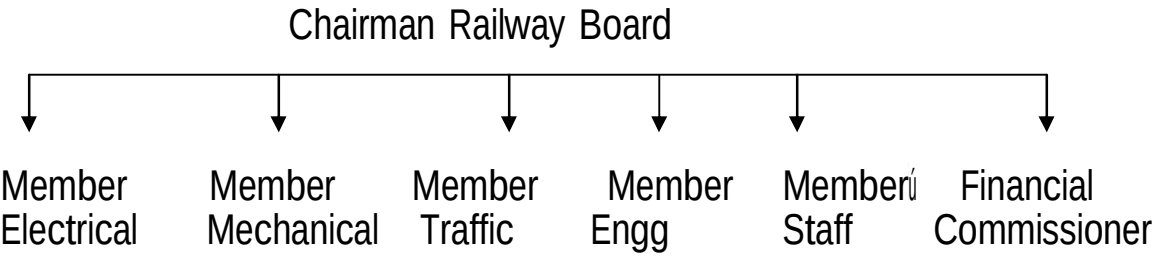
Chapter 01

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 16 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 6 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

- 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.

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 arraged 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.

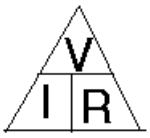
In a closed circuit kepping temperature and physical properties constant the ratio of voltage and current of the circuit is constant, it is known as resistance of the circuit.

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-

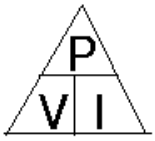


Likewise in DC circuit -

Power = voltage x current = watts,

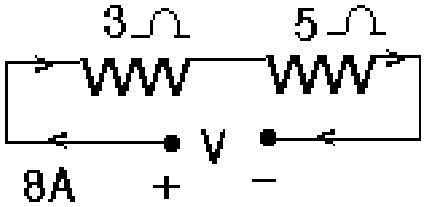
Current = power/voltage = amperes (P/V = I)

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

$R = R_1 + R_2$

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

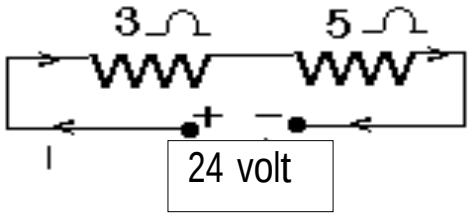
Now Voltage = Current X Resistance

$\therefore \quad V = 8X\ 8 = 64$ 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 $R_1 = 3\Omega$ and $R_2 = 5\Omega$

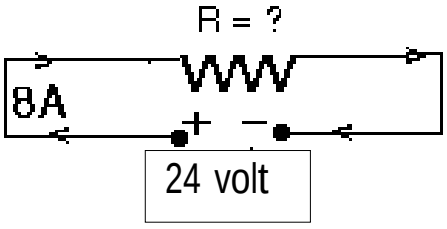
Therefore $R = 3+5 = 8\Omega$

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

$\therefore$ 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 $R = \frac{24}{8} = 3\Omega$

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 = $\frac{\text{Power (P)}}{\text{Current (I)}}$

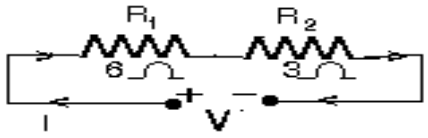
Example- Wattage of a fan is 36 Watts, it is connected to 24 volts DC supply. Calaculate the current drawn by the fan?

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. ÆÔ •ÖÖŸÖÖ Æ...
3. Voltage across the resistance in parallel is same.

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

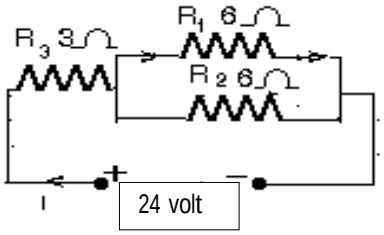
Therefore $R = \frac{R_1 \times R_2}{R_1 + R_2}$ (Applicable only if there are two resistances)

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

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

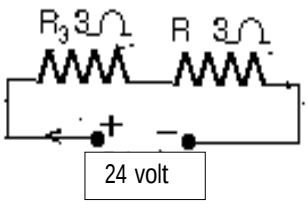
When two resistances are connected in series and parallel-



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

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

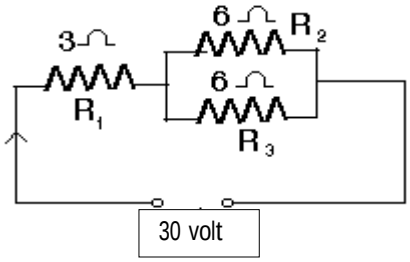
Example- Electric iron of 500 watts capacity is connected to 230 volts supply. What amount of current it will draw?

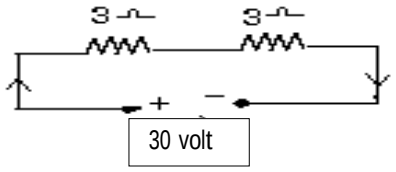
P = V x I

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.

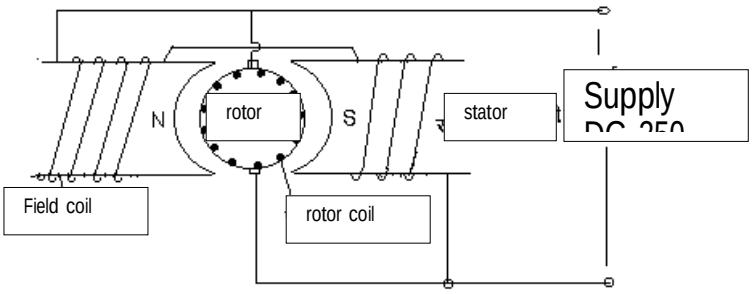
Sub-lesson - 6 Principle of Electrical motor and Generator.

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.

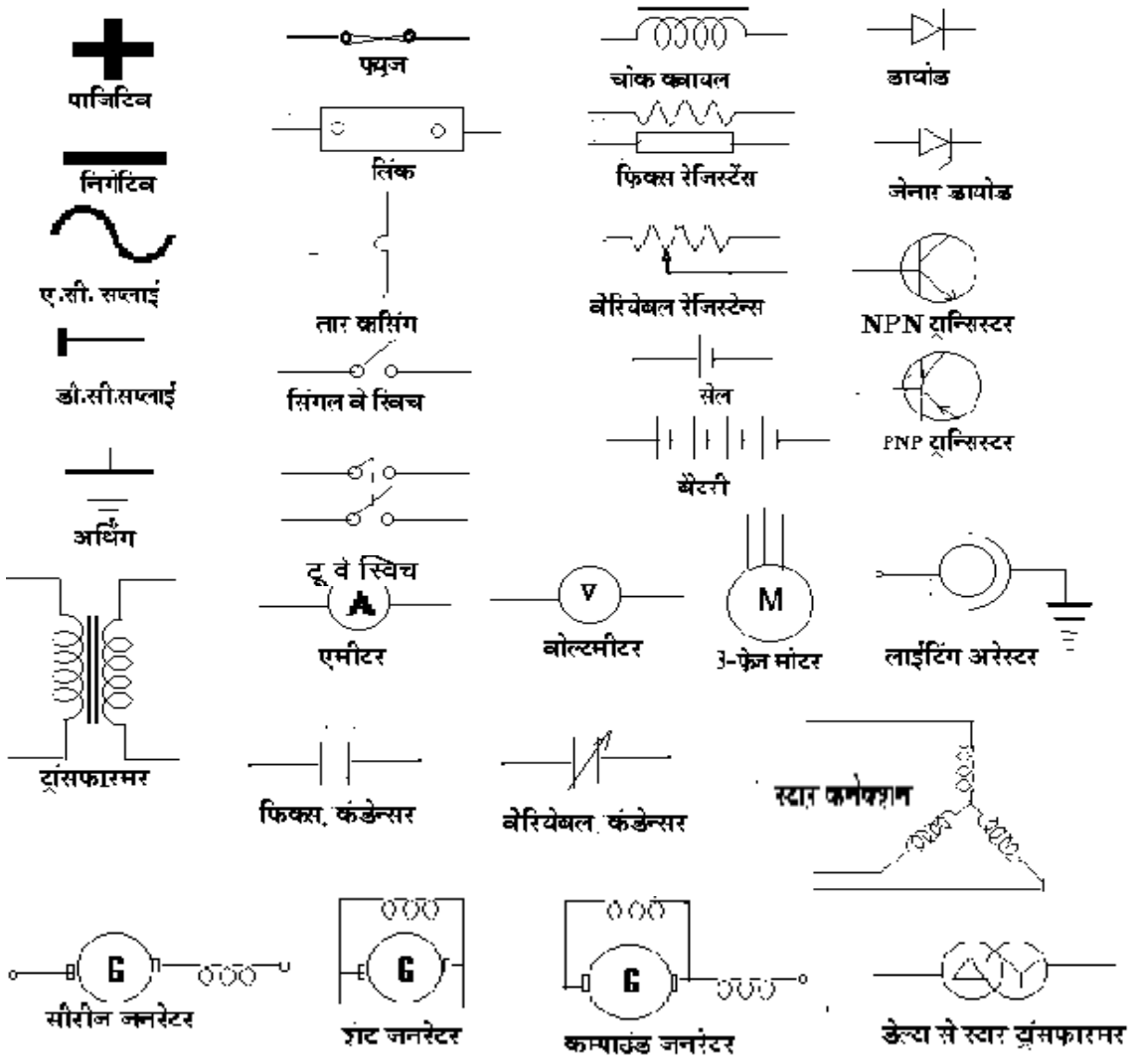
All parts and diamessions in the drawing should be clearly visible. For this it is drawn in three sizes.

