8. West-central Railway	Jabalpur
9. North-eastern Railway	Gorakhpur
10.North-western Railway	Jaipur
11.North-central Railway	Allahabad
12.North-eastern Frontier Railway	Maligaon
13.South-eastern Railway	Garden Reach, Kolkata
14.South-western Railway	Hubali
15.South-central Railway	Secunderabad
16.South-eastern coastal Railway	Bilaspur
17. Metro Rail	Kolkata

Every zone is further divided in to the divisions. The head of the Division is DRM. For General services Sr.DEE(G) is the branch officer assisted by DEE(G) and or ADEE(G).

For production units/factory GM is the head. Head of the workshop unden zonal railway is CWM.

Production units-

1. Integral coach factory - Perambur,Tamilnadu.
2. Rail coach factory - Kapurthala, Punjab.
3. Chittaranjan Locomotive works - Chittaranjan, W. Bengal
4. Rail wheel plant - Bangluru, Karnataka.
5. Diesel Locomotive Works - Varanasi, Uttar Pradesh.
6. Diesel Modernisation workshop - Patiala, Punjab.
7. Rail Spring Work shop - Sitholi,Madhya Pradesh.

Sub-lesson- 2 Various departments .

Main departments-

1) Electrical engineering.
2) Mechanical engineering.
3) Engineering (civil)
4) Signal and telecommunications.
5) Commercial.
6) Operating.
7) Stores.
8) Accounts.
9) Personal.
10) Medical.
11) Security.

Sub-lesson- 3 Division / Workshop

DRM is the head of the Division. He is assisted by ADRM and the other branch officers.

In work shop Chief work shop manager (CWM) is head of the work shop. This organization is not under division. GM is head of the zone.

Sub-lesson- 4 Organisation of electrical branch.

Railway board level	**Zonal level**
Chairman Railway Board(CRB)	General Manager(G.M.)
Member Electrical	Additional GM (A.G.M.)
Executive Director	Chief electrical engineer(CEE)
Director	Chief elect.service engineer(CESE)
Joint Director	Chief electrical loco engineer(CELE)
Deputy Director	Chief elect. traction engineer(CETE)
Assistant electrical engineer	Chief elect. distribution engr(CEDE)
	Assisted by Dy.C.E.E./S.E.E./ A.E.E.

Divisional level-

- D.R.M.
- A.D.R.M.
- Senior Div.Elect.Engr.(Gen.)
- Senior Div.Elect.Engr.(TRD.)
- Senior Div.Elect.Engr.(TRS.)
- Senior Div.Elect.Engr.(TRO.)
- D.E.E.
- A.D.E.E.

Sub-lesson- 5. Various fields of electrical works.

1. General services-

a) **Out side maintenance (OSM)-** They look after operation and maintenance of electrical installation at stations, service buildings, yards, quartes, pumping station, air conditioning, etc.

b) **Train lighting and air conditioning (coaching)-** They look after train lighting and air conditioning of coaches.

2.Traction distribution (T.R.D.)-

a.Power supply installation.(PSI)
b.Over head equipments (OHE)
c.remote control equipments(RCE)

3. Traction rolling stock(TRS)-

Repairs and maintenance of electric locomotives.

4. Traction rolling operations(TRO)-

Movement of locomotives with running staff.

Sub-lesson- 6 Various welfare schemes.

Personal officer is nominated at Railway, Division and workshop level for monitoring. Welfare instectors team is available for their assistance. Their duty is to make the staff aware about the welfare scemes and help them.

Welfare schemes-

1. Railway recreation centre.
2. Railway schools.
3. Children camps.
4. Holiday homes.
5. TV sanetorium.
6. Canteen facility.
7. Co-operative society.
8. Hostel facility.
9. Clubs.
10. Scholarships, etc.

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Lesson-2 Portable and hand tools.

Sub-lesson- 1 Name, size and uses of hand tools.

Sr No	Name of tool	size	Use
01	Plier, nose plier, side cutting, etc	15 cm 20 cm 25 cm	To hold or cut the wire, tighten nut bolts, etc.
02	Screw driver	10,15,20, 30,60 cm	To loosen or tightenthe screw.
03	Firmer chisel	15 cm, 2 to 5 cm wide	Carpentry work.
04	Cold chisel	--- do ---	To cut the iron/steel, to make holes, etc.
05	Hammer	250 gram to 7 kilogram	For black smith, etc to prepare a job.
06	Mallet	---do---	--- -- do-- ----
07	Files	Flat, round, half round, triangular, etc.	Fo filing the job.
08	Drill machine	Hand driven and electrically operated	To make holes in wooden or iron job.
09	Spanners	Flat, double end, adjustable, box type, wrenches	To open or tighten the nut bolts
10	Centre punch	-----	For marking on the job
11	Tennon saw	250, 400 mm	To cut the wooden job

12	Hack saw	Fixed, adjustable	To cut the iron job
13	Steel foot	15,30 cm	For measurements
14	Try square	150,300 mm	To shape the job with proper angle.
15	Electrician knife	---------	Splicing of insulation, etc.
16	Soldering iron	25,40,65,125 watts	For soldering purpose
17	Standard wire gauge	-----	To measure the size of wires, etc.
18	Micrometer	-----	To measure thickness, diameter, etc accurately
19	Vice	Pipe vice, bench vice	To hold the job tightly
20	Tachometer	------	To measure the speed of the machine

Sub-lesson- 2 Crimping tools.

To have the tight and proper termination and joints crimping tool is used. There are various type of the crimping tools.

1. Hand press, crimping plass.
2. Hand operated multi purpose tool.
3. Hand operated multi purpose tool with dies.
4. Hand operated hydraulic pressure type portable tool.

Capacity- Up to 400 sqmm.

Sub-lesson- 3 Precautions while using the tools.

1. Do not keep sharp tools like knife, screw driver, etc. in the pocket without cover.
2. Sharp and pointed tools shall be handed over to others from handle side.
3. While using chisel cutting should be done away from the user.
4. Before using tools ensure that the handles are tight and there is no oil or greese on it.
5. Use always new and proper size tools.
6. Do not keep tools on the top of the ladder while working on the highted place.

7. Treatment should be done immediately if injured while working.

Sub-lesson- 4 Torque wrench.

Where tightness of the bolt is required accurately done in that case the torque wrench is used. The required value of torque is set and then the bolt can be tightened to the set kg-metre torque. With this the damage due to loose or over tightness are avoided.

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Lesson- 3 Measuring tools.

Sub-lesson- 1 Scale/steel rule, caliper, vernier caliper, micrometer.

Scale- It is a simple instrument used to measure the length, width, etc. Its accuracy is less. At one side cm and mm are calibrated on the other side inches and soot can be measured.
Caliper- With the help of inside and outside caliper, diameter of the round shape job like pipes can be measured. But it requires scale to know the measurements.
Vernier calipers- These sre used to measure the diamensions more accurately. It has two scales, one is called main scale and the other is known as vernier scale.
Micrometer- It is use to measure the diamensions with maximum accuracy. The measurements can be done up to 1/1000 inch, 1/100 cm. the least count is up to 1/2000 or 0.0005.

Sub-lesson- 2 Least count, accuracy, calibration.

Least count- It is the ratio of one division on main scale to the total number of divisions on vernier scale. E.g. if main scale has minimum division of one and vernier scale has total 25 divisions then -

Least count = 1/25 =0.04

Accuracy- accurate measurement of a substance is not possible. It is affected by the temperature, error in the instruments, human error, etc. If

100 cm long object is measured by different persons at different time the readings may be different. One may take it as 99 cm, other 96.5 and so on. The reading with minimum error shall be recorded. Thus the ratio of actual reading obtained to the correct reading is called accuracy.

Calibration- when the instruments are in use regularly the error are increased after some period. Its reliability is reduced. Thus to have the correct reading it has to be calibrated with respect to the standard instrument in the laboratory (Test room). This is called calibration which is done periodically.

Sub-lesson- 3 Measuring instruments, size and types.

Measuring instruments are of following types-

1.Absolute instruments- The instruments used in laboratories and reaserch work are absolute instruments.

2.Secondary instruments- These are most commonly used in day to day work.

On the basis of working measuring instruments can be classified as -

i)Indicating type- It shows the instantaneous reading. E.g. voltmeter, ammeter, wattmeter, etc.

ii) Recording type- In this type the reading can be read directly as well as it is recorded also to access afterwords. E.g. Thermometer, speedometer, etc.

iii) Integrated type- It shows resultant reading after integrating various elements together. E.g. KWH meter, Ampere hpur meter, etc.

Sub-lesson- 4 Use of Scale, vernier calipers, micrometer.

Scale- It is a simple instrument used to measure the length, width, etc. Its accuracy is less.

Vernier calipers- These sre used to measure the diamensions more accurately.

Micrometer- It is use to measure the diamensions with maximum accuracy.

Sub-lesson- 5 Voltmeter, ammeter, megger, multimeter and tachometer.

Volmeter- In electrical circuit voltmeter is used to measure the voltage. It is connected in parallel in the circuit.
Ammeter- It is used to measure the current flowing in the circuit. It is connected in seies with the circuit.
Megger- It is used to measure the insulation resistance of the machine/ equipments or installation.
Multimeter- Current, voltage, resistance, etc can be measured with the help of multimeter.
Tachometer- It is used to measure the speed of the machine in RPM.

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Lesson- 4 Material handling and storage.

Sub-lesson- 1 Types of material, class, and characteristic.

Electrical material is classified as below-
1.Conductor- The material in which there is negligible opposition to the flow of current is called conductor.
Conductors are of two types-1.High conductivity material. 2.Low conductivity material.

High conductivity material- in this type the resistance negligible. It is used for winding wires, cables, etc.
Example- silver, copper, alminium, etc.

Low conductivity material- The resistance of these material is considerable. These are used for making heater coils, load resistance, etc.
Example- Tungusten, nichrome, etc.

2. Insulator- To prevent the leakages in the electrical system insulators are used. It is required in electrical machines, distribution systems,etc. it offers very high resistance to the flow of current.
Example- Porcelein, rubber, mica, PVC, dry wood, etc.

3. Semiconductor- Its characteristics are in between conductor and insulator. These are mostly used in the electronics circuits.

Example- germanium, silicon, etc.

4. Magnetic material- The material which can be converted into magnet easily or offers very low reluctance to the flow of magnetic lines of force. Example- iron, steel, nickel, etc.

Sub-lesson- 2 Shelf life, aging and baking cycle.

Shelf life/ aging- The life and quality of the material is affected with the method of storage, season, physical and chemical properties. Due to moisture its insulation resistance is decreases. If temperature rises its insulation quality is deteriorated.

Insulation resistance can be tested by megger. If IR value is less it can be improved by baking ang applying varnish.

Sub-lesson- 3 Baking cycle.

It is the process of baking new or old winding in oven with the varnish at the temperature of 100 degree centigrade. Due to this process contact of air with the winding material is disconnected. Thus it becomes moisture free and its mechanical property is also improved. Due to baking -

1.IR value is increased.
2.Mechanical property is improved.
3.Life of the material is increased.

Sub-lesson- 4 Sources of insulating material.

1. Fibrous material
2. Mineral product- oil
3. Ceramic material- porcelain.
4. Rubber products.
5. Wax products.
6. Resin material.

Sub-lesson- 5 Quality

Quality of the material should be as follows-

1.High resistance (for insulating material)

2.High conductivity (for conductors)
3.Low density (low weight)
4.It should not be inflammable.
5.It should be flexible.

Sub-lesson - 6 Precautions in stores.

1.There should not be losses during handling.
2.Fire and accidents shall be prevented.
3.Theft shall be prevented.

Sub--lesson- 7 Selection of material.

1.Quantity of material should be as per requirement.
2.Mechanical, thermal, chemical properties should be as desired.
3.It should be easily available, durable and cheap.
4.It should be procured from reliable sources.

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Lesson - 5 Personal safety

Sub-lesson- 1 Use of Tools and other equipments.

1.While handing over the tools, it should be given handle side.
2.Do not keep sharp tools like screw driver, files, knife, etc in the pockets.
3.Use insulated tools while working on electrical appliances.
4.While working on rotating machines ensure that its supply is switched off and nobody else can switch it on accidently.
5.Do not work on live mains neither encourage others to do so.

Sub-lesson- 2 Use of Safety belts, helmet, ladders.

While working on highted places use safety belts and helmets. Do not keep any tool or material on the top of the ladder. The ladder should be hold properly by other person.

Sub-lesson- 3 Working on electrical equipments.

1.Do not play mischief with the electrical equipments.
2.Always switch off the before working.

Sub-lesson- 4 Insulated tools.

Always use insulated tools. Use rubber mat where ever voltage exceeds 60 volts.

Sub-lesson- 5 Earthing.

All the non current carrying metallic bodies of the electrical equipments shall be earthed to safeguard from electrical shock due to leakage current.

Sub-lesson- 6 Fuse, MCB.

To prevent the damage to electrical circuit from overload, short circuit, etc fuse and miniature circuit breaker (MCB) shall be used.

Sub-lesson- 7 Dealing with the electrical accident.

1.Switch off the electric supply immediately.
2.Remove the victim from the live electrical wires.
3.Give first aid and call doctor immediately.
4.Advice all concerned officers.
5.Use fire extinguisher where ever required.
6.In all installations fire extinguishers, sand buckets shall be available.
7.Staff should have the knowledge of operation/use of fire extinguishers.

Sub-lesson- 8 Fire extinguishers.

1.Sand buckets and chemical fire extinguishers shall be available.
2.Staff should have the knowledge of its operation/use.

Sub-lesson- 9 General safety rules.

1.Do not work on live electrical lines.
2.Use insulated tools, gloves, rubber mat, etc.
3.Do not pull the wire for removing pin from the plug. Hold the pin and pull it.
4.while replacing fuse element switch off the main switch.
5.Ensure that the earthing is proper and use three pin plugs.
6.All electrical connections should be tight.
7.Do not play mischief with the electrical equipments.

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Lesson- 6 Safety in the electrified section.

Sub-lesson- 1 Induction effect on electrical lines.

There are two types of induction effect on electrical lines-
1.Electrostatic induction, 2. Electromagnetic induction.

1.Electrostatic induction- This effect is produced due to high voltages.

2.Electromagnetic induction- This effect is due to current flowing in the overhead equipments (OHE).

Sub-lesson- 2 Precautions while working on LT line.

While woking on LT line in electrified section , the line should be earthed at both sides of the place of working. Every team working should ensure that the separate earth is used. (two earths per kilometre)

Sub-lesson- 3 Precautions while working on platforms and FOB.

While working on platform and foot over bridge there is a possibility of danger due to induction effect. The staff working should ensure that the line is earthed properly.

Sub-lesson- 4 Safety precautions at various work sites.

1.Working on crane- During crane working in the section presence of authorized electrical staff is essential.

2. Working on isolator- Isolators should be operated on no load. Thus load should be disconnected before operation of the isolator. These are provided in the yard. The key for the operation is kept with the station master. Register with the name of the authorized person to operate the isolator is available with station master.

3. Bonding- In electrified section all the structures and masts are connected with rails (Earth) by earting conductors is called bonding. It safeguards from the danger of leakage current.

4. Temporary jumper- While replacement of the rails the return path of current should be kept undisturbed for temporary jumpers are used.

5. Permit-To-Work- Before starting the work on OHE in section the staff should obtain permit to work certificate. The duration of power block is mentioned in this PTW alongwith section location. After the work is completed it should be adviced to the TPC. Thereafter the line is charged by the TPC.

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Lesson- 7 Fire fighting.

Sub-lesson- 1 Types of fire extinguisher.

Mainly these are of five types-

1.Soda acid type.
2.Foam type.
3.Carbon di-oxide type.
4.Dry chemical powder type.
5.Other means like- sand buckets, fire brigade.

1.Soda acid type- In this type the nozzle is attached to the body of cylinder. Cap is provided on the top plunger. This is suitable for dry fire. Inside water mixed sodium bi carbonate is formed. Its range is upto 20 to 25 feet. It is not usefull for electrical fire.