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.



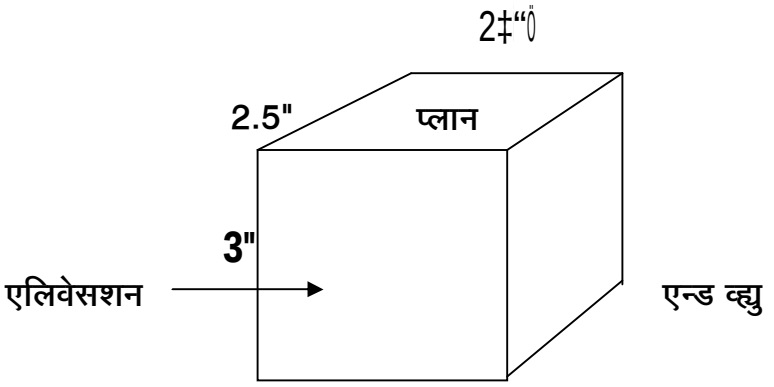
Sub-lesson - 4 **Plan, Elevation, End view**

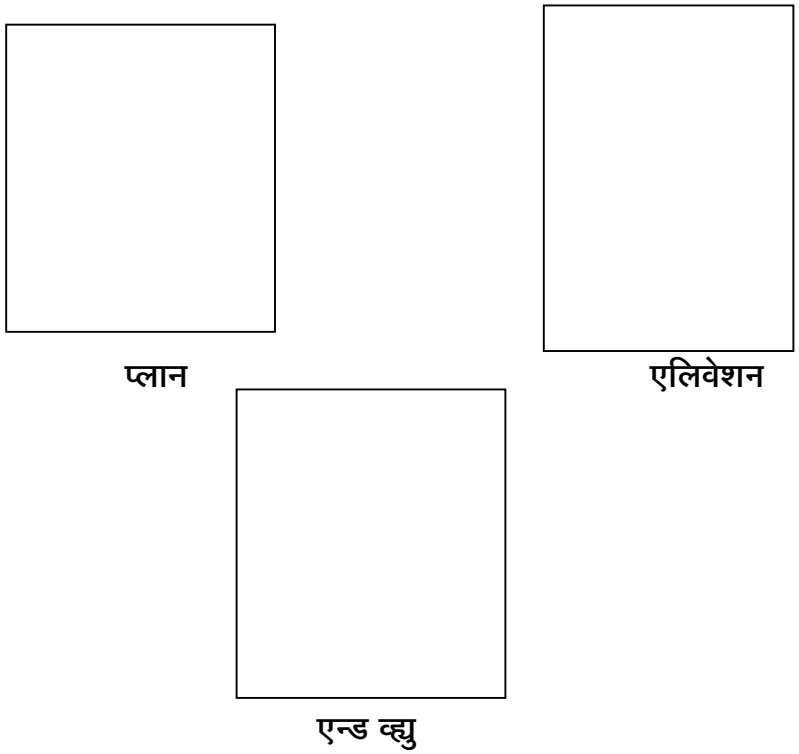
1.Plan- The drawing of the object when viewed from the top is called plan.

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

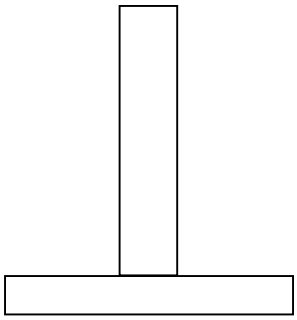
B-2 and B-3 size drawing boards are most commonly used.

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

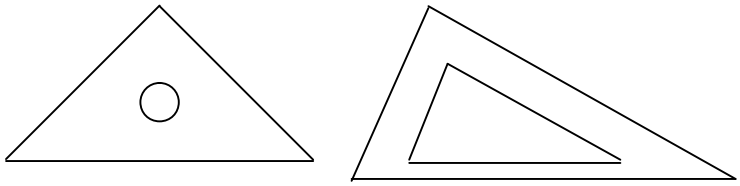
1.Drawing paper- It should be ISI approved with sufficient and uniform thickness. Various sizes are as follows.

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. ú

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 charecteristics 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-05

Name, Locations and size of the Major TL/AC equipments.

Lesson - 1 Train lighting Belts

Sub-lesson - 1 Type of Belts, Number and Life

Mainly the belts used in Railways are of two types. Flat belts and V belts.

i) Flat belt:- Flat belt is used for underframe mounted alternators. In this type alignment of axle pulley and alternator pulley is disturbed at the curvatures due which belts are broken or slipped away from the pulleys.

Size used - length- 4.11 m and width- 4 inches.

ii) V Belt - V belts are used for Bogie Transom mounted brushless alternators. Alignment of axle pulley and alternator pulley does not disturb at any time with yhis arrangement. Thus belt remains in position.

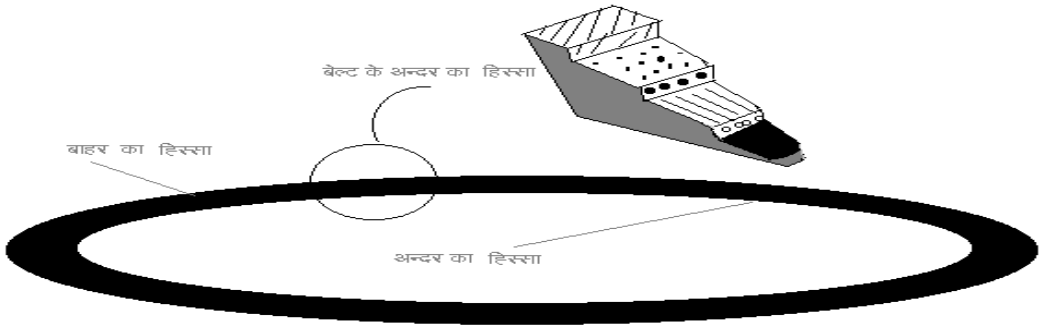
Belt size C122 . In non AC coach 4 belts are required, and in AC coach 6+6 = 12 belts are required for each alternator.

Storage life of the belt is 2 years.

Sub-lesson - 2 Grading of V belts and its use.

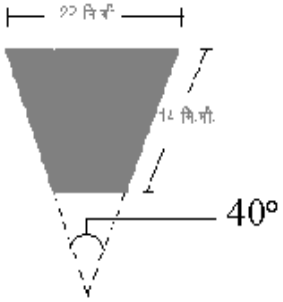
Belt having accurate specified length is given grade number 50. For more length than the specified grade number 51, 52 is given, where as for smaller length grade number as 49, 48 is given. There is a difference of 2.5 mm between two grades.

Figure-



Sub-lesson-3 Belt, measurements and alignment.

Alignment of alternator pulley and axle pulley should be accurate , however tolerance of 5 mm per metre is allowed.



Belt size-- C-122
Width (W)= 22 mm
Thickness(T)= 14 mm
Belt grade- 50

Sub-lesson- 4 Types of pulleys, power transmission.

Two sizes of V belt pulleys are in use-

1. Axle pulley	- 525 mm for non AC coach.
	- 572.6 mm for AC coach.
2. Alternator pulley	- 175 mm for non AC coach.
	- 200 mm for AC coach.

Lesson - 2 Generating equipments.
Sub-lesson - 1 Type, capacity, Ratings and working.

In train lighting when train moves its axle rotates thus through axle pulley, alternator pulley and V belts mechanical power is transmitted to alternator. Brushless alternator converts mechanical energy in to electrical energy. Three phase AC supply is taken to rectifier regulating unit (RRU) where it is converted from AC to 110 Volts constant DC supply. This is used to charge the batteries and also fed to the coach lights and fans.
Capacity of Alternator-

1. For MG/NG	- 3 KW= 30 volts x 100 ampere = 3000 W
2. For non AC coach	- 4.5KW= 120 volts x37.5 ampere=4500W
3. For AC 2 T coach	- 18 KW= 135 volts x 133 ampere= 18000W
6. For AC 3 T coach	- 25 KW= 130 voltsx 193 ampere = 25000W

Power increases with current and voltage.

Working- when train is in motion alternator generates sufficient power/ voltage to charge the battery feed lights, fans, etc. in the coach. Alternator generates 3 phase supply which is controlled and converted in to DC by RRU feed to load as per demand.

Sub-lesson - 2 Function of Rectifier Regulator unit.

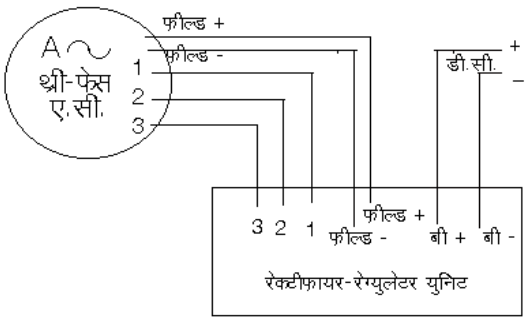
Every alternator is provided with RRU and its functions are-

1. To convert AC current in to DC and feed to field winding to strengthen the magnetic fieldto get desired output voltage.
2. To convert 3 phase AC supply into DC to charge battery and to feed to the load.
3. To control the voltage according to setting.
4. To control the current according to setting.
5. To prevent reverse flow of current from battery to alternator.