2.Foam type- In this type nozzle is attached with the cap. There is a locking arrangement for the cap. It is useful in B class fire i.e. fire related with liquid and oil. The foam produced is conductor of electricity hence

not usefull in electrical fire. It can be used for A class fire. Its range is 20 to 25 feet.

3.Carbon di oxide- Its shape is like the gas cylinder. There is a horn with the discharge tube. Available in 3 to 15 pound capacity. Its range is from 8 to 10 feet. It can be used for local fires and it do not affect the material on which it is used.

4. Dry chemical powder type- In this type there is a trigger valve in the discharge tube. Pressing device is provided on the cap. It is used for the electrical fire. It can be used in all types of fires. The range is 4 metre and pressure 50 psi.
Mixture in form of powder is kept in the container- sodium bi carbonate 97%, magnesium sterate $1^1/_2$%, magnesium carbonate 1%, tri calcium phosphate 1/2%. Carbon di oxide gas container is kept inside.

5.Other devices- a) Sand buckets- Buckets are filled with sand. Whenever required it can be used for throwing on the fire.

b) Fire brigade- There is a pump in the fire brigade so that the water canbe sprayed on fire with very high pressure and from a distance of 50 to 100 feet. There are 2 to 3 feet high pipe stands and length of delivery hose pipe is 50 to 100 feet. At the end of the hose nozzle is fitted with valve.

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Lesson - 8 First Aid

Sub-lesson- 1 Shock treatment.

1) First of all switch off the main switch.
2) Remove patient from the contact of electric supply.
3) Take the victim to airy place having sufficient light.
4) Cover him with blanket to feel warm.
5) Encourage him.
6) If there is difficulty in respiration, give him artificial respiration.

Sub-lesson- 2 Treatment of injury.

1) Apply bandage.

2) Try to stop the bleeding.
3) If the bone is fractured, do not move it.
4) Clean the wound with detol.
5) Massaj the patient body.
6) Give him tea.
7) Take him to Doctor immediately.

Sub-lesson- 3 Treatment on burns.

1 Apply potato water/ burnol ointment/ coconut oil on the burns of the patient.
2 Prepare a mixture of ten gram soda in half litre water. Soak the cloth in this mixture and put it on the burns.
3 If the patient is unconscious try to bring him in conscious state

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Lesson - 9 Material handling and operation of equipments.

Sub-lesson - 1 Types of Equipments.

Manual equipments-
1) Carrier- Box tray, hand trolley, etc.
2) Taking advantage of gravity on slope.

Mechanical equipments-
1) Lifting equipments.
2) To carry on road.

Sub-lesson- 2 Function of equipments.

Manual- In this method the material is transported manually in boxes or trolleys. This consumes more time and requires more labour.

With the help of gravity- In this method with the help of slope material can be transported easily.

Mechanical device- In this method mechanical devices are used for transportation of material. The labour require is less and it consumes less time. These are available to move material horizontally as well as vertically. Devices- fork lift, truck, crane, hoist, etc.

Sub-lesson- 3 Lifting chain, wire rope.

1. Lifting chain and wire rope is used in crane for handling heavy material. Wire rope, lifting chain should be inspected periodically. Machine should not be overloaded.

Sub-lesson- 4 Precautions.

1.Weight should be lifted according to the capacity of the machine.
2. Work should be carried out under the supervision of skilled person carefully.
3. Wire rope, lifting chain should be inspected periodically.
4. Machine should not be overloaded.

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Lesson - 10 Environment and cleanliness of working place.

Sub-lesson - 1 Storage of material

1. Material should be kept at proper place.
2. Corridor, gallery, road, etc. shall be kept clean.
3. Anti corrosion arrangement shall be done.
4. Anti theft measures shall be adapted, material shall be secured properly.
5. Arrangement for prevention of fire shall be made.

If material is stored at proper place in proper way then the losses and accidents can be prevented more over service is improved.

Sub-lesson - 2 Cleanliness at place of working

1.Tray shall be used to avoid dust, dirt, oil spilling.
2.Stair case, benches, road, etc. of work place shall be cleaned every day.

3.Oily material and other waste shall be collected in the dust bin.
4.Every week the floor shall be cleaned.
5.Drainage shall be cleaned time to time.
6.Adequate illumination level and air shall be available at work place.
7.White washing shall be done once in a 14 months.
8.Painting shall be done once in a 5 year.

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Chapter - 02
Lesson - 1 Basic electrical technology and definitions.

Sub-lesson - 1 Electrical circuit, current, voltage, resistance.

Electrical cicuit- It is a path of conductors arranged for the flow of current. In a circuit load, wires, controlling devices, and protection equipments, etc. is provided.

Close circuit- It is a complete circuit in which normal current flows.

Open circuit- The circuit is not complete; there is a break in the circuit. Thus current flowing in this circuit is zero.

Short circuit- In this the circuit is completed byepasing the load i. e. the positive and negative or phase and neutral of the supply cotacts each other without any resistance. Hence the abnormal current flows in the circuit. It damages the appliances/circuit.

Types of electrical circuit-

1. Series circuit
2. Parellel circuit

1. **Series circuit-** The circuit in which there is only one path for the flow of electric current is called series circuit.
2. **Parellel circuit-** The circuit in which there are more than one path for the flow of electric current is called parallel circuit.

Difference in series and parallel circuit-

Series circuit	Parallel circuit
1. There is only one path for current.	There are more than one path for current.
2. load is connected in the form of garland.	Load is connected in the form of ladder.
3.Voltage is divided as per the value of individual resistance.	Voltage is same across all resistances.
4. Current is same in all resistances.	Current is divided in branches. Current is different as per the value of load resistance.
5. Total resistance increases when connected in series.	Total resistance decreases when connected in parallel. Total resistance is less than the lowest resistance in the circuit.

Current- flow of electrons in a circuit is called current. Its unit is ampere. It is measured by the ammeter. Ammeter is always connected in series with the load.

Voltage- It is a potential difference between two points in a circuit. Its unit is volts. It is measured by voltmeter. It is connected in parallel with the circuit.

Resistance- It is the property of the substance to oppose the flow of current through it. Its unit is ohms. It can be measured by ohm meter or multimeter.

Sub-lesson- 2 Work, Horse power, Electrical power.

Work- It is a product of force and displacement.

Work = force x displacement

For example- If 10 lb weight is lifted at a height of 10 feet the work done will be = 10x10 = 100 Foot-lb.

Simillarly- when 10 Kg weight is lifted at a height of 10 metre then the work done will be =10x10 =100 Kg-metre.

Horse power- Rate of doing work is called power. Unit of mechanical power is Horse power.

550 ft-lb work per second is called one horse power.

or

33000 ft-lb per minute is equal to one horse power.

or

In MKS system 75 Kg-m per second is equal to one horse power.

Electrical power- Unit of Power is watts. It is the product of voltage and current flowing in the electrical circuit.

Electrical power = voltage x current i.e. volt-ampere. It is known as aparant power. In pure resistive circuit power factor is unity so watts = volt-amperes.

1000 watt = 1 kilo watt, like wise 10,00000 (ten lakh) watt = 1 mega watt.

746 watt = 1 HP.

1.34 HP = 1 kilo watt.

Sub-lesson- 3 Ohm's Law

Ohms law states the relation between current, voltage, and resistance in the electrical circuit.

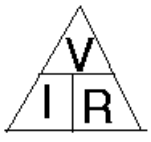
In a closed circuit kepping temperature and physical properties constant the ratio of voltage and current of the circuit is constant, it is known as resistance of the circuit.

V/I = Constant.or R

V/I = R

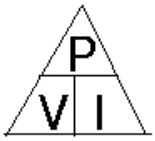
V/R = I or I X R = V . where V = voltage in volts, I = current in amperes and R = resistance in ohms.

Ohms law triangle-



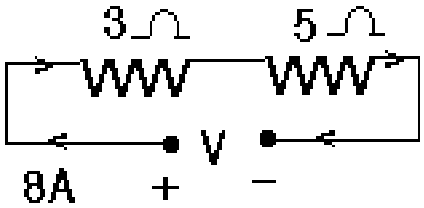
Likewise in DC circuit -

Power = voltage x current = watts,
Current = power/voltage = amperes (P/V = I)
voltage = power/current = volts (P/I = V)



Example- 1

Find out voltage of the circuit given below-



Voltage = Current X Resistance

Since resistance are in series, total resistance of the circuit

$R = R_1 + R_2$

$\therefore \quad R = 3 + 5 = 8\ \Omega$

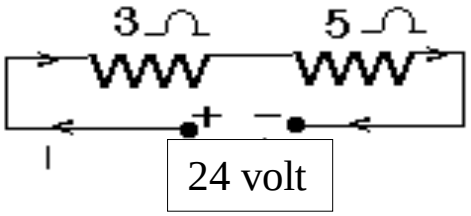
Now Voltage = Current X Resistance

$\therefore \quad V = 8X\ 8 = 64$ volt.

Ans-The voltage of the circuit is = 64 volts

Example- 2

Find out the current flowing in the circuit given below-



Total resistance of the circuit R = R_1 + R_2 where R_1= 3Ω and R_2 = 5Ω

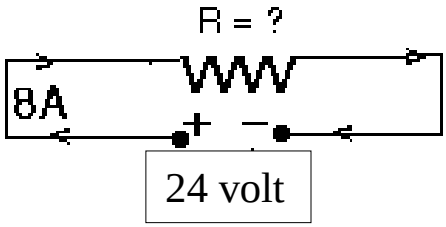
Therefore R = 3+5 = 8Ω

Current I = $\frac{\text{voltage}}{\text{Resistance}}$

∴ Current flowing in the circuit (I) = $\frac{24}{8}$ = 3 amperes

Example- 3

Find out the resistance of the circuit-



Resistance of the circuit = $\frac{\text{Voltage}}{\text{current}}$

Therefore R = $\frac{24}{8}$ = 3Ω

The resistance of the circuit is = 3Ω.

Formulae to calculate power-

1. Power (P) = Current (I) X Voltage (V)
2. Current (I) = $\frac{\text{Power (P)}}{\text{Voltage (V)}}$
3. Voltage = $\frac{\text{Power (P)}}{\text{Current (I)}}$

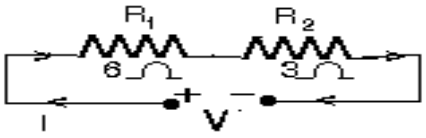
Example- Wattage of a fan is 36 Watts, it is connected to 24 volts DC supply. Calaculate the current drawn by the fan?

We know Current (I) = $\frac{\text{Power (P)}}{\text{Voltage (V)}}$

P = 36 watts, V = 24 volts, C = ?

Current I= 36/24 = 3/2 Ampere = 1.5 Ampere.

When two resistances are connected in series-



1. Ammount of Current flowing through the resistance is same.
2. Voltage drop across the resistance is different.

When the resistances are connected in series the total resistance of the circuit is the addition of these resistances.

$R = R_1 + R_2$ where R is the total resistance and R_1, R_2 are the resistances in series.

Therefore R = 6 + 3 = 9 ohms

When two resistances are connected in parallel-

When two resistances are connected in parellel in a circuit tehn-

1. Current is divided according to the value of the resistan.
2. Total resistance of the circuit is less than the lowest resistance in the circuit. ÆÖ •ÖÖÝÖÖ Æ...
3. Voltage across the resistance in parallel is same.

Total resistance = $1/R = 1/R_1 + 1/R_2$

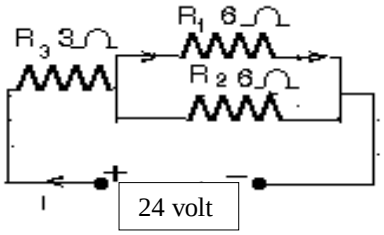
Therefore $R = \frac{R_1 \times R_2}{R_1 + R_2}$ (Applicable only if there are two resistances)

In the given circuit $R = \frac{6x3}{6+3} = \frac{18}{9}$ = 2 ohms

Or $1/R = 1/R_1 + 1/R_2$ i.e. $R = \frac{1}{1/R_1 + 1/R_2}$

$$= \frac{1}{1/6 + 1/3} = \frac{1}{\frac{1+2}{6}} = \frac{1}{3/6} = 6/3 = 2\ \Omega$$

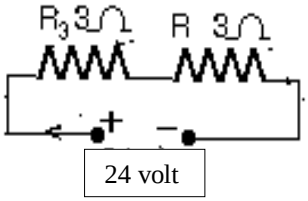
When two resistances are connected in series and parallel-



First calculate total resistance of parallel circuit $R = \frac{R1X\ R2}{R1 + R2}$

$$R = \frac{6x6}{6+6} = 36/12 = 3 \text{ ohms}$$

Now the circuit is reduced to-



Now the resistances are in series hence $R = R_1 + R = 3+3= 6$ ohms

If 24 volts is applied voltage of this circuit then find out the current flowing in the circuit?

Total resistance of circuit is R = 6 ohms, voltage V= 24 volts,

Therefore current I = V/R= 24/6 = 4 amperes

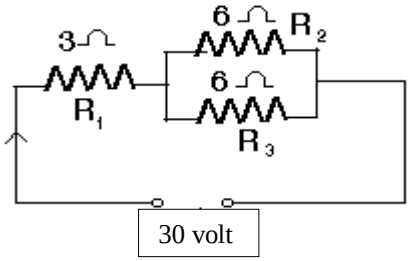
Power P = voltage (V) X Current (I) = 24 X 4 = 96 watt

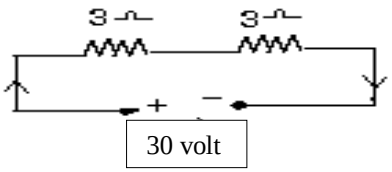
Example- Electric iron of 500 watts capacity is connected to 230 volts supply. What amount of current it will draw?

P = V x I

Given- P = 500 watt, V= 230 volts
Therefore Current I = P/V = 500/230 = 2.13 ampere.

Example- Find out a) Total resistance, b) current and c) power in the following circuit ?





a) Total resistance of the parallel resistances

$$Rp = \frac{R_1 X R_2}{R_1+R_2} = \frac{6X6}{6+6} = 36/12 = 3 \text{ ohm.}$$

Total resistance of the circuit R = R3 + Rp = 3+3 = 6 ohm.

b) Current flowing in the circuit I = V/R
We know- V= 30 volts, R = 6 ohm
Therefore I = 30/6 = 5 ampere

c) Power P = V X I
We know- V = 30 volt, I = 5 ampere
Therefore P = 30X5 = 150 watt.

Sub-lesson - 4 Magnetism, electromagnet, Ampere-turn, MMF.

1.Magnet- The property of the substance to attract or repel the iron or other magnetic material is called magnetism. And that substance is called magnet.
Magnetic material- iron, nickel, cobalt, etc.

If a magnet is suspended freely in the air then its north pole rests in the north and south pole in the south direction.

If it is cut into any number of N S pieces, every piece will be a complete magnet having north and south pole.

Similar poles of the magnets repeleach other and the opposite poles attract each other.

Comparison between electrical circuit and magnetic circuit.

SrNo	Electrical circuit	Mgnetic circuit
01	There is a flow of electrons called current i	There is a flux.
02	There is electromotive force. EMF	There is magneto motive force. MMF
03	There is a resistance.	There is a reluctance.
04	There is a conductivity.	There is a permeability.

Magnetic field- The area in which there is a effect of flux is called magnetic field.

Lines of Force- In a magnet Flux flows from north pole to south pole and south pole to north pole through air or other medium in the form of magnetic lines of force.

Magnetic Material- These are of three types.

1.Di-magnetic material.
2.Para-magnetic material.
3.Ferro-magnetic material.

1.Di-magnetic material- lead, gold, copper, mercury, etc. The permeability of these material is less than one.

2.Para magnetic material- platinum, oxygen, copper sulphate, etc. The permeability of these material is slightly more than one.

3.Ferro-magnetic material- iron, nickel, cobalt, etc. These material has very high permeability.

Electro magnet- When we pass the current in the winding made on the iron rod, it becomes the magnet. This is called electromagnet.

When the flow of current is stopped, still some magnetic power remains in the iron. This is known as residual magnetism.

Application- 1.All electrical machines, 2.Measuring instruments and relays.