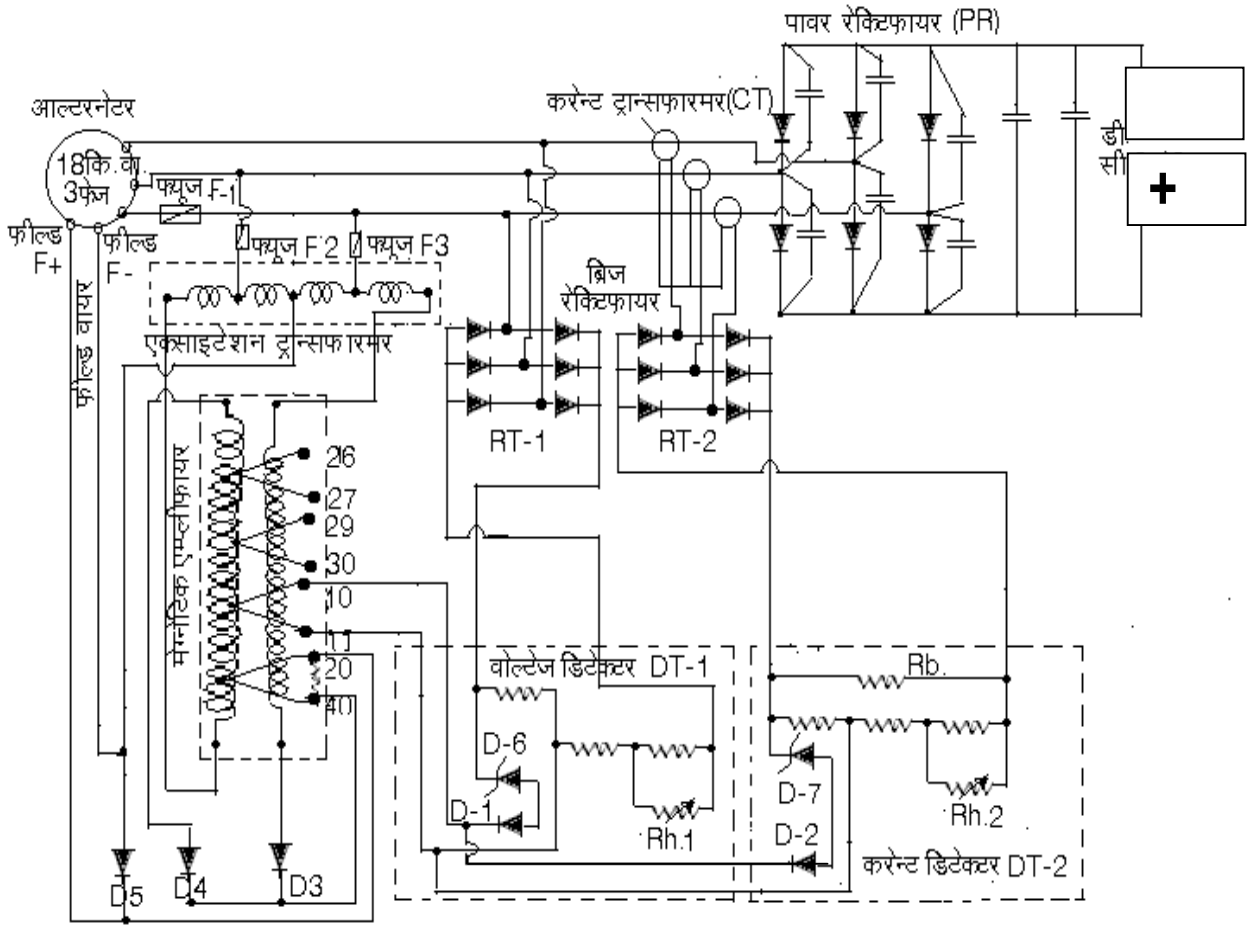
Working principle of RRU- As per the speed of the train current of the field coil varies. When speed of the train increases current of the field is controlled (reduced) and it do not alow the voltage to increase and vice versa. Thus the output voltage is kept constant at variable speeds.

When the train is running rotor of the alternator rotates. Rotor has teeths and slots. When it rotates due to teeth and slots air gap between stator and rotor chages continuously due which the reluctance varies. Due to rate of change of flux linkage EMF is induced in the main winding. This voltage is coverted into DC and applied to field winding through excitation transformer, magnetic amplifier, field diodes and field is strengthened. In turn the output AC voltage also increased up to the set limit. Then thrugh voltage detector magnetic amplifier gets control current. The impeadence of the MA increases and current is reduced which is in the series with the field coils thus output voltage reduces and vice versa. The process is continuous and contrls output votage to set standard.

Wiring diagram of rectifier regulating unit-



Circuit diagram of 18 KW brushless alternators RRU-



Description of various equipments used in 18 KW RRU-

Fuse F1- 120 amperes, Fuse F2 and F3 field fuse- 6 amperes,
Current transformers (CT-1,CT-2,CT-3) ,
Power rectifiers(PR) – 800 volts, 150 ampere,
Field diodes (D-3, D-4) - 800 volts, 12 amperes,
Blocking diodes (D-1, D-2) - 1000 volts, 1 ampere,
Voltage detector (DT-1), Current detector (DT-2),
Rheostats (Rh-1, Rh-2) - 1 Kilo-ohms, 25 watts,
Capacitor (C-1) - 0.25 mfd, 600 volts, (C-2) -10 mfd,250 volts,
Capacitor (C-3) -10 pieco-farad, 500 volts,
Bridge rectifier (RT1) for Voltage detector (DT-1),

Bridge rectifier (RT2) for Current detector (DT-2) ,
Surge protection diode (D-5) - 800 volts,12 amperes,
Zener diode for voltage detector (DT-1) - 100 volts, 10 watts,
Zener diode for current detector (DT-2) - 27 volts, 10 watts,
Burden resistance (Rb) - 220 ohms, 14 watts.

* * *

Lesson - 3 Battery

Sub-lesson - 1 Type of battery,working and capacity.

In self generation coach when train is at hault or running below cut in speed of alternator, battery supplies the electricity to lights, fans, etc. In all SG coaches Lead Acid cells are used. These are of two types-

1. Flooded type or normal Lead acid cell.
2. Valve regulated lead acid cell. (VRLA) or sealed maintenance free lead acid cell. (SMF)

Capacity- capacity of the cell is measured in ampere-hours.

SrNo	Type of coach	Type of battery	Capacity
01	24 volts DC	Lead acid single set 12 cell	320 AH
02	110 volts DC Non AC	i.Monoblock cell(18X6 volt) ii.VRLA/SMF 54X2 volt Alternator 4.5 KW	120 AH 120 AH
03	110 volt DC AC 2 T	Lead acid cell 56X2 volt Alternator- 18 KW	800 AH
04	AC2T/AC3T RMPU	VRLA 54 or 56 cell X 2 volt Alternator 25 KW	1100 AH

Sub-lesson- 2 Charging and discharging of Battery

When train speed is more than cut-in speed of alternator the supply to battery charging is from alternator through RRU. At the time of maintenance on pit line it is charged through external battery charger.

In AC coach 3 phase 415 volts AC battery charger of 200 ampere out put capacity is provided. The battery charging and precooling is done through this charger.

Sub-lesson- 3 Electronic equipments.

In SG AC coach 200 ampere capacity battery charger is provided. Input of charger is 3 phase AC 415 volts through step down transformer and rectifier voltage is converted to output of 104-140 volts DC.

In Roof Mounted Package Unit 110 volt DC input supply received from alternator / Battery is converted in to 415 volts 3 phase AC by Invertor of 25 KVA capacity. In every RMPU coach two invertors for NPP side and PP side are provided.

Sub-lesson - 4 Lights, Fans load calculation.

Presently in 110 Volt coach 40 Watt and 25 Watt lamps and 20 Watt FL tube are provided. Calculation of load is done as follows-

SrN	Item	watts	Total No	Total wattage	Load in amperes
01	Lights	40	16	640	640/110 =5.8 amps
02	Door, gallary	25	06	150	150/110 =1.36 amps
03	Lavatory	25	04	100	100/110 = 0.907 amps
04	Gallary	25	02	50	50/110 =0.45 amps
05	Fixed fans	38	18	684	684/110 = 6.22 amps
06	Reading lamps	15	02	30	30/110 =0.27 amps
				Total load	17.34 amps

Sub-lesson - 5 Protection of wiring, fuse, anti-theft measures.

In coach wiring Poly Vinyl Chloride (PVC) isulated wire are used.
Sizes of wires:-
For ligts and fans wiring - 4 mm^2
From junction box to cut-out ú -16 mm^2

In underframe - 35 mm^2
Battery to regulator - 50 mm^2

In under-frame wires are placed in the metal/steel conduits, however in the roof these are placed in the PVC conduits.
Measures taken to prevent fire and short circuits:-

1. In the coach in place of open rewirable fuses High rupturing capacity fuses (HRC) are provided.
2. In place of rotary switches Miniature circuit breakers (MCB) are used.
3. Negative and positive wires are run separatetly in the roof and fuses are provided on both side for every appliance.

Masures Taken for prevention of theft-

1. Train lighting voltage is different than domestic voltage.
2. Special locking system is provided for light fittings.
3. Conduits are used for wiring.
4. Safety rod with double nuts is provided for battery box.
5. Tmbler switches are used without covers.

Lesson - 4 AC Equipments.

Sub-lesson - 1 AC Equipments and principle of refrigeration.

Refrigeration- It is the process in which the heat from any place, substance, air is extracted and the temperature of that place, substance, air, etc is brought down. For this the vapour compression system is used.

Principle-

1. Heat always flows from higher temperature to lower temperature.
2. Temperature of the gas is decreased with decrease in pressure and it increases with increase in pressure.

For any substance amount of heat required to change its state from liquid to gas or liquid to solid and vice-versa at constant temperature. This is called latent heat.

Sub-lesson - 2 AC coach, refrigeration cycle.

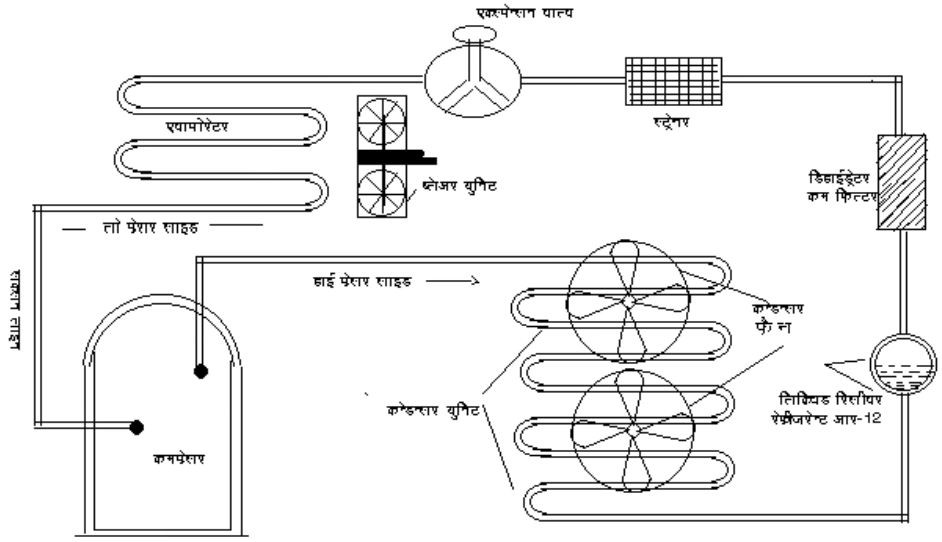
1. Capilary is used with sealed compressors.
2. Thermostatic expansion valve is used with open type compressor.

Main parts of conventional type AC coach.

1. Open type compressor.
2. condessor unit.
3. Liquid receiver.
4. Dehydrator cum filter.
5. Strainer.
6. Expanssion valve.
7. evaporator.

All parts connected with copper tube to form refrigeration cicuit. F12 or F22 refrigerant gas is used in these coaches.

Conventional AC coach refrigeration cycle diagram-



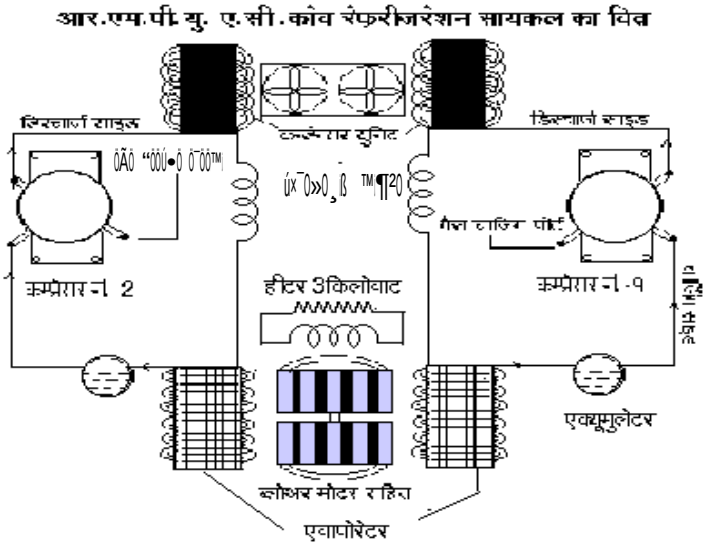
Sub-lesson - 3 Description of refrigeration cycle.

1. Compressor sucks the refrigerant gas from evaporator through suction line. This low temperature low pressure vapour is compressed and thus high pressure gas is discharged towards condenser through discharge line. As the pressure of the gas is increased its temperature also increases.
2. The high pressure high temperature gas is cooled down in condenser and it changes its state from gaseous to liquid.The latent heat is

extracted and rejected in atmosphere. From condenser liquid refrigerant is passed to liquid receiver.

3. From liquid receiver it passes through dehydrator cum filter where moisture content if any is removed and it is filtered.
4. when refrigerant liquid is passed through strainer imurities are cleared and pure high pressure liquid refrigerant is passed through expansion valve.
5. Thermostatic expansion valve controls the flow of refrigerant to evaporator according to the load. When it passes through the pressure of refrigerant drops and its boiling point reaches. Thus while passing through eavaporator coil it absorbs heat from the surrounding air and the air is cooled. Liquid refrigerant absorbs latent heat and changes its state from liquid to gas while leaving the evaporator. This cooled air (conditioned air) is passed to AC coach via ducts, and through suitable grills it is thrown in the compartments. Thus the cycle repeated and coach is cooled down.

Refrigeration cycle diagram of RMPU coach-



Description of one side (one plant) of the RMPU coach-

1. Compressor 3.5 ton - 2 Nos
2. Condenssor motor 1.0 HP - 2 Nos
3. Blower motor 1.5 HP - 1 No

4. Heater 3 KW - 1 No
5. Refrigerant R22 - 2 x 2.8 Kg = 5.6 Kg
6. Invertor 110 V DC to 415 V 3 phase AC, 25 KW - 1 No
7. Alternator -25 KW - 2 for complete coach

Sub-lesson - 4 Pressure cut-out

Low pressure cut-out - This cutout is provided in the suction line. It is set to operate on 10 psi. Thus when suction pressure droped below 10 psi this cutout operates and breaks the supply of no volt coil of contactor of compressor and the compressor stops working. If the suction pressure is increased to 30 psi it switch on the compressor.

High pressure cut-out - If discharge pressure of the system is increased beyond desired pressure then this cutout disconnects the supply of compressor motor. If the pressure is reduced to normal its cutout is reset manually and then plant can work again.

Setting is done at 240 to 250 psi.

Oil pressure cut-out- It operates when the lubrication oil pressure of the system falls below the desired value. And disconnect the supply of the compressor. When desired pressure is reached it shoud be reset and then plant can work. The setting of this cut-out is 25 psi.

All these cut-outs are provided for the safety of the plant.

Sub-lesson - 5 Electric motors, Electronic material.

In conventional AC coach following motors are used -

1. Compressor motor 110 volts DC ,10/12.5 HP one each on both side.
2. Condensor motor 110 volts, 1 HP two each on both side.
3. Blower motor 110 volts, 0.75 HP/0.65 HP one each on both sides.
4. Heater 6 KW single unit one each on both sides.

In RMPU AC coach all motors are 3 phase-

1. Hermetically sealed compressor 2 x 3.5 ton on each side. 5250/5000 watts 3 phase 415 volts each.
2. Condensor fan motor 2 x 1 HP on each side.
3. Blower motor 1.5 HP, 3 phase, 415 volts.
4. Invertor/convertor 110 volts DC ,415 volts , 3 phase AC, 25 KVA one on each side.

5. Heater 2 x 3 kw on each side.

Unit of heat.

1.BTU- The amount of heat required to raise or lower the temperature Of one pound of water by one degree fareinheit is called one british thermal unit (BTU).

2.Kilo-calorie- The amount of heat required to raise or lower the temperature Of one kilogram of water by one degree centigrade is called one kilo-calorie.

3.Ton of refrigeration- Generally the capacity of refrigeration plant is ls expressed in ton of refrigeration. The amount of heat required to To convert one ton of ice (2000 lb) of 32^0F to te water of same temperature in 24 hours is known as one ton of refrigeration. The amount of heat required per pound is 144 BTU.

Therefore for 2000 lb total heat required will be = 144x2000 BTU ln 24 hours.

Per hour heat required will be = $\frac{144 \times 2000}{24}$

= 12000 BTU/Hr.

Hence 12000 BTU/Hr = 1 Ton of refrigeration.

Note - Heat load of one person in AC coach is taken as 400 BTU/Hr.

Sub-lesson - 6 Window AC, split AC, Central AC.

ln all above appliances mechanical vapour compression system is used.

1. Window AC- ln this system compressor, condenser, evaporator, capillary,etc. is accommodated in a compact space as a one unit. These are very compact and easy to install. These are installed in a window of suitable size and thus called window AC. These are readily available from 0.5 ton to 2 tons. Generally used for airconditioning of small rooms.

2.Split AC- ln this type compressor and condenser unit is kept out side of the room at desired place. Only evaporator unit is installed inside the room. Due this the maintenance can be done easily from outside. The noise level is also vely less.

Central AC - This system is used for the air conditioning of the big buildings, halls,etc. Separate room is required to install this system. All

the refrigeration equipments are installed in this room and cold air (conditioned air) is taken different parts of building through duct line and it is distributed through grills and diffusers. In chilled water system first water is chilled instead of air and it is taken to various parts of the building. The air is blown on the coils of chilled water and air gets cooled.

Sub-lesson - 7 Water cooler.

In water coolers sealed compressors are used. Condenser , evaporator, capillary is installed in one frame. The storage water tank is surrounded by the evaporator coils. Thus refrigerant takes heat from this water for vaporization resulting in to cooling of the water in the tank. Thermostat is provided for automatic operation of the unit. The temperature is set at 15 degree centigrade. Hence when this desired temperature is reached supply of water cooler is cut-off by the thermostat and the temperature is maintained.

Sub-lesson - 8 AC Roof Mounted Package Unit.