Magneto motive force-(MMF)- As EMF is essential to have the flow of current in the electrical circuit likewise The force which is essential to have the flux in the magnetic circuit is called MMF.

Ampere-turn- It is the unit of magneto motive force.

Ampere turn = current flowing in the coil X No. of turns in the coil.

Sub-lesson - 5 Cell, Alkaline cell.

Cell- It is a device which stores electrical energy in the form of chemical energy.

Cells are of two types-1. Primary cell, 2. Secondary cell.

Primary cell- The cells which can not be recharged, thus once these are used it has to be thrown away. i.e. Dry cell, torch cell, deniel cell.

Secondary cell- These cells are charged with help of external source of supply. During charging it stores electrical energy in the form of chemical energy. Hence it is also known as storage cells or accumulators. During discharge the chemical energy is converted into electrical energy thus these are also called as secondary cells. When it is connected to load after desired time it gets discharged. It requires recharging to use again and again. Therefore after recharging again it is ready to use.

Types of secondary cells-

1.Lead acid cells.

2.Alkaline cells. a) Nickel iron cells, b) Nickel cadmium cells.

Battery- When more than one cells are connected in series or parallel is called battery. When the cells are connected in series then battery voltage increases. If these are connected in parallel then the battery capacity is increased.

Alkaline Cell- It was invented by the scientist Edison hence it is also known as Edison cell. The container of this cell is of nickel plated steel. Positive plate is of nickel hydroxide ($Ni(OH)_2$ and the negative plate is of iron oxide (FeO). In this cell electrolyte is made up of 21% caustic potash (KOH) mixed with some lithium hydroxide (LiOH). Thes cell are very good as compared to lead acid cell. Cell voltage in fully charged condition is 1.4 volts. 1.2. volts on load and the cell is treated as discharged below 1.1 volts.

During discharge- $Ni(OH)_4 + 2K \rightarrow Ni(OH)_2 + 2KOH$ (+ plate),

$Fe + 2OH \rightarrow Fe(OH)_2$ (- plate)

During charging - $Ni(OH)_2 + 2OH \rightarrow Ni(OH)_4$ (+ plate),

$Fe(OH)_2+2K \rightarrow Fe +2KOH$ (- plate)

Comparison of lead acid cell and nickel iron cell-

SrNo	**Description**	**Lead acid cell**	**Nickel iron cell**
01	Container	Hard rubber (Ebonite)	Iron (Nickel plated)
02	Positive plate	Lead per oxide (PbO_2)	Nickel hydroxide ($Ni(OH)_4$
03	Negative plate	Pure lead (Pb)	Iron (Fe)
04	Electrolyte	Dilute sulphuric acid (H_2SO_4) 1:4 ratio	21% mixture of caustic soda (KOH)
05	Seperator	Rubber or PVC	Ubberor PVC
06	Maximum voltage	2.2 volts per cell	1.4 volts per cell
07	Specific gravity (SpG.) in fully charged condition.	Approx. 1215 or more	1220 constant
08	Storage	If kept in discharged condition for more time it can fail.	It will not fail if kept in discharged condition for longer period.
09	Weight	Weight is more	Weight is less
10	Discharge capacity	Heavy current can be drawn.	Lower current discharge.
11	Mechanical quality	Mechanically not strong	Mechanically strong
12	Gasing	During charging dangerous fumes are exhausted out.	No gasing out.
13	Capacity	Higher	Lower
14	Cost	low	High
15	Maintenance	more	Less

Note- The difference in nickel iron and nickel cadmium is only that the negative plate of nickel cadmium cell is of cadmium. Since the internal resistance of cadmium is very low thus it is superior to nickel iron cell.

Sub-lesson - 6 Principle of Electrical motor and Generator.

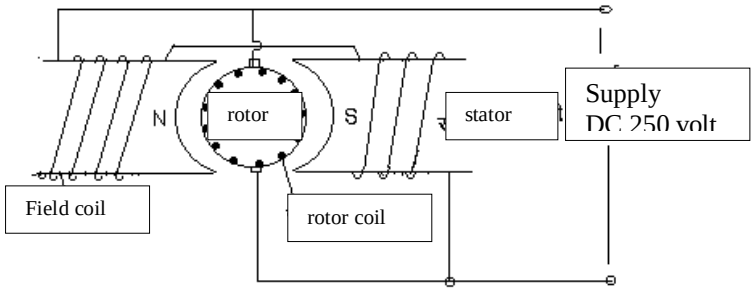
Electrical motor- The machine which converts electrical energy in to mechanical energy is called motor.

Priciple- When a current carrying conductor is situated in magnetic field, it is acted upon by a force which tends it to rotate. This the basic principle of the motor,

DC motor has two windings-

1. Stator winding.

2. Rotor winding.



When supply is given to both of these windings, due to current stator and rotor field is established. Diection of field is as per the direction of current. Due effect of these field force is acted upon a rotor and it rotates.

In 3 phase AC induction motors supply is given to only stator winding and the rotor is short circuited. Due to current in stator magnetic field is produced. The flux is alternating hence due to induction effect emf is induced in rotor. As it is short circuited current starts flowing in the rotor. Stator has rotating magnetic flux thus rotor starts rotating to oppose the cause of producing magnetic field in it.

In single phase AC motor stator field is not rotating type. There fore the starting winding is provided which creares starting torque to move the rotor in desired direction by placing this winding 90 degree apart from the running winding.

Generator- Machine which converts mechanical energy into electrical energy is called Generator.

Principle- Generator works on the Farade law of electro magnetic induction.

First law states that whenever conductor cuts the magnetic flux, EMF is induced in it.
Second law states that the magnitude of EMF induced is directly proportional to the rate of change of flux linkage.

In stator field winding is fed DC supply to form the magnetic field. The main winding is on the rotor thus when rotor rotates it cuts magnetic flux and EMF is induced in the rotor winding. The supply is taken out with the help of carbon brush and slip rings in case of Alternator. In case of DC generator in place of slip ring commutator is used. Commutator converts AC supply to DC.

* * *

Chapter- 3

Lesson -1 Drawing, procedure to draw circuits and reading.

Introduction - Drawing is known as the language of engineers. Every thing can not be communicated with the words. But with the help of drawing we can communicate every thing in detail alog with diamessions, shape, etc.

Sub-lesson -1 Lettering.

Lettering- It is used to write the title, diamenssions, and other information in the drawing. Writing should be clear, neat, beutifull, and of proper size. The lettering is vertical or inclined type.

Types of lettering-

1. Single stroke letter- This a very simple form of writing. Pointed pencil is used and letter is finished in one stroke thus letters are thin. For lettering generally capital letters are used. Size of the lettering is as given below-

a) Main title, drawing No, etc. - 6,8,10 and 12 mm height.
b) Sub title - 3,4,5, and 6 mm height.
c) Name of the material, diamenssions, and other notes - 2,3,4,5 mm height.

Example-

A B C D 1 2 3 4 Vertical

A B C D 1 2 3 4 70 degree Inclined

2.Gothic Letter- If sigle stroke letter is made thicker then it can be called as gothic letter. Thickness of all letters should be same. These type of letters are generally used to write the title of the drawing. Normally the thickness of letters should be between 1/5 to 1/10 th of the height of the letter.

Ratio of height and width should be 5:4 (except A,K,M,W. for these letters height and width shall be the same.)

C,D,G,O,Q letters in vertical form should be ofcircular shape and in inclined form it shall be of oval shape.

Example- **A B C D 1 2 3 4 (vertical)**

A B C D 1 2 3 4 (70 degree inclined)

Sub-lesson - 2 Different sizes of drawings.

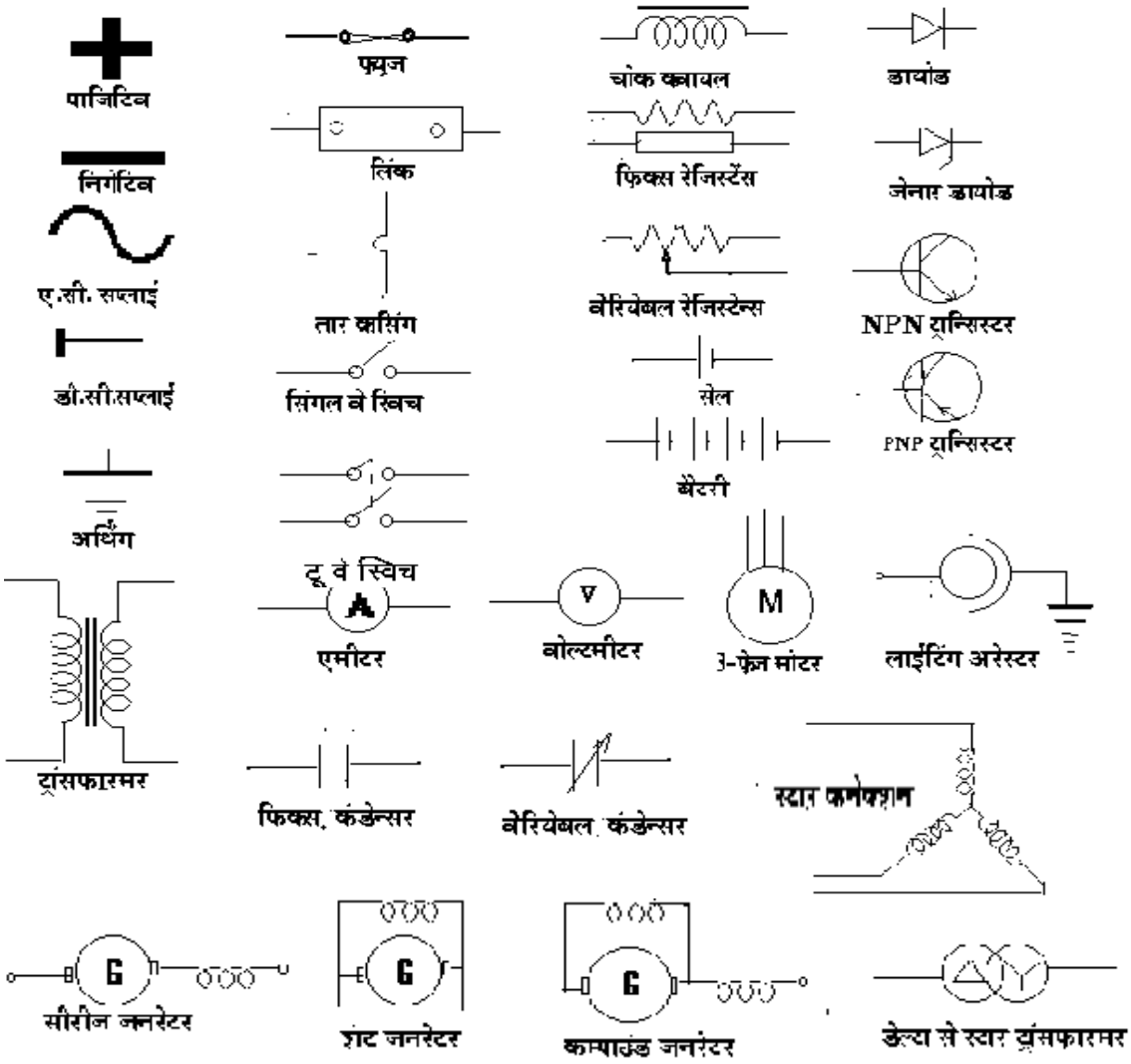
All parts and diamessions in the drawing should be clearly visible. For this it is drawn in three sizes.

1.Full size - When the drawing as per actual diamenssions is drawn then it is called full size drawing. Object will look as it is.

2.Enlarge size - When the object is small then the then its diamenssions are increased in multiples so that it looks clearly. E.g. Scale = 1:10 or 1:100 etc.

3.Reduced size - when size of the object very big then it is drawn with reduced diamenssions so that it can be easily accommodated in the drawing sheet. E.g. scale = 10:1 or 100:1 etc.

Sub-lesson - 03 Symbols used in circuit drawing.



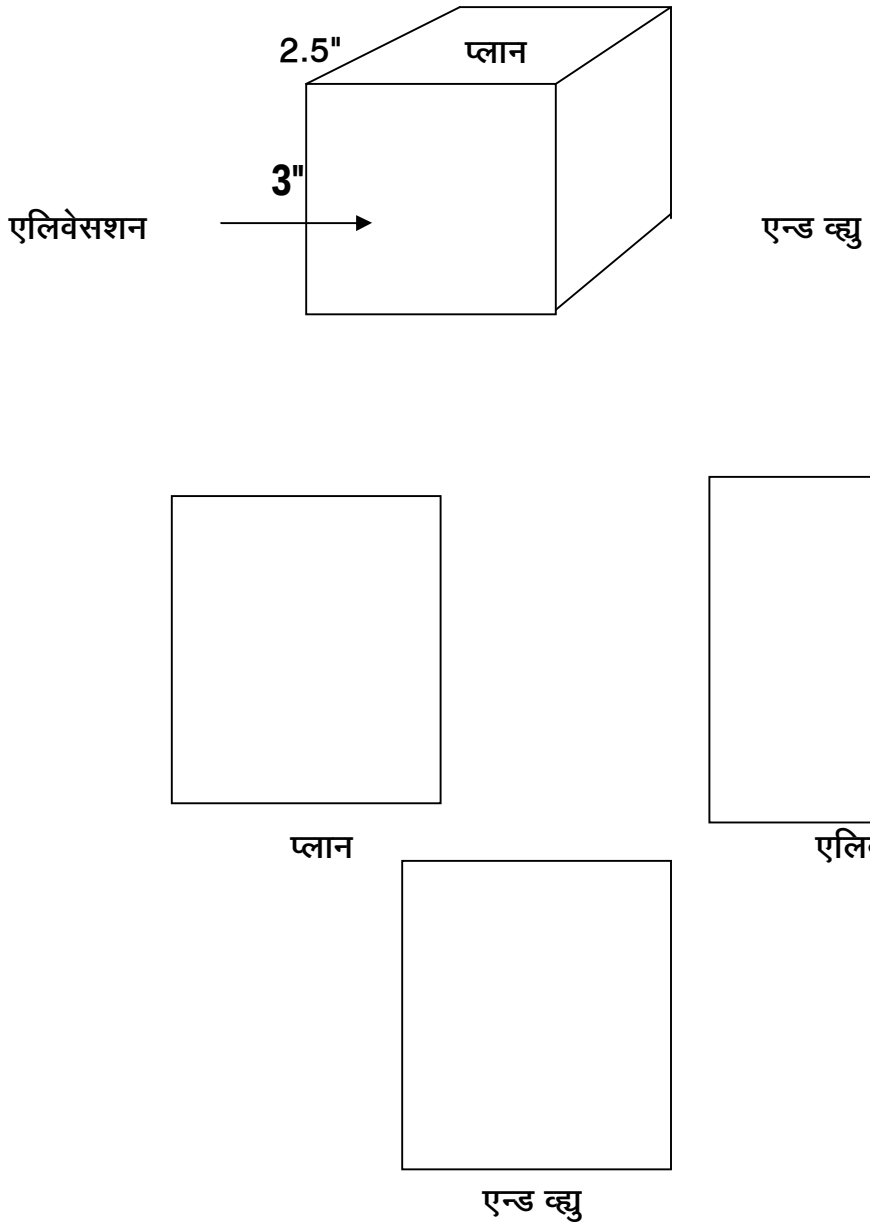
Sub-lesson - 4 Plan, Elevation, End view

1.Plan- The drawing of the object when viewed from the top is called plan.

2.Elevation- The drawing of the object when viewed from the front side is called elevation.

3.End View- The drawing of the object when viewed from the side is called end view.

Example-



Sub-lesson- 5 Scale

For larger objects reduced scale drawing is prepared likewise for smaller objects enlarged drawing is prepared. The scale is chosen for this purpose having suitable representation factor.

Representation factor = $\frac{\text{length of object in drawing}}{\text{Actual length of object}}$

For enlarged drawing representation factor will be always greater than one. i. e. if 1 inch object is shown 5 inches in drawing then representation factor will be 5/1 = 5.

Plain scale- it has two divisions one is main division another is called sub-division. Thus we can measure inches and soot or cm and mm in one scale.