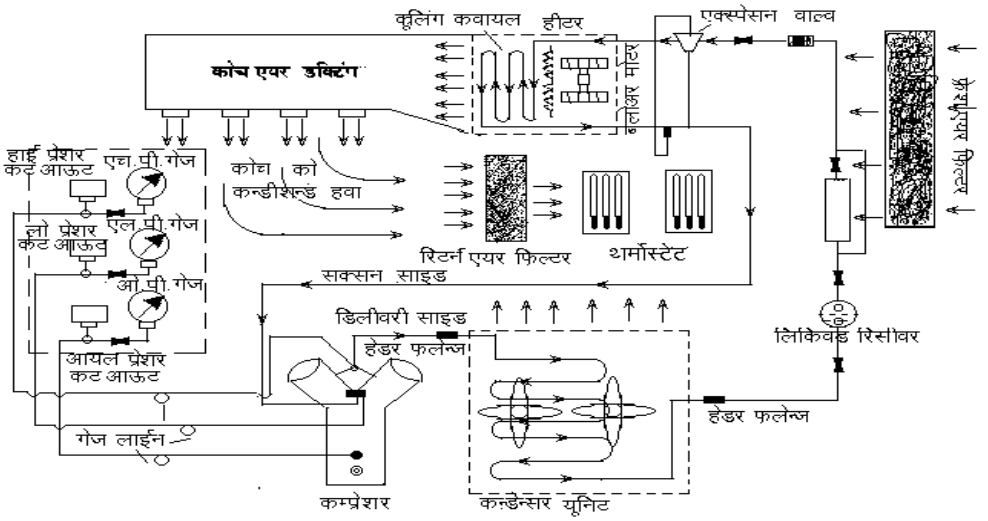
Equipments - In RMPU of AC coach there are two of alternators of 25 kw capacity. Valve regulated lead acid battery (VRLA) of 1100 Ampere-hour capacity is used. It is also called sealed maintenance free battery.

Precooling unit/battery charger capacity is 200 amperes-

Input	- 415 volts 3 phase AC
output	- 110 / 140 volts DC
Invertor-	
capacity	- 25 KVA X 2
Input	- 110 volts DC
Output	- 415 volts 3 phase AC
Heater	- 3 kw two nos on each side.
Sealed Compressor	- 5250 watts each 2 nos on both sides
Condensor motor	- 1 HP 2 nos on both sides.
Blower motor	- 1.5 HP one on both side.
Thermostat-	
Setting in summer	- 22,24, and 26 degree centigrade. Setting
in winter	- 17,19 and 21 degree centigrade.

Refrigerant gas - R22, 2.8 Kg per compressor.Total gas in a coach 2.8 X 4 = 11.2 Kg Approx.

Diagram of Air flow inside the AC coach-



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Chapter - 06

Train lighting AC equipments, Tolarence.

Lesson -1 Train lighting AC equipments, Tolarence.

Sub-lesson -1 Maintenance of coach, pulleys.

While fitting the axle pulley and alternator pulley the alignment should be proper so that the life of belt and pulleys is enhanced.

1. The distance between axle centre, pulley centre and wheel hub is fixed as follows-

   IRS, ICF, BEML — Axle centre to pulley centre = 514 mm. From side of the pulley to wheel hub = 129 mm.

2. Both parts of the axle pulley should be matched properly. Marking should be done so that it is not mismatched.
3. Proper size of nut bolts should be used.

4. The gap between two parts of the pulley should be 4.5 $\pm$ 1.5 mm.
5. White paint mark should be provided on both side of the pulley after tighting it properly.
6. Pulley should be tightened at 30 Kg-metre torque.

Sub-lesson - 2 Problems in V belts and its solution.

1. Uneven tession in belts - During replacement of V belts it should be ensured that all belts are of same company and same grade. If the same grade belts are not available one grade difference is allowed. Belt tension should be adjusted with the help of tension rod.
2. New and old belts should not be mixed.
3. There can be a overload due to twisting of belt, or misalignment, or any manufacturing defect. If belt is twisted then it should be put right immediately. Ensure that there is no manufacturing defects.
4. Tighting of pulley and defects- The reasons are-
   a) Nut bolts are not matching.
   b) Procedure of fitting is wrong.
   c) Alignment is not proper.
   d) Wrong storage procedure.
   Avoid all the problems mentioned above.

Sub-lesson - 3 Belt cutting, belt tensioning.

For flat belts-

1. Always cut with the help of cutting machine. Ensure that both ends are cut squarely and 90 degree angle.
2. Fastners should be fixed at 25 mm from the edges.

Belt tension- for flat belts-

1. Belt tension of all the belts should be same.
2. After the belts are tightened alternator angle should be 40 to 45 degree.
3. Belt tension for 75 mm belts should be 75 kg and for 100 mm belts it should be 130 kg.

Lesson - 2 Generating equipments.

Sub-lesson-1 Alternator and regulator.

Brushless alternator output is three phase AC which is feed to the RRU where it is converted from AC to DC (rectified) and regulated. Out put of RRU is used for battery charging, lights, fans, etc.

Alternator out put setting is as below-

1. Charging voltage per cell should should not be more than 2.3 volts.
2. For flooded type lead acid 54 cell regulator voltage setting should be 124.2 volts.
3. For 56 cells it should be 128.8 volts maximum.
4. For VRLA 56 cells - M/E.126±0.5 volts, S/F125 ± 0.5 volts.
5. For VRLA 54 cells - P. 123±0.5 volts, M/E.122 ± 0.5 volts.
   S/F.120±0.5 volts.

This is as per SMI - RDSO/PE/TL/VRLA.0024-2003 (Rev.0)

Sub-lesson - 2 Maintenance, Rectification of defects.

a) Check the tightness of axle pulley by striking hammer. Check the availability of checknut, bolts, split pin, etc. If defective replace /repair the same.

b) If belts are loose retighten it and if it is broken/cut replace.

Maintenance of Alternator

i) Clean the surface by compressed air.
ii) Check suspension pin, bush, nut bolts, safety chain, etc.
iii) Check connections of output terminals. If it is loose or broken attend and put right reconnect.
iv) Check the flexible pipe fitting.
v) Fix the terminal box cover properly. If it is missing provide new to avoid dust, dirt diposition on the terminals.
vi) Check for overheating, loose connection, etc. and if found so.

Common defects-

a) No generation or low generation.
b) No voltage control.
c) Current limit is less.

Sub-lesson - 3 Reasons for no generation

1. Loss of residual magnetism. Field is flashed with DC supply.
2. Field coils are open circuited or burnt. Check with multimeter and attend.
3. Short circuit, open circuit, or earth fault in main winding. Check with multimeter and attend.
4. Check belt tension. Tighten if required.

Defects in rectifier regulating unit-

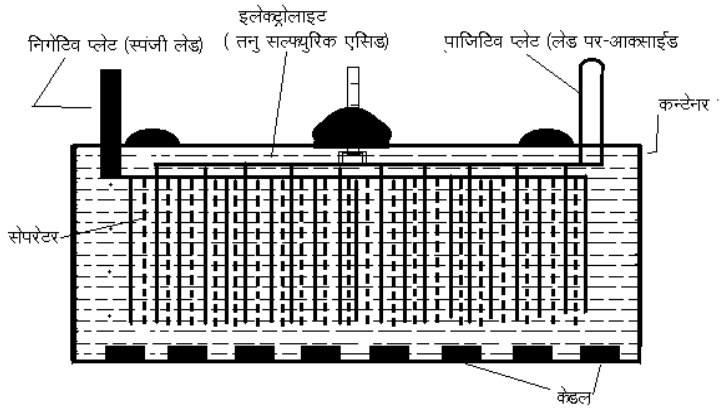
1. F -1 and / or F -2 field fuse blown.
2. Free wheeling diode is short.
3. Open circuit in field rectifier.
4. Main fuse blown.
5. Main power diode defective.
6. Voltage detector (DT) is defective.
7. Current detector is defective.
8. Defects in magnetic amplifier or field transformer.
9. Any other misclleneous fault.

Lesson - 3 Battery

Sub-lesson -1 Charging, discharging, and its types.

Charging- When battery is connected to DC supply (Battery charger) it draws the current due to which chemical action takes place and the electrical energy is stored in the battery in the form of chemical energy.

Construction of lead acid cell



This process is called charging.

Chemical action-

$$Pb + 2\,H_2SO_4 + PbO_2$$
$$\text{\_ ve plate} \quad \text{electrolyte} \quad \text{+ ve plate}$$

Discharging- When train is at hault or running at less than cut in speed of alternator battery supplies current to the lights, fans, etc. changing chemical energy in to electrical energy. The energy stored in battery gets reduced. This process is called discharging.
Chemical action-

$$PbSO_4 + 2\,H_2O + PbSO_4$$
$$\text{\_ ve plate} \quad \text{water} \quad \text{+ ve plate}$$

Types of charging-

1. Normal charging.
2. Boost charging.
3. Trickle charging.
4. Float charging.
5. Initial charging.

1. **Normal charging-** In this method charging is done by current at the rate of 10% of AH capacity of the cell for 10 hours.
   Example-
   For 120 AH cell charging current =120x10/100 = 12 amp. i.e cell is charged at 12 ampere rate for 10 hours. 0r for the 110 volts battery charging voltage of 120- 125 volts is applied.

2. **Boost charging-** In this method charging is done by current at the rate of double the nomal charging current i.e. 20% of AH capacity of the cell for 5 hours.
   Example-
   For 120 AH cell charging current =120x20/100 = 24 amp. i.e cell is charged at 24 ampere rate for 5 hours.
   It should be ensured that temperature of cell does not go beyond

45°C - 49°C.

3. **Trickle charging-** If charged cell is kept idle for more than 15 days it should be charged at the rate of one third of the nomal charging current. This is called trickle charging.

4**. Float charging-** in this method the charged cell is kept connected with the same charging voltage source. Thus the cell is always fuly charged.Generally the cell is charged by constant voltage method.

5. **Initial charging-** For initial charging very low current is applied. Charging current for 120 AH cell =120/80 =1.5 ampere for 80 hours.

Sub-lesson- 2 Precautions while working on battery.

1. Do not allow any flame near battery.
2. Battery room should be airy, and well ventilated.
3. Do not spill electrolyte any where.
4. Prevent battery from damages.
5. Use safety goggle, hand gloves,etc while working.

Probable defects in battery-

1. Container broken	- Wrong packing.
2. Internal short circuit	- over heating, overcharging, sedimentation.
3. Sulphation	- keeping battery in discharged condition for longer duration.
4. Reverse polarity	- over discharge, reverse charge.
5. Buckling	- wrong storage,abnormal temperature rise.
6. De-coloration	- Distilled water is not topped up.

Colour of positive plate after charging is brown, and negative plate is slaty.

Important points in cell maintenance-

1. Keep the cell dry, clean and in airy room away from sunlight.
2. Top up the cell time to time to maintain proper electrolyte level.
3. Charge the battery immediately when it is discharged.
4. Apply petroleum jelly to the terminals of the cell to prevent corrosion.
5. charging voltage per cell should not be more than 2.3 volts per cell. For VRLA cells it should be 2.25 volts per cell.

6. During charging temperature should not go beyond 45°C.

Sub-lesson -3 Procedure of preparing electrolyte.

1. Use sulphuric acid of 1840 spg.
2. Fill the jar with the distilled water first and then slowly add suphuric acid with continuous stirring.
3. Electrolite should be prepared in glass or plastic tank/container. Ratio of acid and distilled water shall be 1:4 and spg 1190-1200. Allow to cool the electrolyte.

Filling of electrolyte in the cell-

1. first clean the cell.
2. open the vent plug and fill the electrolyte in the with the help of funnel. Check the float level.
3. replace the vent plug and check level after 10-15 hours. If the the level is not proper top up the cell with electrolyte.

Sub-lesson - 4 Distilled water plant.

1. De-mineralising water plant.
2. Solar distilled water plant.

Lesson - 4 Circuits and devices.

Sub-lesson -1 Lights, fans, and safety items maintenance.

a)

i. Clean bulb globe, tube light covers and replace if broken.
ii. Replace /repair defective berth lights.
iii. Attend side lamp, tail lamp, etc of SLR.
iv. Clean the tube light fittings.

b)

i. Check all fans smooth working. Check fuses, mcb, switches, regulator, etc.
ii. Check fans blades,
iii. Check carbon brush, spring, etc.
iv. If fan is noisy check bearings, blade, jaali and repair it.
v. Check the movement of the moving fan.

c)

i. Check all lights for proper working.
ii. If bulbs are fused, replace.
iii. Check the switches and put right.
iv. Check the cut-out fuses.
v. Check the lamp holder.
vi. Check wiring circuits.

Sub-lesson - 2 Protection of circuit from fire.

a**)** Fuses are provided for protection of lights and fans circuits-

i) Use 16 amperes HRC fuse for L_1,L_2 and fan circuit in junction box.
ii) Main negative fuse of 35 amperes HRC or 20 SWG.
iii) Branch fuses of 35 SWG shall be used.
iv) For sockets use 16 amperes HRC or 22 SWG fuse.

b) Now a days MCB is used in place of rotary switches which provides protection against overloads and short circuits.

c) PVC conduit is used for coach wiring and positive and negative wires on saperate sides.

Lesson- 5 AC equipments.

Sub-lesson -1 Schedule maintenance.

1. Daily.
2. Weekly.
3. Monthly.

Sub-lesson -2 AC coach schedule maintenance.

1. Trip schedule.
2. Monthly schedule.
3. Quarterly schedule.
4. Annual schedule.

Sub-lesson -3 Trouble shooting of AC equipments.

a) Reasons for high discharge pressure-

1. Condensor fan not working.
2. Condensor dirty or jamm.
3. Compressor valve is partially opened.
4. More gas charged.
5. Presence of air in the system.
6. Atmospheric temperature is more.

b) Reasons for low discharge pressure -

1. Less gas charged.
2. Compressor cylinder not loading.
3. Speed of compressor motor is low.
4. Compressor valve reeds faulty.
5. Suction pressure is low.

c) Reasons for low suction pressure-

1. Less gas in the system.
2. Expanssion valva setting is not proper.
3. System chocked.
4. Air filter is dirty.
5. Evaporator chocked or dirty.
6. Blower not working or speed is low.
7. Compressor cylinder not unloading.

d) Compressor sweating-

1. Expanssion valve setting is not proper.
2. Thermal bulb of expansion valve is dislocated from suction line.
3. Blower not working or speed is low.
4. Air filter is chocked up.
5. Suction pressure is low. Liquid is coming to compressure.
6. ore lub oil is circulated.

e) Cooling is more-

1. Thermostat is defective.
2. Thermostat is bye-passed.
3. Compressor motor contact is welded.

Sub-lesson - 4 Reasons for low cooling in the coach.

1. Thermostat defective.
2. less gas in the system.

3. System is chocked.
4. Air filter is dirty.
5. Blower motor not working, or low speed.
6. Condensor fan not working or condenser is dirty.
7. Presence of air in the system.
8. Atmospheric temperature is high.
9. Compressor cylinders not loading.
10. Copressor otor speed is low or reeds are leaking.

* * *

Chapter-07

TL/AC equipments.

Lesson -1 Testing , erection, and commissioning.

Sub-lesson -1 Testing of alternator.

1. No load test.
2. Load test.
3. Temperature rise test.
4. Insulation resistance test.

1. No load test- For 25 and 18 KW alternator base load is taken as 10 ampere battery or resistance. This test is carried out running alternator from 400 to 2500 rpm speed. At various speeds the variation in the voltage shall not be more than 5% . Setting is done by potentiometer. Alternator should generate cut in voltage at 400 rpm.

i) 18 or 25 KW - 400 to 2500 RPM, base load 10 ampere.

ii) 4.5 KW - 357 to 2500 RPM, base load 10 ampere.
At 357 RPM 110 volts shall be generated and variation should not be more than 5%.

2. Load test-
For 18/ 25/ 22.75 KW alternator on half load.

1) Full load of 25 KW is 193 amperes, i.e. half load is 97 ampere.

2) 97 amp battery load or resistance and speed from 400 to 2500 RPM.

3) During testing at 100 rpm the variation should not be more than 4%. At 800 rpm full output shall be generated. Setting is done at 1500 rpm and 97 amp load.

Setting is done at 50 % load and 1500 RPM

For 4.5 KW alternator full load is 37.5 amperes. Testing is done on
19 amperes i.e. half load.
Testing speed 600 to 2500 rpm.
Variation not more than 5%.
Voltage setting is done at 19 amp and 1500 rpm.

a) For VRLA cells - 122 volts (for 54 cells)
-126 volts (for 56 cells)
b) for ordinary cells -124 volts (for 54 cells)
-128 volts (for 56 cells)

3.Temperature rise test-

Testing speed- 2500 rpm.
Full load - 133 ampere 18 KW.
- 175 ampere 22.75 KW.
- 193 ampere 25 KW.

Testing duration- 5 hrs	**Max.temperature**
Alternator terminals	100° C
Power diodes	100° C
Bearings	100° C
Stator and field winding	90° C

For 4.5 KW full load 37.5 amp. And speed 2500 rpm.
Duration - 5 hrs.

Alternator terminals	100° C
Power diodes	100° C
Bearings	35° C (above ambient)
Stator and field winding	90° C

4. Insulation resistance test-

Insulation resistance is measured with 500 volts megger-

	AC coach alternator - 18 /25 KW	Non AC -4.5 KW
1. Between stator and body	- 20 Mega ohm	- 01 Mega ohm
2. Between field wdg & earth	- 20 Mega ohm	- 01 Mega ohm
3. Between stator and field	- 20 Mega ohm	- 01 Mega ohm
4. Between RRU terminals (all shorted) and body	- 10 Mega ohm	- 01 Mega ohm

Sb-lesson - 2 Safety devices testing.

Low pressure cut-out- Close te expansion valve and run the compressor. Check pressure in the LP gauge. At 10 psi plant should cut-off.

Now open the expansion valve and check the LP gauge. When the pressure increase to 30 psi plant should cut-in.

High pressure cut-out- Remove the condenser fuse and switch on the plant. Discharge pressure will go on increasing. When it reaches 240-250 psi the plant should trip. Variation should not be more than 5%.

Thermostat setting-

	Low temp.	Medium	High temp.	
Setting -	**22 °C**	**24 °C**	**26 °C**	
				±0.5°C
	17 °C	**19 °C**	**21 °C**	

Check the return air temperature. Plant should cut-in cut-off at ±0.5°C of thermostat setting.

Vane realay- Plant should not operate unless the blower is working and delivering sufficient air. To monitor this vane relay is provided. It is the relay operating on air pressure.

When suction of blower is closed by some means, then vane relay position changes. It disconnects the further control circuit supply. Likewise all the safety devices i.e. hooter, overload relay, single phasing preventor should be tested.

Sub-lesson -3 AC plant testing.

Testing of AC plant is done as below-

1. General test.
2. Precooling test.
3. Pull down test.
4. Spare capacity test.

1. General test- Run the plant and ensure that-

i) Discharge line is hot.
ii) Liquid line is warm.
iii) Suction line is cold.