Diagonal scale- in this scale with main division we get two sub-divisions e. g. metre, decimeter and centimeter.

Sub-lesson- 6 Drawing board, drawing material, and equipments.

Drawing board- It is rectangular board of seasoned soft wood planks of 25 mm thick. On left side the ebonite edge is provided so that the TEE square can glide easily. It is available in the following sizes.

1. B-0, - 1250X900 mm
2. B-1 - 900X600 mm
3. B-2 - 650X500 mm
4. B-3 - 500X350 mm

B-2 and B-3 size drawing boards are most commonly used.

Drawing material- Material required is drawing paper, pencils, drawing clips, sand paper, eraser, etc.

1.Drawing paper- It should be ISI approved with sufficient and uniform thickness. Various sizes are as follows.

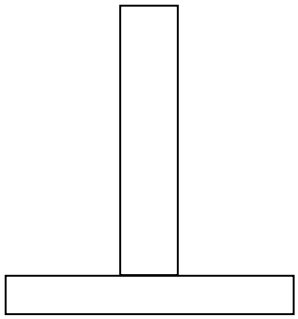
a) A-0 - 841X1189 mm
b) A-1- 594X841 mm
c) A-2 - 420X594 mm
d) A-3 -297X420 mm
e) A-4 - 210X297 mm
f) A-5 - 147X210 mm

2.Drawing pencil- Grade of the pencil is printed on one end e. g. HB, H, 2H, 3H, etc. H means the hardness and B means the softness.

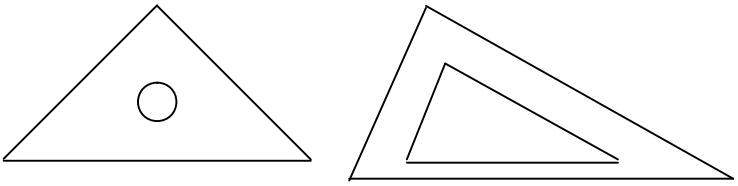
3.Drawing pin/clip- It used to fix the drawing sheet on drawing board.

4.Sand paper block- It is used for sharpening of the pencil.

5.Tee square- It is made up of hard wood or plastic. It is in TEE shape. It is use to draw the parallel horizontal lines. It is also used alogwith set square to draw parallel lines of different angles.



Tee-square



Set-suare

6.Set-square- One set square has 45,45 and 90 degree angles. Another has 30, 60, 90 degree angles. These are made up of plastic or tin. Generally available in 25 cm and 20 cm size.

7.Mini drafter- It can function as TEE square, set square and protractor. It is fixed on drawing board at one place and used as per requirement.

8.Compass- It has two legs, one is pointed and another has arrangement to fix the pencil. It is used to draw the the circles, arcs, etc.

9.Divider- It is used to divide lines in equal parts. To obtain the measurement and transfer to another place.

10.Scale- It is used for conversion of objects measurements to suit the size of drawing sheet.

These are made up of wood, steel, plastic or card board in different sizes. Generally 15 cm length 2cm width or 30 cm lenth and 3 cm width. Thickness is normally 1 mm.

11.Protractor- It is used to measure the angle. It is ade up of transparent plastic.

Sub-lesson- 7 Copying of drawing.

Earlier chemicals were used to to copy the drawings from the tracing paper. In this process white lines on blue background used to emerge. Hence it was called as blue print.

1. Ferro print- white lines on blue background.
2. Ammonia print- blue lines on white background.
3. Xerox print- black lines on white background.

Original drawing is traced on tracing paper and preserved as negative of the photograph.

* * *

Chapter- 04

Lesson- 1 Basic properties of Electrical Materials.

Sub-lesson - 1 Classification of material, types, characteristics and application.

Electrical material is classified in four categories as per their characteristics and applications-

1. Conducting Material.
2. Insulating material.
3. Semiconducting Material.
4. Magnetic material.

1.Conduting material : a) High conductivity material, b) Low conductivity material.

High conductivity material- The resistance of high conductivity material is negligible. Current can pass easily through these materials. Characteristics of these materials is as below-

1. High conductivity.
2. Temperature coefficient of resistance is low.
3. Mechanically strong and should have flexibility.
4. High heat conductivity.

Conductors - These are basically used in the electrical circuits to carry the current. i.e. in distribution lines as cables, wires and for winding of the motors,etc.

Example:- Solid conductors- silver, copper, aluminium, lead, nickel, mecury, etc.

Liquid conductors- acid, alkalies, copper sulphate, sulpher nitrate, etc.

Gaseous conductors- neon, mercury vapour, sodium vapour, etc.

Low conductivity materials- Its resistance is more than conductors but very low as compared to insulators. Therefore it is not a good conductor. Generally these are the alloys. These are used in making heating elements, resistors, filaments, etc.

Example:- Tunguston, nickel chromium, nichrome, etc. ĺ

2. Insulating material- The material which offers very high resistance to the flow of electric current is called insulating material. Normally it will not allow the flow of current. It has many applications in distribution,transmission, and utilization of electricity for most of the electrical appliances to reduce/prevent the leakage current.

Examples:- Solid- Mica, Ebonite, Glass, Marble,Slate, Porcelein, Rubber, silk,cotton, paper, asbestos.

Liquid- mineral oil, varnish, etc.

Gaseous- SF6(sulpher hexa fluoride), etc.

Insulating material should posses following properties-

1. Its insulation resistance should be high.
2. It should be mechanically strong.
3. It should not absorb moisture.
4. It should be good conductor of heat.

3. Semiconductors- These are neither conductor nor insulator. These are used in the electronics appliances like radio, rectifiers, etc.

Example- silicon, germanium, selenium.

4. Magnetic material- The material in which magnet is formed easily is called magnetic material. This is used in most of the electrical machines like motors transformers, measuring instruments, etc.

Magnetic materials are of three types-

1. Ferro-magnetic material- It has very high permeability.
   Example- Iron, cobalt, nickel, etc.
2. Para-magnetic material- It has medium permeability.
   Example- aluminium, platinum.
3. Di-magnetic material- It has very low permeability.
   Example- silver, copper, bismuth, hydrogen gas, etc.

Magnetic material used in machines should have very high permeability and very low iron losses.

Sub-lesson - 2 Shelf life of insulating material, thermal ageing, and Identification.

The life and quality of material depends on its mechanical, chemical, and thermal properties and also on method of storing, carefull maintenance, etc.

Insulation resistance is reduced due to moisture, temperature (heat), effect of adverse season, etc. The condition of insulation is checked by megger time to time. If the insulation resistance is less than the prescribed limit then the remedial measure is taken to improve it.

Classification of insulating material on the basis of temperature.

SrNo	Class	Max. Temperature	Example
01	**Y**	90°C	Cotton, silk, paper, etc.
02	**A**	105°C	Impregnated- cotton, paper, silk, etc.
03	**E**	120°C	Polyurethane, enamel, plastic, etc.
04	**B**	130°C	Mica, fibre glass, etc.
05	**F**	155°C	Mica, fibre glass, asbestos with varnish.
06	**H**	180°C	Mica, fibre glass, asbestos with silicon resin.
07	**C**	Above 180°C	Mica, fibre glass, porcelain, ceramic with high quality bonding material.

Sub-lesson - 3 Baking Cycle.

Insulation resistance of machine winding is improved by varnishing and baking it in the oven. With this not only IR value but mechanical strength is also improved and prevents entry of moisture.

Baking cycle description-

1. Clean the old winding.
2. keep it in the oven and heat up to 100 to 110 °C so that all the moisture goes away.
3. Deep it in the varnish for 2 hrs so that all air is removed and varnish reaches to every where.
4. Take it out and allow the excess varnish to drip in the tank.
5. Bake it in the oven at 110 °C for 4 hrs.

Sub-lesson - 4 Sources of insulation material.

Sources of insulating material are as below-

1. Fibres material- Asbestos, wood. Paper, card-board, cotton, Empire cloth, etc.
2. Mineral Products- Mica, marble, slate, mineral oil,etc.
3. Vitrous and ceramic material- Glass, quartz, silica, porcelain, etc.
4. Rubber and its products- VIR, Ebonite, Gutta-percha, etc.
5. Waxes & Compounds- Paraffin wax, Bitumen compound.
6. Synthetic resin product- plastic, backelite, PVC, polythene, varnish, enamel, etc.

Sub-lesson - 5 Expected qualities of material.

All material should have good mechanical, thermal, and chemical properties i.e.-

- High conductivity, high resistance, and low di-electric loss.
- Low weight.
- Good heat conductivity, good viscosity.
- Ir should be non inflammable and fire retardant.
- It should not be affected by oils, acid, alkalies.

- It should not be affected by any chemicals or metals mixed in the soil. It should not absorb moisture.
- It should be mechanically strong to sustain vibrations.
- It should be capable to work on higher temperatures.
- It should be easily available.
- It should have sufficient flexibility.

Sub-lesson - 6 Choice of material.

Following points shall be remembered while selection of material-

- ✓ It should be capable to fulfill requirements like voltage rating, current rating, di-electric strength, etc.
- ✓ It should be easily available.
- ✓ It should have maximum good qualities.
- ✓ For special material evaluation of cost at various stages.
- ✓ Easy to manufacture/produce.
- ✓ It should be reliable and durable.
- ✓ It should be cheaper.
- ✓ It should have good electrical, physical, mechanical and chemical properties.

* * *

Chapter - 5

Maijor power supply equipments

Lesson No. -1 Name and location of Maijor power supply equipments

Sub-lesson -1 Types of transformers and uses

Transformer- Transformer is a static device which transforms electrical power from one circuit to another without changing its frequency.This is the function of transformer.

Principle of a transformer :- Transformer works on mutual induction principle. i.e. if two coils are placed side by side and AC supply is given

to one coil an EMF is induced in the second coil and it is proportional to the number of turns of the coil.

In generating stations(Power House) transformer is used to step up the voltage of AC supply and thus current is reduced without change in frequency and power. At distribution substation the transformer is used to step down the voltage sutaible for distribution and utilization.

Transformer has two windings-

1. Primary winding- which is connected to the incoming supply.
2. Secondary winding- Load is connected on this winding.

Both of these windings are placed on the same magnetic core.

Types of transformers-

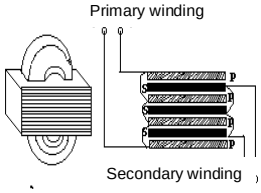
1. Based on construction.
2. Based on application.
3. Based on winding connections.
4. Based on type of cooling.

1. Based on construction- 1) Core type 2) Shell type 3) Berry type.

i) Core type- In this type as shown in picture (A) there is only one path for magnetic lines of force. Their efficiency is low. These are used in the small equipments.

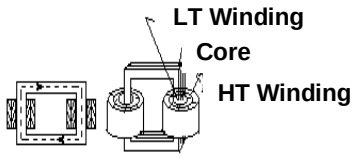
ii) Shell type- In this type there are two paths for the magnetic lines of force. Thus efficincy is more as compared to core type as shown in the picture (B).

iii) Berry type- In this type there are many magnetic paths as shown in the picture (C) thus it is efficient than or and shell type. These are used for high capacity.



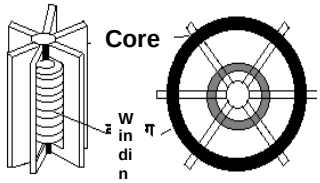
Shell type transformer

A



Core type transformer

B



Berry type transformer

C

2. Based on the application-

i) Power transformer
ii) Distribution transformer
iii) Instrument transformer

1. Power transformer- Transformers above 200 KVA capacity installed in generating stations, factories, and both side the transmission lines are called power transformers. These are available in single phase or three phase. These are put into service as per the requirement. When there is no load the transformers are switched off. Thus thse are designed for maxmimum efficiency at full load. Leakage reactance of these transformers is kept higher than the distribution transformer since voltage regulation is not important. These are designed to keep minimum copper loss.

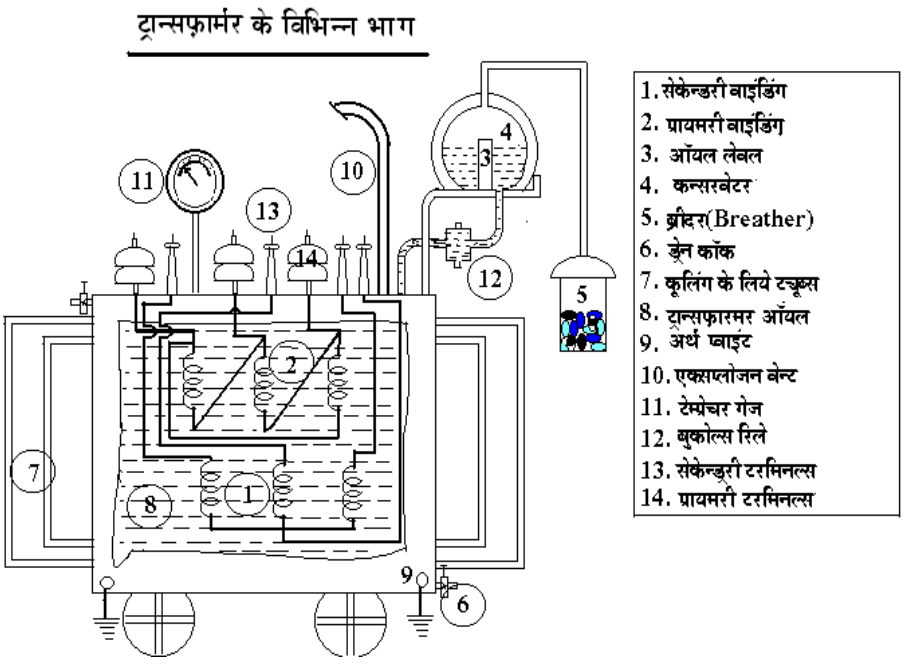
2. Distribution transformer- Generally transformers up to 200 KVA used the substations to step down distribution voltage (11 KV) to standard service voltage (415 V) are called distribution transformers. These are connected in service for round the clock whether the load is available or not. Thus all the while there is iron loss. Hence these are designed to keep iron loss minimum. Normally in General services 11/0.433 KV transformers are used and these are installed at the load centre.

3. Instrument transformer- These are used with the measuring instruments and protective relays.

a) Current transformer (CT)- Where huge current is to be measured it can not be handled by normal ammeter. CT reduces it to 5 ampere so that the small ammeter can measure it e.g. to measure 400 amperes current CT of 400/5 A ratio is used. Secondary of the CT should not be kept open while it is installed on busbar or cable. Otherwise it will burnt out.

b) Potential transformer- To measure the higher voltages conveniently and safely PT is used. PT steps down the voltage to the range suitable for meter e.g. to measure 11000 volts PT of 11000/110 volts is used. This called PT ratio.

3. Based on winding connection- a) delta connected b) star connected



a) delta connection- In this type of connection finishing end of phase 1 winding is connected to the starting end of phase 2 winding. Finishing end of phase 2 winding is connected to the starting end of phase 3 winding. And Finishing end of phase 3 winding is connected to the starting end of phase 1 winding. In delta connection phase voltage is equal to the line voltage.

b) star connection- In this type of connection either starting ends or finishing ends of all the tthree phases are joint together and supply can be connected or taken through free ends. The lead brought out from joint is called neutral and free ends called phases.

In this connection line voltage is root three times the phase voltage i.e. Vp x 1.732 thus if voltage between phase and neutral Vp is 230 volts then voltage between phase 1 and phase 2 (line voltage) V will be 230 x 1.732 = 400 volts. To have the advantage two different voltages on secondary side distribution transformers are always delta-star connected i.e. primary winding delta and secondary winding star.

4. Basd on type of cooling- Teemperature of the transformer rises while it in service. To improve efficiency and ensure proper working various cooling methods are employeed. Most commonly used are given below.

a) natural air cooled transformer (AN)

b) oil filled natural air cooled transformer (ONAN)

c) oil filled air blast cooled transformer (OB)

Transformation ratio- when ac supply is given to the primary winding current flows and it creates alternating flux. This induces EMF in winding which opposes the applied voltage thus it is called back EMF. It is due to self inductance. This EMF is approximately equal to th applied voltage.

The EMF induced in secondary winding is due to mutual induction.It also opposes the vary cause producing it.

If primary voltage = Ep secondary voltage = Es
Primary current = Ip secondary current = Is
No. of primary turns = Np No. of secondary turns = Ns

Then transformation ratio = K= $\frac{Ns}{Np} = \frac{Es}{Ep} = \frac{Ip}{Is}$

यदि अनुपात = 1 हो तो दोनो तरफ़ वोल्टेज बराबर ।

K is the transformation ratio. If K is more than 1 the transformer is called step up and if K is less than 1 then it is called step down.

Q1- In a 3 phase delta star | 11000/400 volts step-downtransformer secondary winding has 40 turns per phase. Find out the number of turns in primary winding?

Ans- Given- primary phase voltage Vp = 11000 volts
Secondary phase voltage Vs = 400/√3 = 231 volts
Secondary per phase turns Ns = 40
Primary pr phase turns = Np

Tranformation ratio= $\frac{Ns}{Np} = \frac{Vs}{Vp} = \frac{Ip}{Is}$

Putting values $\frac{231}{11000} = \frac{40}{Np}$

$Np = \frac{40 \times 1000}{231} = 1905$ turns

Relay- Relay is a combination of set of contacts which makes or breaks the circuit as per the controlling sensing eliment. It has normally open (NO)or normally close (NC) contacts.

What happens when current flows in relay coil- when current flows in a relay coil condition of both contacts is changed. i.e. NO closes and NC opens. This are used in the control circuit to open or close the circuit as desired. This effect is due to formation of magnet in relay coil with the flow of current through it which operates the relay. Types of relays are-

1. Current relay
2. potential relay
3. thermal relay

Contactor- contactor is a magnetically operated switch. It has fixed and moving contacts. These are mounted on a contact carrier. Position of contact carrier is cotrolled by a) spring set b) and electromagnet. When the coil is not magnetized contact carrier remains in off position because of spring tension. When no volt coil get energized force is acted against spring tension and and carrier is attracted and NO moving contacts makes contact with the fixed contacts. Thus circuit is closed. Position of NC contacts exactly opposite of this.

This are used in the motor starters. Starting current of the motor is about 6 to 8 times the normal current. Thus the contactors are made to handle this current for making and breaking the circuit. Whle making and breaking the circuit , there is sparking at fixed and moving contacts. To suppress this arcing arc schutes are provided.

Coil should be chosen as per requirement other wise it affects the life of the contactor. These are manufactured to operate on +10% Ãû -15% of the declared voltage.

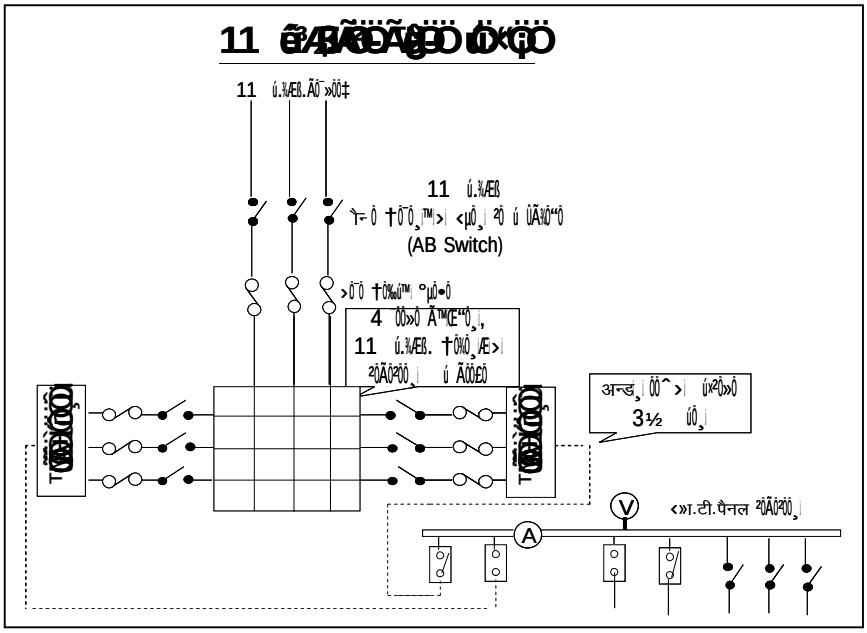
Sub-lesson -2 Layout of Sub-Station

Transmiossion voltage is to step- down to low voltages as per the requirement of the consumer load for which sub-stations are essential. Distribution sub-stations are of three types.

1. Pole mounted sub-station- It is sutaible where space is less and the load is also less. In this type the transformers are installed on yhe pole itself. Incoming HT supply is connected through AB switch.

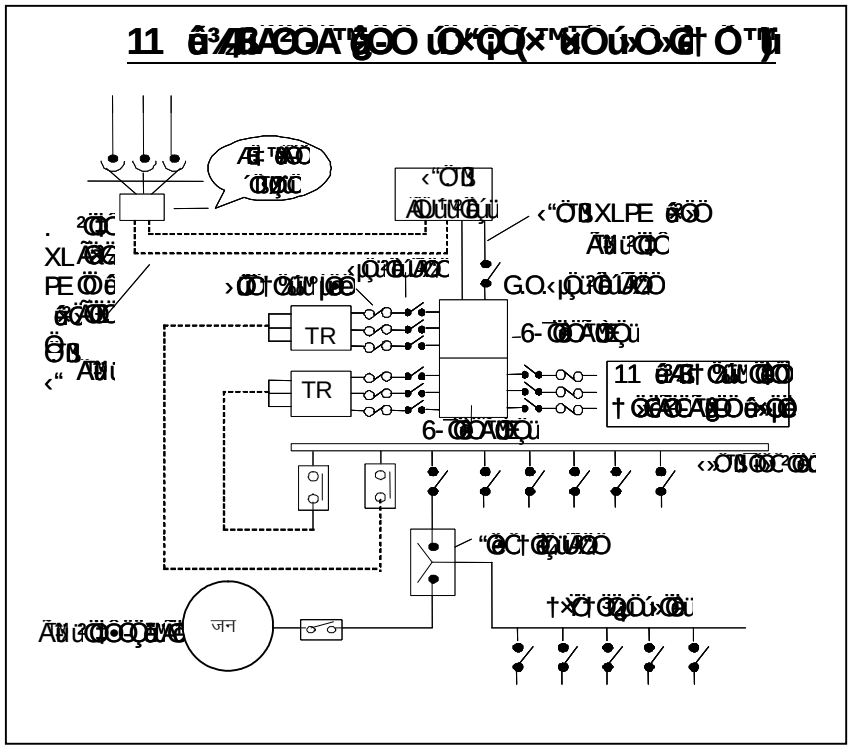
Controlling swiches are provided on outgoing side for the feeders. These type of sub-stations are preffered upto 200 KVA capacity.

2. Outdoor type sub-stations- Where the transformer capacity is above 250 KVA these sre installed on the plinths in open place and proper fencing is provided for the protection. Stand-by transformers are also provided in the sub-station. HT supply is connected through AB switch and drop-out fuses are provided for transformer protection.



3. In-door type sub-station- In factories, etc transformers are installed in the covered shed or buildings. This is called in-door type sub-station. HT supply is arranged through cables. All switch-gears and transformers are used.

Transformers are installed on the low level plinth and arrangement for oil drainage is also made for big sub-stations.



Name of the equipments used in the sub-stations-

1. 4-pole / 6-pole structure with bus-bar
2. HT metering
3. HT circuit breaker / AB switch
4. Lightening arrester
5. transformer AB switch
6. Drop-out fuses
7. Main transformer and stand-by
8. LT cable
9. LT control panel
10. safety equipments as per IE rules
11. Schematic diagram of sub-station
12. Emmergency lighting

Gang operated switch -

It is a manually operated off load switch provided in HT supply. Generally it has three poles operated in a gang. All poles should be opened or closed at atime. These are available in 200 and 400 amps rating.

Sub-lesson -3 Over-head line.

Transmission and distribution of supply- Transmission line is used to transmit huge electrical power with EHV to the distannt locations. In India there are 66, 132, 220, and 400 KV transmission lines for which over-head lines are used.

11KV an 33 KV lines are brought from main substations to small sub-stations to step-down voltage to 440 volts for distribution to consumers for which over-head lines are used.

Electrical power can be transmited and distributed with the two methods- 1. Over-head system 2. Under ground cable system

1. Over-head system- In over-head system iron 0r concrete poles are erected. With the help of cross arm and insulator conductors are strengthened. The bare conductors of copper or aluminium of various capacity according to load current are used in this system. As per IE rule No.85 the maximum length of span for low and medium OH line shall not exceed 65 meters without the permission of EIG.

Main parts of the OH line-

1. **Supports or poles-** To maintain the clearance between ground and conductor which is known as vertical clearance supports are

required. 1/6 th part of its lngth is normaly burried in the ground with the foundation of 1:3:6 ratio concrete.

Minimum Clearances are maintained as per lE rule.

place	For low and medium voltage	For high voltage	For extra high voltage
At road crossing	5.8 m	6.1 m	6.1 m + 0.3 m for every 33 KV or part thereof
Along the road	5.5 m	5.8 m	6.1 m + 0.3 for every 33 KV or part thereof
At other places	uninsulated 4.6 m insulated 4.0 m	5.2 m upto 11 KV	6.1 m

2. Cross arms- acts as a support for insulator.

3. Insulator- It supports and provide insulation between conductor and earth.

4. Conductor- It carries the current. Normally in LT line all aluminium conctors (AAC) are used. In HT lines aluminium conductor steel reinforced (ACSR) conductors are used.

5. Stay rod- It is provided to secure supports in position.

6. Stay wire- It is also provided to secure supports in proper position.

7. Guard wire- Guard wire is provided below the conductors to prevent it from falling down in case it breaks.

8.Stay tightener- It is provided to facilitate the re-tightening of the stay to maintain proper tension.

Advantages of OH line-

1. It is cheaper.
2. Inspection and and fault finding/rectification is easy.
3. It is asy to tap the connection.
4. Enhancement of capacity is easy according to demand of load.

Disadvantages of OH line-

1. It is incovinient in highly populated area.
2. It is prone to short circuits and fire.
3. Line losses are more due to induction effect.
4. Maintenance is more.
5. It can damage due to lightening surges.

Sub- lesson - 5 Battery capacity, life and electrolytes specific gravity

Battery capacity- Battery capacity is given in Ampere-Hours. It indicates that how many amperes can be supplied to load for specific period. In other words amount of current required for charging the battry in specified period. This is called the capacity of the battery.

i.e. the product of rate of discharge current and the period for which it can deliver that current is the capacity of the battery.

Example:- 10 ampere is the discharge current rate for 9 hours it means that the Capacity= Ampere x No. of Hours

= 10 x 9

= 90 ampere-hours (AH)

Efficiency of the battery = Discharge AH / Charging AH x 100

= 90x100/100

= 90 %

It means that charging time will 10 hours but discharging time will be 9 hours.

Electrolite- The mixture of acid or alkali and distilled water used in cell Through which when current is passed chemical reaction takes place is called Electrolite.

Specific gravity- Hydrometer is used for measurement of specific gravity. It is made up of glass tube and a bulb. Scale is provided on the tube. It is kept inside the another glass tube. When it is filled with the eletrolite the inside tube floats at the level proportionately to the acid content. Thus the specific gravity can be read on the scale provided on the glass tube. When battery is discharged the electrolyte is dilute and therefore inside tube will sink in the electrolyte more, Exactly the case is reverse when cell is charged and electrolyte is strong.

Specific gravity of lead acid cell is more than 1210. when specific gravity is reduced to 1180 the cell is treated as discharged. It requires charging immediately. Life of lead acid cell is 4 years.

Sub-lesson-6 Street light fittings

Required Illumination level - 2 to 5 lux

Lux = lumens per square meter. It is the unit of illumination level.

Type of Fittings (luminaires)-

1. FL - fluroscent lamp.
2. HPMV- high pressure mercury vapour lamp
3. LPSV- low pressure sodium vapour lamp
4. HPSV- high pressure sodium vapour lamp
5. CFL - compact fluroscent lamp

Sub-lesson- 7 Yard Lighting

Types of yard lighting-

1. Tower lighting or high-mast tower lights.
2. Distributed lighting.
3. Gantry lighting.
4. Combined system (combination of all three types)

Sub-lesson- 8 Types of conductors

There are three types of conductor-

1. solid conductor
2. Liquid conductor
3. Gaseous conductor

Solid conductor- it is the conductor in solid form and offers very low resistance to the flow of current. E.g. silver, copper, aluminium, brass, lead, nichrome, tunguston, etc.

Liquid conductor- it is the conductor in liquid form which offers very low resistance to the flow of current. E.g. mixture of sulpher nitrate,dilute sulphuric acid,copper sulphate. Etc.

Gaseous conductor- in physical condition it is in the gaseous state and offers very low resistance to the flow of current. E.g. neon gas, organ gas, mrcury vapour, sodium vapour, etc.

Sub-lesson - 9 Common conductors

Common conductors are-

1. all aluminium conductor
2. aluminium conductor steel reinforced (ACSR)
3. cadmium copper conductor (usefull for long spans)
4. galvanized iron conductor (G.I. Wire)
5. all aluminium alloy conductor (AAAC)

Types of insulators- There are following types of conductors which offers very high resistance to the flow of current.

1. pin type insulator
2. suspension type or disc insulator
3. shackle insulator
4. reel or bobbin insulator

Sub-lesson - 10 Types of wiring

Types of wiring are as given below-

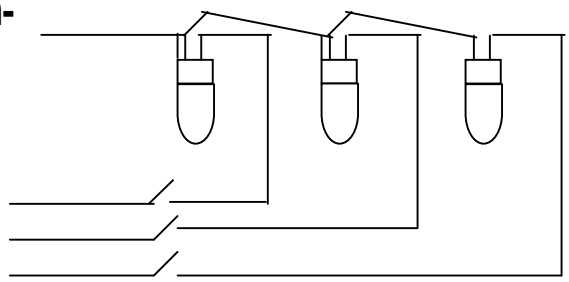
1. Cleat wiring
2. Wooden casing caping
3. PVC casing caping
4. Wooden batton wiring
5. Metal conduit wiring
6. PVC conduit wiring

Systems of wiring- These are of three types-

1. Loop in loop out
2. T Type
3. Ring type

1. **lop in loop out wiring-** wires are cut by looping it different circuits are made. Further by looping new circuits are made. This is loop in loop out method.

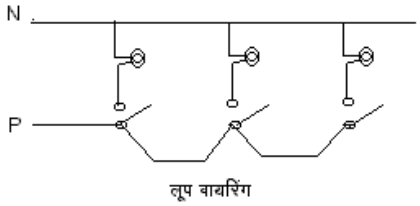
Diagram-



Loop in loop out

2. T wiring- in this type phase is taken through switches and neutral through bulb holders.

diagram-



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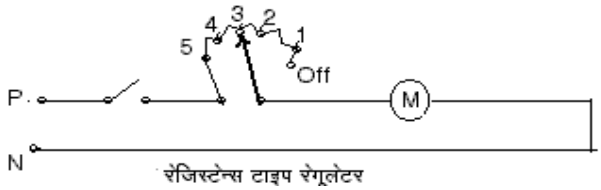
Sub-lesson-11 Fans and regulators

Motor of ceiling fans are permanent capacitor type in which there is no centrifugal switch required. Capacitor is directly connected in series with the starting winding. It always remains in the circuit. In this typ of motors starting an running torque is low an its winding wire for starting and running winding is nearabot similar. Rotor is of squirrel cage type. Regulator is connected in series with the fan for speed control.

Types of regulators-

1. resisrance type
2. transformer type
3. electronic type

Diagram- resistance type regulator-



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Sub-lesson- 12 Types of reflectors.

1. all steel reflector, vitrous enameled white inside.
2. open defusing glass globes.
3. polished metal reflectors.
4. chronic enameled iron shed white inside.
5. double faced mirror stripped type.
6. parabolic reflector with mirror glass or polished metal.
7. vitrous enameled steel sheet (pvc reflector)

Sub-lesson- 13 Types of DC Motors.