2.Precooling test- Increase the temperature of the coach up to 45° C with the help of heater or higher capacity bulbs. Keep the fresh air filters closed during this test. Run the plant. Coach should be cooled in hour and plant should cut-off automatically.

3. Pull down test- Keep the fresh air filter open. Switch on all electrical load. Equivalent electrical load per passenger is taken as 120 watts. Load of person carrying out the test shall also be taken as 120 watts. Icrease the inside temperature of the coach up to 45°C.

120 watts X 46 passengers = 5520 watts. Total load of aall passengers in AC2T coach. Switch on both the plants. Coach should be cooled within 2 hours and plant should cut-off.

4.Spare capacity test- The cut in time and cut off time of the plant is noted. If in one hour cutt off time is 20 minutes and cut in time is 40 minutes then spare capacity is calculated as given below.

$$\text{Spare capacity} = \frac{\text{Total cut off time}}{(\text{Cut of time} + \text{cut in time})} \times 100$$

If cut-of time in one hour is - 20 minutes
Cut-in time - 40 minutes.
Putting values-

$$\text{Spare capacity} = \frac{20}{(20 + 40)} \times 100$$

$$= 2000 / 60 = 33.33\ \%$$

Thus more the spare capacity means cooling capacity of the plant is more.

Sub-lesson- 4 Trouble shooting.

1. No generation by alternator-

1. Loss of residual magnetism.
2. Field widing open circuit, short circuit, burnt.
3. Main winding open circuit, short circuit, burnt.
4. Defects in RRU like- main fuse or field fuse blown, voltage detector defective, current detector defective, free wheeling diode short, magnetic amplifier defective, excitation transformer defective, etc.

2. Low generation by alternator-

i) Loose V belts.
ii) Voltage and current setting is not proper.

3. Over generation by alternator-

i) Voltage detector of RRU defective.

4. Battery run down-

i) Alternator setting is not proper.
ii) Reverse cell.
iii) Cell short.
iv) Defective cells.

5. Cell overheating-

i) Low electrolyte level in cells.
ii) Alternator output voltage is high.
iii) Cell short.

6. Frequent topping up required-

i) Cell ovr charge.
ii) Alternator setting is not proper.
iii) Charging voltage is more than 2.3 volts per cell.
iv) Cell container is cracked and leaky.

Sub-lsson-5 Coach testing.

Proto test-

These are not carried out on all coaches. If 10 coaches are built in workshop it is carried out on only one coach.

Proto type tests are as follows-

1. Average illumination test.
2. Equal distribution of light.
3. Voltage drop test.
4. Joint heating test.
5. Insulation resistance test.
6. Water prof test.

Routine test-

These are carried out on all coaches-

1. Voltage drop test.
2. Joint heating test.
3. Insulation resistance test.
4. Alarm chain pulling system test.

AC coach testing program-

1. Refrigeration leak test.
2. Air flow test.
3. Commissioning test.
4. Super heat test.
5. Conditioning air leakage test.
6. Air delivery test.
7. Precooling test.
8. Pull down test.

9. Spare capacity test.
10. Safety device test i.e. LP,HP,OP testing.
11. Generation.

Sub-lesson- 6 Coach builders.

All tests shall be carried out in front of the customer engineer and certificate to be obtained likewise.

Sub-lsson-7 Safety items.

1. Alternator suspession pin. (link)
2. Axle pulley, pin.
3. Safety chain pins.
4. Battery box suspension system.
5. Circuit fuses and MCBs.
6. Fan guard. (Jaali)

* * *

Chapter -08

Lesson- 1 Maintenance, code of practice, special maintenance Instructions

Sub-lesson-1 110 volts DC coach wiring.

Alternator 4.5 kw, Ampere Setting 37.5 A, Voltage setting 124 volts
Monoblock battery (One monoblock cell 6 volts)18 Nos. -120 AH capacity
VRLA 54 cells -120 AH
Light circuit - L1, L2 , Fans - F, Socket - S

L1 (Emmergency Light) - when EFT connections are made to feed adjacent coach then L2 is kept off. Through L1 Night lamps, lavatory, corridor lights are swithed on.

Cable size-

i) 4 mm^2 7/0.85 = 10 Amps i.e. 7 strands of 0.85 mm. dia.
ii)16 mm^2 7/1.7 = 20 Amps i.e. 7 strands of 1.7 mm dia.

iii)35 mm^2 7/2.52 = 50 Amps i.e. 7 strands of 2.52 mm dia.
iv)50 mm^2 19/1.7 = Amps i.e. 19 strands of 1.7 mm dia.

Symbol size

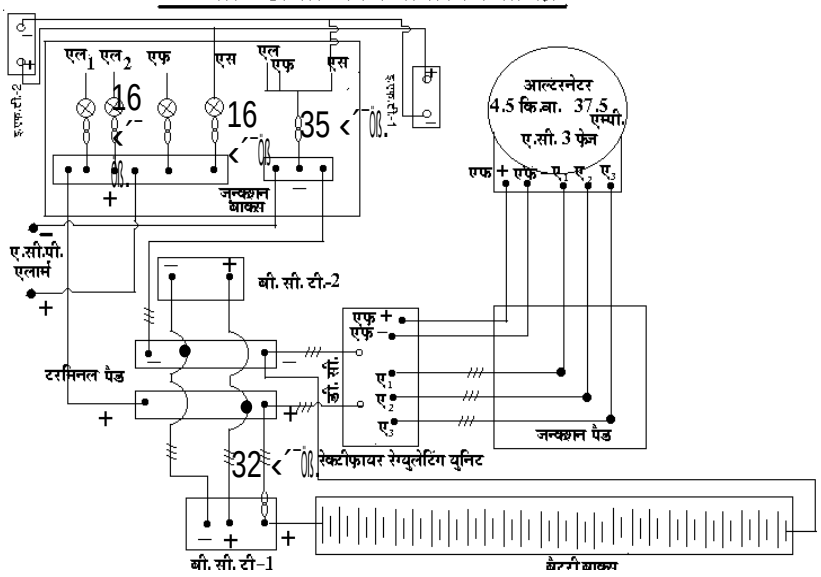
4 x´Ô.´ÖÖ.´

16 x´Ô.´ÖÖ²

35 x´Ô.´ÖÖ.²

50 x´Ô.´ÖÖ².

110 वोल्ट डी.सी. कोच वायरिंग रेखाचित्र



लेड एसिड सेल मोनो ब्लाक 6 वोल्ट X 18 = 108 वोल्ट 120 एम्पीअर - आवर (AH.)

Color code-

3 phase AC - Gray
Fan+ - Red
Fan - - Black
Light + - Yellow
All other + - Red
All other - - Blue

Illumination level-

It is measured at From floor of the coach - 840 mm above.
From back of the seat - 500 mm horizontal.
First class compartment - 30 Lux (lumens per square metre)

Second class compartment - 30 Lux
Parcel van - 40 Lux
Dining car - 30 Lux
Luggage compartment - 20 Lux
Coach with 20 w FL tube - 60 Lux
Corridor, toilet - 16 Lux

Lux - one lumen light faling on one square metre area is called one lux.

Voltage drop, tail voltage-

The voltage drop at the farthest point from the battery should not be more than 3 volts.

Example: If voltage at battery is 108 then 108-03 = 105 volts tail voltage.
If voltage at battery is 106 then 106-03 = 103 volts

Fuse sizes table-

SrNo	Name of the circuit	Location	Size/capacity
01	Branch fuse	FDB	35Swg./ 6 Ampere
02	L1,L2,F & socket 1&2	Junction box	22Swg./16 Ampere
03	Main negative	Junction box	20Swg./35 Ampere
04	Battery fuse	Battery	20Swg./32 Ampere
05	Alternator/regulator	RRU	Main- 20Swg./32 Ampere Field- 35Swg./6 Ampere

Sub-lesson - 2 Code of practice for prevention of Electrical fire.

Causes of electrical fire- short circuit, loose connection, leakage, undersize cable, overload, oversize fuse, careless working, inferior quality of material, violation of rules.

Code of practice for prevention-

Air clearance- The clearance between current carrying cable terminals and coach body should be minimum10 mm, and between positive and negative terminals 4 mm. (Air gap between body and terminal)

Damage to insulation- cable insulation should not be spliced for testing purpose at any point other than terminals. PVC grommet or bushes shall be used between body as well as at crossings.

Insulation test shall be carried out by 500 volts megger and IR value should not be less than 2 mega-ohms.(minimum IR value in worst season not less than 1 mega-ohms)

1. **Crimping-** All terminals and joints should be crimped properly and double nut with spring washer should be used.
2. **Re-wiring-** Codal life of wiring is 12 years, hence re-wiring should be done after 12 years. IR value should be checked periodically. It should be replaced if found defective.
3. **Coach wiring-** PVC cables should be used in coach wiring. Steel conduit should be used in underframe and PVC conduit for roof wiring.
4. **Insulation tape-** Always use PVC adhesive tape for wire joints. Tape size 0.2,0.22,0.25 mm should be used.
5. **Wooden cleats-** wooden cleat or block should be seasoned and two coats of fire retardant paint (FRP) should be applied to it.

Guidelines for maintenance-

All loose wires should be tight properly. Switch on all lights and fans load and check all terminals for overheating. Check earth leakage. Check all fuses, they should be of proper size. Coach having positive leakage shal not be sent in service. Negative leakage coach should be attended after one trip any how.

After carrying out repairs in sick line the insulation resistance test should be done.