Machine which converts electrical power in to mechanical power is called motor. Where DC supply is used for motors they are called DC motors.

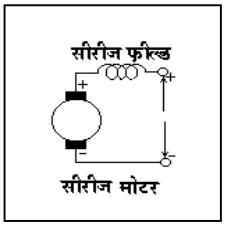
Working principle of motor- whenever a current carring conductor is placed in a magnetic field it is acted upon by a force which tends it to rotate. Fleming left hand rule is applied to find out the direction of rotation. Place first finger, middle finger and thumb perpendicular to each other (90 degrees), if middle finger shows the direction of current then first finger will show the direction field and thumb shows the irection of motion.

Main parts- 1. stator (field) - stator is a stationary part and it has winding called field winding.

2.Armature (Rotor)- as its name indicates it is a rotating part on which armature winding is placed. To feed current to the armature arrangement is made with the help of comutator and brush-gear. Basically there is no difference in the construction of DC motor and generator.

Types of DC motors- DC motors are of three types-

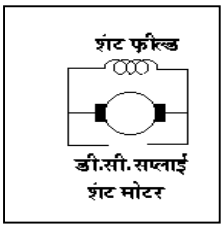
1. DC series motor, 2. DC shunt motor, 3. DC compound motor.



1. DC series motor- field of this type of motor has less number of turns of thick wire which is connected in series with the armature winding. Thus current in the armature and field winding is same. Due to this the starting torque is high. On no load speed of this motor is abnormal and hence it is never started without load.

Applications- e.g. cranes, tram, traction, trolley car etc.

2.DC shunt motor- In this type of motor field winding is of thin wire having more number of turns. Therefore its resistance is high. It is connected parallel to the armature winding. Speed of these motors is almost constant. The starting torque is 1.5 to 2 times. Speed control of this motor can be easily done with the help of shunt regulator.



Aplications- e.g. pump, lathe m/c, drill m/c, printing m/c, etc.

Torque - By the term torque meant the turning or twisting moment of a force about an axis. It is measured by the product of the force and the radius at which this force acts.

Therefore Torque T = force (f) x radius (r)

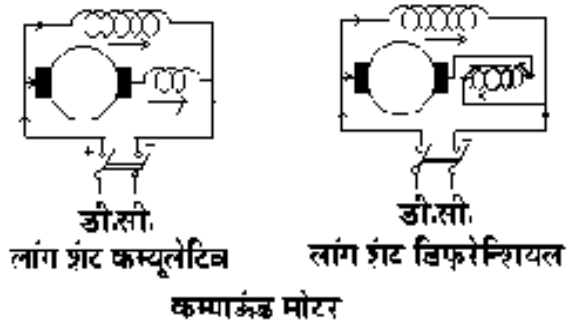
The unit of torque is Newton-metres.

3. compound motor- in this type of motor speed is constant and the starting torque is also more. It has two field winding known as series field and shunt field.

Applications- compressors, pumps, punching m/c, press m/c, crusher, etc.

These motors are further classified in to two types on method of field connections-

1. cumulative compound motor
2. differential compound motor



1. Cumulative compound motor- In this type the series field winding is connected in such a way that it assists shunt field. With this connection a) if load is more the starting torque will be more and speed is reduced. b) if it is off-loaded then shunt winding prevents overspeed.

Applicatios- tool m/c, coal crusher, etc.

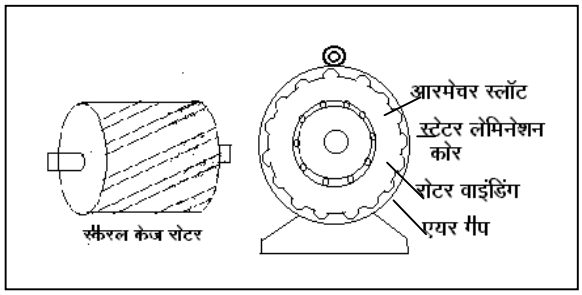
2. Differential compound motor- In this type the series field winding is connected in such a way that it opposes the shunt field. With this connection speed is contant. Before starting this motor series field is shorted. This prevents the excitation of series field prior to shunt field to avoid the starting of motor as a series motor.

Sub-lesson-14 AC motors

Motors working on AC supply are called AC motors.

1. Single phase AC motors
2. Three phase AC motors

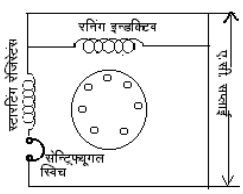
1. Working of single phase motors- Construction of single phase motor is also like a three phase motor, only difference is it has two windings in stator called starting winding and running winding. With only one winding pulsating field is formed. Due this motor is unable to start unless you move its rotor in any one direction. In order to avoid this rotating magnetic field is required. To have the rotating magnetic field second winding is essential.



Typeas of single phase motors-

1. Split phase motor
2. Shaded pole motor
3. repulsion motor
4. universal motor
5. Capacitor start induction run motor
6. Permanent capacitor motor
7. Capacitor start and capacitor run motor

Capacitor start induction run motor- In this type a capacitor is provided



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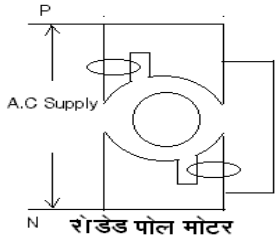

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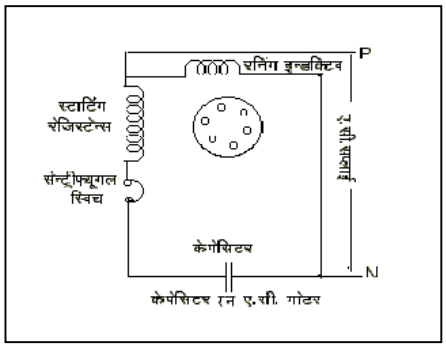
in series with the starting winding. Due to this starting torque and p.f. is improved. The centrifugal switch is provided in starting winding which opens it at about 75 % speed of motor is attained. Rotor is of squirrel cage type which rotates because of rotating field produced by both the winding. After the centrifugal switch is opened it conues to work running winding field only.

Universal motor- field of this type of motor has less number of turns of thick wire which is connected in series with the armature winding. Thus current in the armature and field winding is same. Due to this the starting torque is high. On no load speed of this motor is abnormal and hence it is never started without load. Speed of this motor is reduced if load is increased.

3. Capacitor start and capacitor run motor- In this type of motor there are two capacitors connected in series with the starting winding. One is called running capacitor and another is called starting capacitor. Starting capacitor remains in circuit only at the time of starting the motor for fraction of second and then it is disconnected from circuit with help of relay. Thus the starting and running torque of these motors is high.



Applications- Air conditioners, compressors, etc

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Sub-lesson-15 Motor starters

Why starter is required- Rsistance of squirrel cage winding is very low and at stand-still position it will appear as atransformer with short circuited secondary. Threfore if it directly connected to the supply then it draws heavy current at starting. This will have effect on the supply voltage. It will drop abnormally and may affect other installations particularlly the effect will be more in case of motors above 5 HP.

Fuctions of motor starters-

1. To facilitate to start and stop the motor.

2. To limit the starting current.
3. To prevent restarting of motor in case of supply failure and restoration without knowledge.
4. To prevent failure of motor due to overloads, undervoltage,etc.

Therefore starter is essential for the motors. For motors upto 5 HP Direct on line (DOL) starter starter is provided. For motors above 5 HP star-delta or auto-transformer starter is provided which limits the starting current of the motor. Once the motor pick-up the speed back EMF is produced which opposes the applied voltage. Thus the current is reduced and motor draws its rated current.

Example:- Suppose resistance of winding is 5 ohms and voltage Applied is 100 volts.

Therfore starting current = V/R = 100/5

= 20 amperes

After starting attaining speed if back EMF = 80 volts

Then current = $\frac{E - E_b}{R} = \frac{100 - 80}{5} = \frac{20}{5}$ = 4 amps

Thus at starting since back EMF is zero current is high which is decreased when back EMF is developed as motor picks up the speed.

Types of starters-

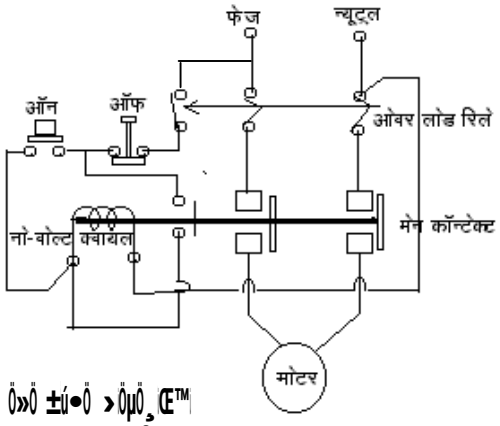
Srarters for squirrel cage induction motor-

1.Direct on line starter (D.O.L.) The starter which connects motor to supply mains without limiting current is called DOL starter. These are of two types single phase and three phase. There is no much difference in single and three phase starter except the number of pole of the contactor. In three phase 3 poles and in single phase 2 poles are required.

In DOL starter when 'on' button is pressed one phase reaches to no volt coil of the starter. Neutral or second phase is directly connected to the another terminal of the no volt coil. The magnet is formed in the coil and it attracts pluger inside on which main and auxillary contacts are mouted. Since main contacts are close supply is passed through over load relay from L1, L2 and L3 to the motor contacts M1, M2 and M3 and it starts. If due to any reason motor is over loaded then it draws more current than its rating. It heats up

the the bi-metalic strips of relay and as per seting O/L relay breaks one phase of the no volt coil and cotacts are opened. Thus it prevents motor from damages. This type of starter is used upto 5 HP. Starting current is approx. 6 times the full load current.

Starters connection diagram-



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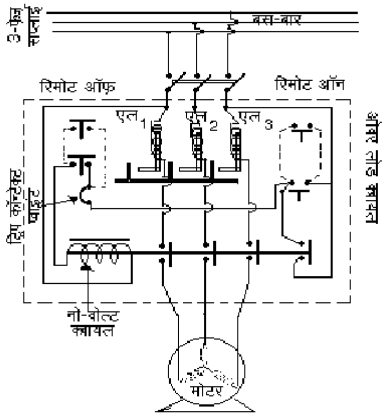

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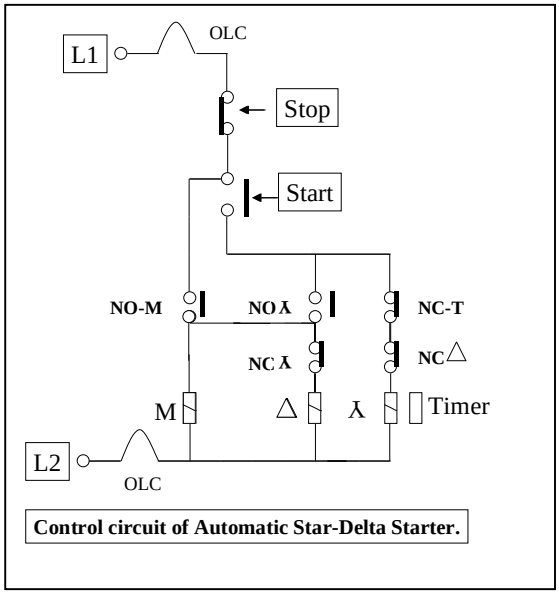
2. Star delta starter- This type of starters are generally used for motors above 5 HP and up to 15 HP. When starter is switched on, the motor winding is star connected and the starting current is limited to starting current divided by under-root 3 i.e. 1.732. The current is further controlled as the speed increases the back EMF also icrease.



Control circuit of Automatic Star-Delta Starter.

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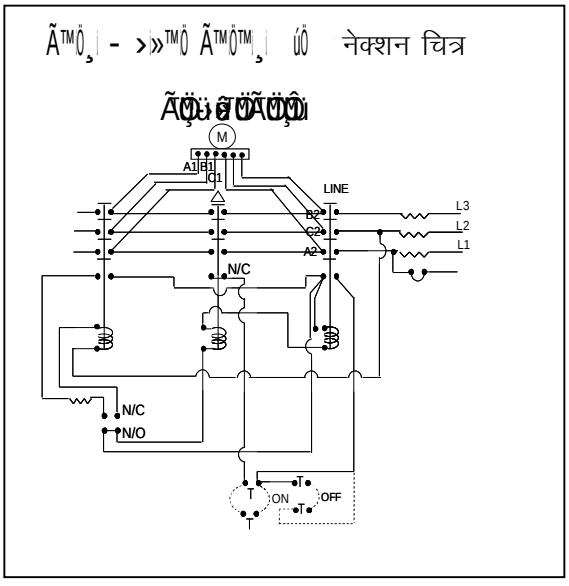


After attaining full speed in star position the starter is switched over to delta position thus motor gets full voltage and it picks up designed full speed and work normally.

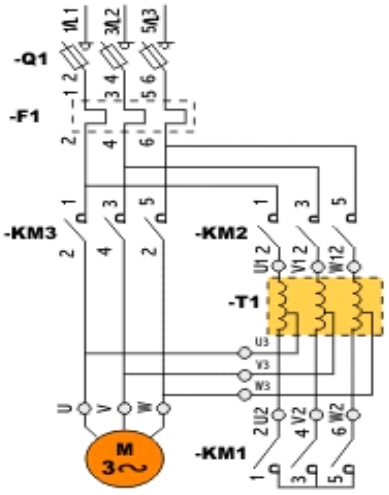
Applied voltage is 400 volts but in star it is = $\frac{400}{\sqrt{3}}$ = 230 volts

These are of three types manual, semiautomatic and fully automatic. Thermal over-load realy having bi-metalic strips are provided for the protection of motor from over-loads. Capacity of overload relay is approx. 60% of the rated current since it is provided in the branch circuit where load current is divided in to two paths. For automatic change-over from star to delta FASD starter timer is provided its setting should be done as given below-

- First keep the setting at maximum position.
- Start the motor and allow it to run to full speed. Note this time.
- Stop the motor reset the timer for the noted time.

3. Autotransformer starter- In this type the starting voltage applied to motor is stepdown to desired value by autotransformer and thus the current also reduces. Whe nmotor pick-up the speed and back EMF is produced the full voltage is applied to motor changing the tap of the transformer.

No volt coil holds handle of starter in position and releases in case of power failure. Over-load relay protects motor from damage due to over-load.



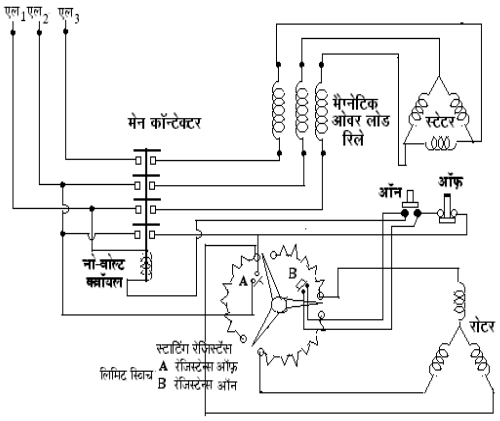
Auto-transformer starter

4. Soft starter- With the electronic device the reduced voltage is applied to motor at starting and gradually and very smoothly it is increased to full voltage. Due very smooth starting the life of motor

also increases. It is energy efficient but its cost is very high and thus rarerly used in railways.

Starter for slip-ring induction motor-

Rotor resistance type starter- This is used for slip ring induction motor. The rotor os this motor has winding and three leads of this winding are connected to slip-ring provided on rotor shaft. With help carbon brushes mounted on slip-ring external resistance is connected in thr rotor winding at starting. This limits the starting current of the motor to desire value. Gradually as motor picks-up the speed it is reduced and finally it is bypassed and motor starts working on full speed. Initial torque of this motor high.



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Sub-lesson-16 **Cable**

Types of cables-

1. L.T. cable = 1000 ¾ÖÖ»™ ŸÖ ú
2. H.T. cable = 11000 ¾ÖÖ»™ ŸÖ ú
3. supper tension cable = 33000 ¾ÖÖ»™ ŸÖ ú
4. Extra high tenssion = 66000 ¾ÖÖ»™ ŸÖ ú
5. Oil/gas filled pressurized = 1,32000 ¾ÖÖ»™ ŸÖ ú

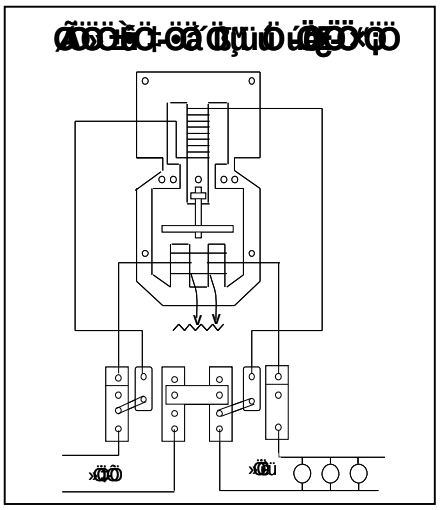
On the basis of insulating material-

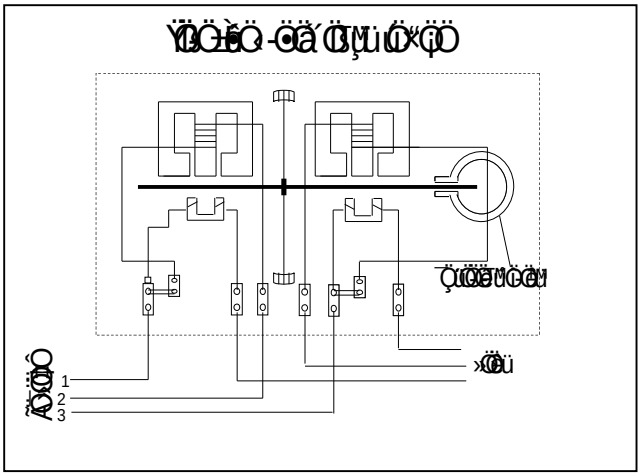
1. Paper insulated lead covered (PILC)
2. Poly vinylle chloride insulated (PVC)
3. Cross linked polymer extruded (XLPE)

On the basis of conductor- copper or aluminium.

Laying of underground cable- Cable trench of 40 to 60 cm width and 1 mtr depth is made. Dry sand layer of 15 cms is provided at bottom. Cable is layed and covered with the sand and warning covers or bricks are provided. Then the trech is filled with the soil. C.I. cable route markers are provided to identify the route of the cable in future.

Single phase energy meters- Disc of single phase energy meter rotates due rotating field created by current coil and pressure coil. These are placed at electrically 90 degrees apart.





Construction- In this meter two coils are placed on one core as shown in the picture. Current coil made up of less number of turns of thick wire. Pressue coil is of more number of turns with thin wire. Disc rotates due rotating field created by current coil and pressure coil. These are placed at electrically 90 degrees apart.

The field of current coil is proportional to the current passing through it and pressure coil field is proportional to voltage. Thus torque produced is proportional to yhe power. If time factor is applies it gives the energy consumed and it is recorded with help of gear train.

The following adjustments are available in this meter-

1. Power factor corection

2. torque

Three phase energy meter- There are two current coils and two pressure coils in this meter. Torque produced by these coils act on a single disc. In some meters there are two discs on same spindle. To measure energy in unbalanced circuit three current coils and three pressure coils are provided. Rest of the feature are similar to single phase energy meter.

* * *

Chapter-6

Maintenane of major electrical supply equipments

Lesson-1 **Defects in starters**

Sub-lesson-1 Defects in starters

A) Awitched on but motor does not start-

i) Supply fuses are blown.
ii) Open cicuit in no volt coil or wiring
iii) Tripping of single phasing preventor.
iv) Connection of motor is wrong.
v) Contact of contactor is carbonized.

B) When push buton is pressed motor starts but stops if hand is taken away-

i) There is a carbon on auxiliary contacts or open circuit.
ii) Over load relay is defective or setting is not proper.
iii) Mecanical load is more.

C) Motor starts in star and trips in delta-

i) There is earth fault.
ii) Mechanical load is more.
iii) Timer defective or improper setting.
iv) No volt coil of delta contactor burnt.
v) Motor connection is wrong.
vi) Carbon in NO/NC contacts.

D) Motor rotation is reverse-

i) Phase sequence is altered.

E) Contactor switching on and off-

i) Loose conection in wiring.
ii) Supply voltage is low.
iii) Pole shading ring broken.
iv) Contact strip burnt.
v) Contactor capacity is less.
vi) Surface of contactor not proper.
vii) Cotactor spring tension is less.

Sub-lesson-2 AC and DC motors

Maintenance and overhauling

Points to be noted during maintenance-

i) General cleaning with compressed air having 80 to 10 psi pressure.
ii) Check air gap with air gap filler gauge.
iii) Check oil and Greece.
iv) Check insulation resistance of winding.
v) Check slip-rings, commutators, etc.
vi) Check carbon brushes and brush gear.
vii) Check motor current.
viii) Check motor terminal connection.
ix) Check vibration.
x) Check starter and control gear.

Schedule-

i) Daily
ii) Fort-nightly
iii) Half yearly
iv) Once in a 5 year complete overhauling.

Method of overhauling-

i) Primary inspection.
ii) Stripping out (opening and cleaning)
iii) Replacement of defective parts or repairs.
iv) Varnishing of windings with baking
v) Assembly test/final inspection

1. Primary inspection-

1. Read out machine reports carefully and check al parts.
2. Before opening check IR value and air gap.
3. Prepare connection diagram of armature, field winding, etc.

2. Stripping out/cleaning-

1. Open all parts.
2. Replace wornout bearing and part.
3 Clean oil/greese stick up to windings.
4 After varnishing baking to be done.

3. Assembly inspection-

1. check field connection,etc
2. Measure IR value of winding with 500 volts megger it should be minimum 2 mega-ohms.
3. Carry-out armature drop test.
4. Check motors full load current as per rating and voltage.
5. Check starting current, sparking, temperature of bearing, etc.
6. Full load temperature rise test of winding for 6 hours.
7. High voltage test for new coils.

Sub-lesson- 3 To identify bearings noise

a) Reasons for abnormal noise in al bearings-

i) Lubrication oil/greese dried.
ii) Balls worn-out.
iii) Due to vibratons ball range damaged.

b) If spare motor is kept on a place where there is vibration its bearings can be damaged.

Sub-lesson - 4 Cleaning of reflectors

Due to dust, dirt , etc illumination level reduces by 30% in a three months and 60% in 12 months. Therefore reflector should be cleaned once in a three month with soap water wet cloth.

Sub-lesson- 5 Ceiling fans

Al check nuts, split pins, suspension arrangement, capacitor should be checked. Air flow should be measured with the help of Anemometer.

Sub-lesson- 6 Wiring

In addition to monthly inspection it should be thourolly checked once l a year.

Annual inspection-

1. Service connection
2. Main switch board
3. wiring and its isulation
4. Earth and bonding
5. Swiches and fuse size
6. appliances
7. Fire prevention items.

Service connection (building)-

1. clearance from the building
2. capacity of service line fuse
3. polarity i.e. whether fuse is provided in the phase or otherwise
4. Wire size, condition of insulation,etc.

Main switch board-

- ✓ Check voltage on peak load. Adjust transformer tap changer if it is less than 220 volts.
- ✓ Main switch shall be available near all buildings.
- ✓ Sufficient working clearance should be available near main switch.
- ✓ Check fuse size of the main switch.
- ✓ If wires are damaged replace them.
- ✓ Check IR with 500 volt megger between line and earth. It should not be less than 50 divided by number of outlets or 1 mega-ohm whichever is more
- ✓ Line to line IR value should not be less than 5 mega-ohm.

- ✓ Check earth resistance and continuity with earth tester. It should be maximum 8 ohms.If it is more take measures to improve the same.

Switch and fuse-

- ➢ Clean the contacts of switch
- ➢ Switch should be alwas in phase line.
- ➢ Check for over heating and fuse size.
- ➢ Check portable appliances like table fan, press, table lamp and its cable. Ceck if there is any leakage.

Improvement in earth resistance-

If earth resistance of the domestic installation is found more than 8 ohms then-

i) Clean the earth connetion.
ii) Put charcoal and salt in the earth pit.
iii) Connect more than one earth electrode in parallel.
iv) Whichever wire seems to be damaged replace it.
v) Rewiring should be done after 10 years.

Sub-lesson - 7 Maintenance of overhead line

In order to ensure un-intrupted power supply it essential to carry out preventive maintenance of the O/H line periodically. It is done as given below-

1. Preventive maintenance to ensure safety.
2. Pre-mansoon special inspection-

i) With this inspection problable breakdown due to mansoon can be avoided.

3. When there is a breakdown on line emergency patrolling

Should be carried out to find out the fault location, its nature and to decide the restoration process.

Routine maintenance-

1. Patroling of live line should be done once in a month.
2. Points to be checked -

i) Metal supports- inspect the foundation of the supports/masts. Take necessary measure to prevent it from falling or tilting.

ii) Wooden support-1. check that it is in vertical position. 2) check foundation. 3. check the bottom portion of pole whether it is in sound condition or not.

iii) cement poles-

iv) check for any cracks.

v) Cross arms- check for rusting and see that it is in proper position.

3.Insulators and fittings-

a) check for broken insulator.
b) Tilting of insulator from its position.
c) Check formation of dust,dirt due to pollution.
d) Rusting of its fittings.
e) Check for any hot spots, sign of burns, etc.

After arranging shut-down all the short-comings should be attended.

4.Conductor and earth wire-

Check whether the clearances are as per IE rules or not. Adjust if not correct. Remove any foreign objects like nest of the birds, pieces of hanging wires from the conductors.

5. Conductor fitting/joints-

i) Check the binding wires are in place or not.
ii) Check whether conductor is in proper position or slipped from insulator seat.
iii) Check that the strands of the conductor is not broken.
iv) Check the burnt jumpers loose clamps, if noticed replace them.

6.Stays and its accessories-

i) check for slackness.
ii) broken stay insulators.
iii) Loose or broken stay earthing.
iv) Guy Anchoring.

7. Clearance from trees-

If the branches of trees are imfringing the clearance it should be cut. (2 mtrs clearance)

Sub-lesson- 8 Defects in battery and maintenance

Defects-

1. broken container- due to mis-handling, carelessness, vibrations.
2. cell sulphation- If kept discharged for longer duration.
3. Internal short circuit- Due to overheating, over charging, charging voltage is more.
4. Buckling- Due to over charging
5. Reverse polarity-Over discharging of cell
6. Low electrolite level- leakage, container broken, not topped up in Time, ovr charging.
7. Terminal burnt- Lose connection, dirty.
8. Low specific gravity and low voltage- spilling of electrolyte, no proper charging.

Points to be checked during maintenance of battery-

1. Battery should be kept in dry palce.
2. Battery room should be airy.
3. Do not take any flame near battery.
4. Do not keep any tols on the cell.
5. Use hand-gloves and safety goggles while working on battery.
6. While preparing electrolyte dot not add water in to the acid, but acid should be added in water slowly.

Battery maintenance-

1. Charge battery as soon as it is discharged.
2. Keep cell terminals clean and tight. Use petroleum jelly as anticorrosive.
3. Top up distilled water time to time. Float level should be maintained properly.
4. Do not allow temperature of the cell to rise above 45 degree centigrade.

* * *

Chapter- 7

Sub-lesson-1 Testing, erection, and commissioning

Election of Poles :

First plan the route of the O/H line. Decide the length of span. Keep the treches for ready and collect the material for foundation at site. Crow bars, shovels, ropes, pulley, pick-axe, etc is required for pole erection. Lineman with team will bring the pole to pit. With the help of Derrick for heavy poles and deadman method for light poles it is erected. Ropes are tied on all four sided and wooden ladder is used for safe erection of poles.

Sub-lesson-02 Focusing

Before erection of lluminaire its focus is adjusted and the protetive cover provided on the reflector is removed. Otherwise the efficiency of of the fitting will be affected.

Sub-lesson-03 Connection of choke and condenser.

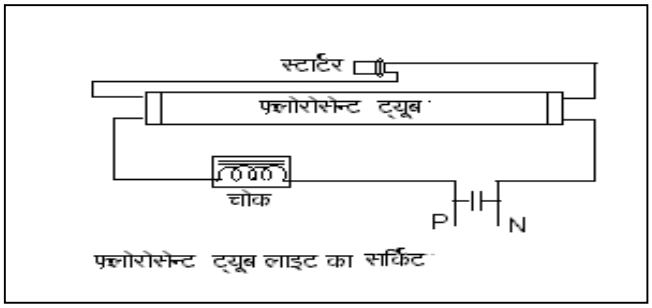
Functions of choke-

1. For gas discharge lamp it requires high etriking voltage. The choke is used for this purpose. It is provided in series with the circuit. It also drops the voltage once the tube is striked and suitable reduced voltage is applied across the tube.
2. In rectifiers and chargers it is used as a filter.

Fuctions of condenser-

i) In single phase motor it is used to create phase difference. And it is connected in series with the starting winding.
ii) It is also used for power factor correction and connected across the load.
iii) It is used in the timer.
iv) It is connected in parrellel I DC circuits as a filter.
v) Used in gas discharge lamps-
   a) Fluoroscent lamp
   b) organ gas lamps
   c) mercury vapour lamps.

Diagram-



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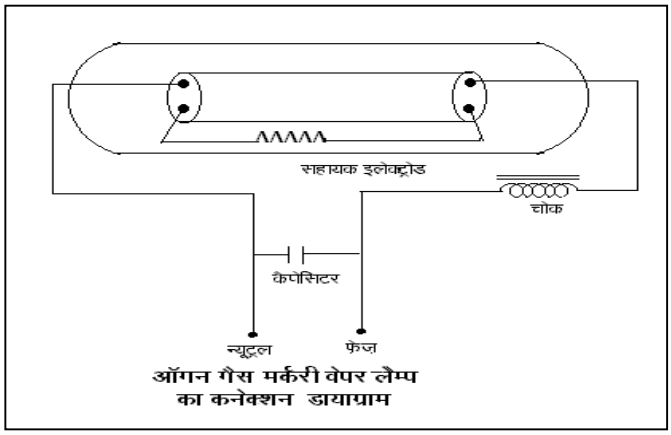

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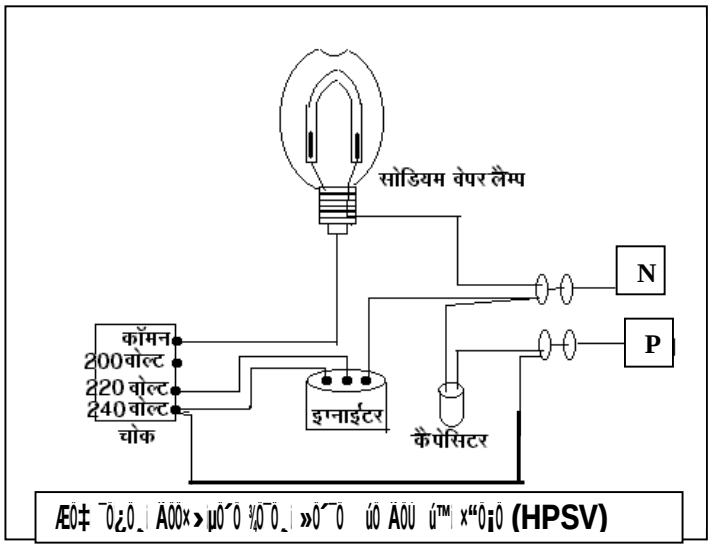

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Sub-lesson-6 Connections in home appliances.

1. All non current carrying metallic parts should be earthed.
2. Sockets should be of three pin type only.

3. For pertable appliances connection should be given by three core cables.
4. conducror should be flexible type with good insulation.
5. Swiches shall be of suitable capacity. And fuse size should be appropriate.

Sub-leson-7 Insulation resistance of wiring.

A) Wiring should be checked with the help of 500 volts megger. The value should not be less than 50 idivided by number of outlets or 1 mega-ohms whichever is higher.

B) Earthing- At 2.5 mtr to 3 mtr depth earth electrode is buried in the ground is called earthing. Lead of GI or copper wire is connected to the earth electrode and taken to the installation to be earthed. Eaths potential is treated as zero. When any metallic non current carrying body, cover, etc. is connected to the earth with this lead then it is said to be earthed. Good earthing is that which diverts fault current to earth safely.

C) Why earting is necessary-

1. If there is leakage current in any appliance with arthing arrangement it is diverted to earth and fuse is blown. The installation thus becomes safe.
2. Earting also safeguards the big buildings from lightening.
3. It safeguards the installation/equipments connected to O/H line from lightening surges.
4. To earth the transformer neutral. It prevents the dangerous variation in voltage due to un-balanced load.

Why separate two earths are required for three phase machines- With two earths in parallel it offers low resistance path for fault current and if any one lead is disconnected the other provides the safety.

D) Earthing procedure- Mainly there are two types most commonly used-

a. Pipe earting
b. Plate earthing

Maximum permissible earth resistance-
a) Power station - 0.5 ohms
b) Major sub-station - 1.0 ohms
c) Small sub-stations - 2.0 ohms
d) Other places - 8.0 ohms

E) How to improve the earth resistance- Earth resistance depends upon the size and length of the electrode, moisture content in the soil, Type of conection and temperature. It can be improved by-

1. increasing size and length of the electrode.
2. putting charcoal and salt in earth pit alogwith water.
3. connecting more than one electrode in parallel.
4. cleaning and reconnection of earthing terminals.

Fuction of megger- for testing of insulation resistance of installation megger is used.

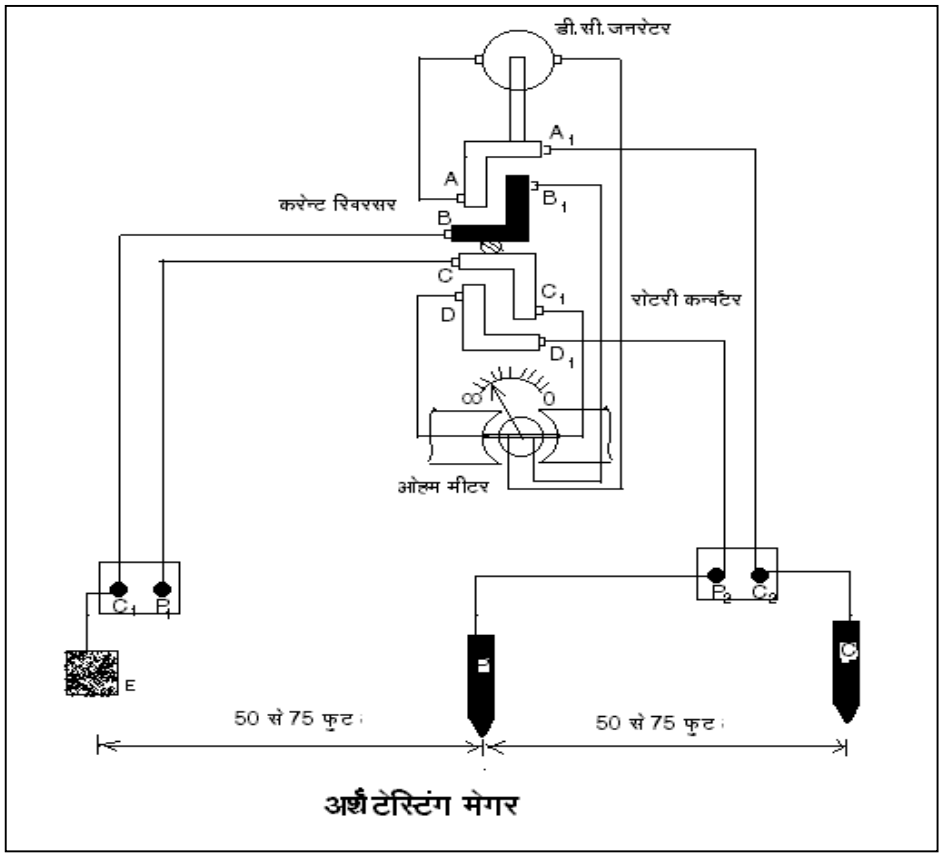
Working principle of megger- A megger insulation tester comprises a DC hand driven generator and and a direct reading, two element, permanent magnet, moving coil type indicator mounted in one case as shown in figure. The indicator movement contains no control spring, but the restraining force is provided by a potential coil connected across DC generator in series with a fixed resistance. The poiter, therefore,takes a definite position only when the generator handle is turned. The deflecting force is produced by a current coil which is connected across the generator through the external resistance under test, and opposes the force created by the voltage coil. When there is infinite resistance between L and E then only pressure coil will produce torque and thus needle will move to infinity. Where as if the resistance is zero then only current coil will produce maximum torque and needle rests on zero.

Megger reads the resistance in thousands of ohms and mega-ohms.

What is earth tester- Earth tester used to test the earth resistance. It has following parts-

1. Hand driven generator, 2. rotory current reverser, 3. synchronous rotor, 4. rotating rtifier, 5. ohm meter

Method of earth testing digram- To measure the earth resistance two iron spikes are driven in to earth at suitable distance.(Distance between each other is approx. 25 mtrs. From electrode under test.) P1 and C2 is shorted. When generator is turned directly the reading in ohms can be read.



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Diesel Generator Set

D.G.set- It is used to produce electrical power. Basically it is used as stand-bye since the cost of generation is more. Earlier Railways had its own power houses using steam turbines. But one by one they were shut down because they were un-economical. Generator converts mechanical energy in to electrical energy.

Working principle- Diesel ios used as a fuel in diesel engines. It is a four stroke engine. These are 1. suction stroke, 2. compression stroke, 3. power stroke and 4. exhaust stroke.

During suction stroke air is entered in the cylinder, then it is compressed during compression stroke. The temperature is rised due to compression sufficient for ignition of fuel. Thus when fuel is injected in cylinder it burns. This exerts force on piston thus power is generated,so this stroke is called power stroke.

Working principal of alternator- Alternator works on the principle of Farade's Law's of electro-magnetic induction. It is coupled with the diesel engine. When engine rotates it drives alternator in turn alternator converts mechanical energy in to electrical energy.

Advantages of DG set-

1. It can be put into service immediately.
2. Losses are low.
3. No skilled operator is required.
4. Maintenance is low.
5. Worn out parts can be easily replaced.
6. Life can be enhanced with little investment.
7. It can be easily provided at load centre thus cost of connections is less.
8. These are available in lower capacities also.
9. Less space is required.
10. consumption of water is less.
11. Maintenance and storage of fuel is easy.
12. It can be procured and installed easily.

Disadvantages- ¡

1. sufficient crude oil is not available in our country. Hence foreign exchange is require for import.
2. There is sound pollution due to DG set.

Other Applications of DG set-

1. In accident relief train.
2. Mid on and end on geration power cars.
3. Accident relief medical equipment van.

Main parts of DG set-

- Diesel engine.
  a)Piston
  b) cylinder head
  c) valve/ports
  d) connecting rod
  e) bearings
  f) supporting arrangement
  g) fuel pump
  h) crank shaft
  i) fly wheel
- Alternator-
  a) Rotor
     i) Salient pole type
     ii) Smooth cylinder type
  b) stator
  c) Excitor

Maintenance of DG set-

1. Daily
2. Weekly
3. Monthly
4. Half yearly
5. Annual
6. Once in a two year
7. Once in a four year

1. Daily-

Engine-

- Check the log-book and carry-out the work accordingly.
- Check water content in separator. Drain it through drain cock.
- Check for any leakage of fuel, lubricating oil, water or exhaust smoke.

- Check water level of radiator, fill it if required, by chromate solution of 3500 ppm. Put the cap of radiator properly.
- Check the oil in the air filter. Replace if required.
- Check for intake air leakage.
- Start the engine and check LOP. It should be 50 to 70 psi on desired speed. If it is less then stop the engine and find out the reasons.
- Lubrication oil level should be checked after 20 minutes when engine is stopped. Top up if necessary.
- Electrical system-

Battery-

1. clean it with dry cloth.
2. Retighten the connections.

Swtch gear-

1. Check self starting switch is working properly or not.
2. check for any abnormality.
3. check phase indicator and panel.

Alternator-

1. Check if there is any abnormality.
2. check for the free passage of cooling air.

2. Weekly- In addition to daily schedule check the following items-

Engine-

- Check engine and governor oil. Top up if required.
- Check for contact heater working.
- Check coolent for antifreezing and viscosity.
- Check belt tension.
- Check dust in the precleaner.
- Check obstructions in air filter.
- Check vibratios.

Battery-

- Check electrlite level.
- Check specific gravity and voltage.
- Check for abnormal heating and any other abnormality in the cells.
- Check container.
- Check charging arrangement and charging current.

3. Half yearly-

Replace engine oil.
Replace lubrication oil filter.
Clean the breather of main fuel tank.
Check coolent pH it should be between 8.5 to 10.5.
Chromet concentration should be 3500 ppm.
Replace water filter element.
Check throttle joints.
Remove delivery hoses of air compressor and clean it.
Replace crank case breather element.

Reconditioning of battery and switch-gear.

Alternator- Check terminal box, junction box, insulation, etc. Clean with dry cloth. Check the condition of cooling fans.

Pumps.

Pump- pump is the machine which lifts the water/liquid from one level to another.

Types of pumps used in Railways-

- Centrifugal pump
- Jet pump
- Screw pump or gear pump
- Diaphragm pump

1. Centrifugal pump- In a centrifugal pump the liquid is admitted to the cetre of the rotor called eye and whirled through a shaped impeller, which imparts it a high velocity and energy as it moves towards the periphery. This happens due to centrifugal force. The water then passes thrugh volute chamber where the high velocity is converted in to pressure smoothly. According to construction there are following types of centrifugal pumps.

1. horizontal shaft CF pump/ Monoblock CF pump
2. Vertical turbine pump
3. Submersible pump (for bore well)
4. Monoblock submersible pump. (for open well)

2. Jet pump- These are used where the space is limited, less discharge is required with high suction head. 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 surrouding water is sucked in to the orifice.
3. Screw pump/ gear pump- It is called positive displacement pump. These pumps are mainly used in machines as a oil pumps for lubrication, etc.
4. Diaphragm pump- a diaphragm pump consists of a thin, flexible diaphragm of rubber or ruberised canvas stretching across a chamber, the cetre of which is moved up and down or to and froby the operating device.

1. maintenance schedule of centrifugal pumps-

A. Daily-

- Check leakage through packing.
- Check bearing temperature.
- Check for vibrations and abnormal noise.
- Check pressure, voltage and current reading.

B. Half yearly-

- Check stuffing box glang.
- Cleaning of gland bolts and oiling.
- Check packing.
- Check alignment of pump and drive.
- Check greese/oil of the bearings.

C. Anuali-

- Complete overhauling painting and out put test.

2. Maintenance schedule of vertical turbine pump-

A. Genaral -

- It should be installed in dry,dustfree and airy place.
- It should be cleaned daily.
- Oil lubricator oil level should checked and topped up and constant flow be ensured during working.
- Check vibrations, discharge head level and belt tension where ever applicable.

B. Lubrication of pump unit-

- For oil lubricated pump clean oil as recomded by manufacturer should be used.
- Check oil level in reservoir and top up if required.

3. Submersible pump-

Reasons for failure of submersible pump-

Main reason for failure of submersible pump is failure of winding (burt) of motor. The reasons are-

- Due to insulation failure.
- Due to over-load.
- Due to voltage fluctuation.
- Due to single phasing.
- Frequent starting of motor.
- Wrong handling, repairs, and water-tight connection.

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Chapter- 8

Sub-lesson-1 Indian Electricity Rules 1956

It is known as Indian Electricity Rules 1956. It is applicable to all installations pertaining to Generation, Transmission, Distribution and Utilisation of electrical energy. Its main object is to ensure safety in Generation, Transmission, Distribution and Utilisation of electrical energy and to prevent the thefts. To review these rule Central Electricity Board is constituated. Members are selected from experts from State government, public sector, Industrial Institutions, etc.

Electrical Inspector to Govt. (EIG)- He carries-out the periodical inspections of the electrical installations under his jurisdiction and ensures the compliance of IE Rules. It is essential to obtain the sanction of EIG before charging the new HT installation. For Railways CEE of the respective zone is nominated as EIG.

Extract of I.E.Rules

Rule - 2: Classification of voltages

upto 250 volts	- Low voltage
Above 250 V upto 650 V	- Medium voltage
Above 650 V upto 33000 V	- High voltage
Above 33000 V	- Extra high voltage

Rule- 32 : neutral conductor should be marked such that it should be easily distinguished from phase conductors.

Rule-34 : Whenever bare conductor is terminated on a building , it should not be easily accessible without the aid of mechanical device.

Rule-35 : At every medium and high voltage distriburion places Danger board should be provided in English or hindi and local language. E.g. s/stations, motors, pumps, transformers, neon signs, etc.

Rule-36 : Work should not be carried out on line without switching off the supply. After ensuring that the supply is switched off the line shall be earthed. Neutral link should be open.

Rule-43 : At sub-stations and switching stations suitable fire extinguishers shall be provided in addition to the fire buckets filled with the sand. First aid box shall be kept upto date and in every shift first aid trained staff should be available.

Rule-44 : In every s/station, generating station, etc. shock treatment chart in English or hindi and local language should be provided at conspicuous place.

Rule-48 : Installations insulation resistance shold be measured periodically.

For low and medium voltage installation it should not be less than 1 mega-ohm with 500 volts megger.

For HV installation it should not be less than 5 mega-ohm with 2500 volts megger.

Rule-51 : At the entry of the service line main switch shall be provided at the easily accessible location.

1. There should be minimum 1 metre clearance in front of the panel board.

2. Maximum 22.5 cms clearance can be kept behind the panel board. If there is an opening for panel board at the back side in that case minimum 75 cms clearance should be provided and entry should be avaible from either side of minimum 1.8 metre height.

Rule -54 : Permissible voltage variation from declared voltage-

Low and medium voltage	$\pm$ 6 %
High voltage	+ 6, -9 %
Extra High voltage	+10, -12.5 %

Rule -55 : Permissible variation in declared frequency- ± 3%
In India declared frequency is 50 Hz, therefore frequency variation from 48.5 to 51.5 is permitted.

Rule -57 : Permissible variation in Trivector meter, KWH meter at 10% to 100% load should not be more than 3%.

Rule -61 : All metallic parts should be earthed properly.

Rule- 68 : Height of substation shall not be less than 1.8 mtrs

Rule-70 : For static condensers automatic discharging device shall be provided.

Rule-77 : clearance between O/H line and ground-

Place	Low & medium voltage	High voltage	Extra high voltage
At Road crossing	5.8 m	6.1 m	6.1 + 0.3 m for every 33000 volts or part there of
Along the road	5.5 m	5.8 m	5.2 + 0.3 m for every 33000 volts or part there of

At other places- up to 11 KV - 4.6 m and if it is insulated line then 4.0 m.
Above 11 KV and high voltage - 5.2 m

Rule -79 & 80 : Clearance from building

Voltage	Above building	From building
Low and medium	2.5 m	1.2 m
Upto 11 KV	3.7 m	1.2 m
Above 11 KV upto 33 KV	3.7 m	2.0 m

Rule -85 : Maximum legth of span for low and medium voltage shall not be more than 65 m.

Rule- 88 : Where continuity of guard wire breaks it should be earthed. The breaking strength of guard wire shall not be less than 635 Kg.

Rule- 89 : Service line should be tapped at point of support.

Rule- 90 : i) In every one kilometer of Over head line at least three at equal distance shall be provided.

ii)Stay insulator shall be provided at minimum three metres height. If stay insulator is not used then it should be permanently earthed.

Rule- 91 : i) Safety device to break the supply in case OH line breaks should be provided in order to prevent the accident.

ii) Anti-climbing devices should be provided to to prevent access to un-authorised persons.

Rule - 92 : i) Lightening arrester shall be provided to protect OH line from lightening surges.

ii) Earth wire of LA should be connected to earth electrode directly without any bends.

----x----x----x----

Recommended Maximum earth resistance is-

Power stations	- 0.5 Ω
Major substations	- 1.0 Ω
Small substations	- 2.0 Ω
At other places	- 8.0 Ω

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