Sub-lesson- 3 Maintenance of lead acid cells

Maintenance of cells-

1. Trip maintenance
2. Fort-nightly maintenance
3. Quarterly maintenance(once in a three month)

1. **Trip maintenance-** On arrival of train all EFT connection should be removed. Switch on all lights and fans and check the battery voltage. For 110 volts coach if voltage is less than 97 volts then battery is treated as discharged. If specific gravity is less than 1180 mark the cell and put date. Floater shall be checked with hand,

check electrolyte level and top up with distilled water if required. The work should be carried out after every trip.

2. **Fort nightly maintenance-** Clean sulphation, dust and dirt from the top of the cell. Check voltage of every cell. If foud less than 1 volt compared to adjacent cell then the cell is condemned. Check spg and put on charging.

Spg correction at different temperatures-

Temp.	**Specific gravity**
10 °C	1210
15 °C	1210
30 °C	1200
40 °C	1190
50 °C	1180

1 °C ± 0.0007
10 °C ± 0.007
] Refferance temperature 27 °C .

Example-

17 °C	47 °C
+ 1.200 S.P.G	+1.200
- .007	.014
1.193	1.214

At 27 °C temp Spg will be 1200

1. **Quarterly maintenance-** Equalising charge should be given to the battery. Keep all the load off and charge the battery for 5 hours. After 2 hours note the voltage and SpG. Stop the charging when three to four consecutive readings are same. 15 minutes after charging if the voltage is less than 2.1 volts then this cell should be sent for repairs. Change the pilot cell numbers.

Sub-lesson- 4 Do and Dont for V belts.

Do-

1. Belt grade should be same.(same length).
2. Belts should be stored in airy room and it should be dust free.

3. Belt tension should be proper. For 4.5 kw alternator 105 kg. , for 12 kw 195 kg. , and for 18/25 kw 330 kg (both side) $\pm$ 5 kg difference is permissible.
4. Retighten the belts after one trip or 300 kms run.
5. Keep gap of 75 mm between supporting plate and fixing nut.
6. Alignment of axle pully and alternator pulley should be proper.
7. Replace defective pulley.
8. Difference in belt grades in special circumstances is permitted for not more than two grades.(48-52)

Donts-

1. Oil or greese should not stick up to belts.
2. Do not use different belt grades.
3. Do not mix old and new belts together.
4. Do not use different make belts together.
5. Do not keep belts loose.
6. Do not disturb tensioning device.
7. Do not use repaired pulley

Sub-lesson- 5 Maintenance schedule of AC coach.

1. Trip schedule
2. Monthly schedule
3. Quarterly schedule
4. Annual schedule.

Maintenance should be carried out as per instruction issued by RDSO.

1. **Trip schedule-** After every trip check and clean axle pulley, belts, alternator, condesor motor, compressor motor, blower motor, air filter, control panel, precoling unit, light, fans, etc.
   Attend the defects mentioned in the log-book.

2. **Monthly schedule-** All items mentioned in trip schedule shall be checked thoroughly. Replace defective parts.

3. Quarterly schedule- All defective machines should be replaced. Greesing of machines should be done. Replace compressor oil. Cary out IR test, air delivery test. Check anti vibration pads,painting,etc. POH of the coach is done after 4 lakh kms or 18 months whichever is earlier.

Sub-lesson-6 Maintenance schedule of RMPU AC panel.

Trip schedule-

1. Clean filter and panel with with compressed air.
2. Check safety devices. No safety device should be by-passed.
3. Check indication lamps. Replace if defective.
4. Clean fresh air and return air filters.
5. Attend defects mentioned in log book.
6. Ensure proper working of the control panel.
7. Check operation of HP cut out.
8. Check LP_2, LP_1 cut outs.

Monthly schedule-

1. Run the plant for half an hour and check the current.
2. In heating position current should be 11 to 14 Amperes.
3. In cooling position current should 20 to 23 amperes.
4. Compressor motor current should be 7 to 10 amperes.
5. Condesor motor current should be 1.5 to 2.0 amperes.
6. Blower motor current should be 1.5 to 2.5 amperes.
7. To measure the currents clamp on meter/tong tester is used.

Quarterly schedule-

1. Put the water in the dip tray and check the drainage.
2. Check noise level of all the motors with shock pulse meter. Check the anti vibration mountings.
3. Charge the R-22 gas if required.
4. Check the locking arrangement of the control panel.
5. IR test of all the motors should be carried out by 1000 volts megger. Minimum IR value should be 2 mega-ohms.

Sub-lesson - 7 Dehydration of refrigeration system.

1. Due to presence of moisture in the system there is corrosion in the pipes/tubes.
2. It affects the quality of lubricating oil.
3. There is the possibility of choking of system due to formation of ice in the capillary/expansion valve.

Hence presence of moisture should not be allowed in system for which the vacuum is created to remove the moisture from the system. This process is called dehydration.

Create the vacuum of 29.6 inches of mercury with the help of 2 HP vacuum pump(735 mm of Hg). Charge the system with nitrogen gas up to 16 psi (1.2 kg/cm sqare). Again create the vacuum of 29.6 inches nd repeat the process twice and then charge the gas.

Gas charging- There should not be any impurity in the gas. Always keep the cylinder in vertical position while charging the gas. Slightly warm the cylinder if required.

Sub-lesson - 8 Lubrication of the compressor.

Lubrication oil level in the crank case should be proper. Due to low lub-oil level compressor can fail/damaged. Oil recommended by the RDSO shall be used.

Approved manufacturer/supplier.

1. Bharat petrolium	B.P. CLAVAS No.-33
2. Indian oil corporation	I.O.C. SERVO FREEZ
3. Hindustan petrolium	H.P. SHEETAL R-51

Quantity of oil-

1. 5 F-60	6 Litter	6 cylinder
2. 5 F-40	4 Litter	4 cyliner
3. 5 F-30	2.7 Litter	3 cylinder
4. 5 F-20	2.5 Litter	2 cylinder
5. SMC-4.65	10 Litter	4 cylinder
6. FK-4	4 Litter	4 cylinder

Oil level test- Compressor oil level can be checked from sight glass (Bull Eye) provided on the crank case.

1. ½ Bulls Eye level should be available when compressor is working.
2. 15 minutes after stopping the compressor 2/3 bulls eye level should be available.

Defects due to excess oil charging-

1. Suction pressure becomes low.
2. Compressor makes abnormal noise.
3. Sweating on compressor.

Teperature-

Compressor crank case should be warm, temperature may be up to 105°C .

Sub-lesson- 9 Instructions for gas charging in RMPU.

1. Before charging the gas leak test shall be carried out. Conduct vacuum test twice.
2. Leak test should be done by charging nitrogen pressure 250 to 300 psi (17.5Kg./cm^2) . Check the leakages.
3. Soap solution is used to detect leakage
4. All leakages shall be attended if any.
5. Reapeat the process till all leakages are put right.
6. Create the vacuum of 29.6 inches of mercury with the help of vacuum pump.
7. Check the vacuum after 4 hours.

Gas charging-

1. Charge 2.8 kg R-22 gas in the system.
2. Check the leakage with the help of halogen leak detector.
3. Pinch the charging line.

Sub-lesson - 10 Instructions for prevention of failures of thermostat.

Common problems-

1. Mercury column breakage.

2. Breaking of glass.
3. Thermostat holder broken/defective.

Preventive measures-

1. Remove return air filter and check thermostat, if broken replace.
2. Clean thermostat bulb.
3. Check for mercury colum breakage, if breaked replace. Do not use it applying heat.
4. Frequent failures started after 4½ years the thermostat is provide. Replace it after 5 years.

Sub-lsson- 11 Precooling Voltage for SMF batteries.

200 ampere capacity precooling unit is provided for AC coach. lnput to unit is 415 volts 3 phase AC and output is DC 140 ± 8 volts. Setting for 54 cells will be 124 volts i.e. 2.3 volts per cell. For 56 cells 128 volts. ln this unit there is a transformer to step down the voltage and rectifier to convert it from AC to DC.

Sub-lesson- 12 Out-put setting of alternator.

In non AC coach 120 AH and in RMPU AC coach 1100 AH capacity VRLA/ SMF batteries are used.
Out-put setting of alternator-

For 54 cells 123 ± 0.5, 122±0.5 and120±0.5 volts for P./ME./SF respectively.

For 56 cells126±0.5 and 125±0.5 volts for ME./SF. Respectively.

Instructions for SMF battery charging and maintenance.
Dos-

- Follow the instructions given in company manual.
- Always keep the battery clean.
- Tight the terminal bolt connection with 11 N-metre torque.
- Trickle charge should be given to spare battery once in a six month.

- Use spring washer for the connections.
- Keep battery away from the heat, flame.
- After the battery is discharged charge it immediately.
- Check battery voltage every month.

Donts-

- Charging voltage should not increase more than 2.3 volts per cell.
- Do not add water or acid to the cell.
- Do not disturb the safety valve.
- Do not boost charge for more than 12 hours.
- Do not try to open the battery.
- Do not mix ordinary cells or cell of different companies with VRLA cells.
- Carry out the maintenance schedule of the cell timely.

* * *

Chapter- 9

Lesson- 1 Specifications

Sub-lesson-1 110 volts code of practice for wiring.

1. Wiring code	RDSO	EL-TL-48
2. Steel conduit	I.S.	9537-1980
3. PVC conduit	I.S.	2509-73
4. PVC gromet	I.S.	583
5. Cable crimping	I.R.S.	E/45/27
6. Junction box	I.R.S.	E/38
7. Fan regulator	I.S.	6680
8. Ceiling light		DRG. NO.- IRS EA/199
9. Side light	SKEL	3048
10.Lamp holder	I.S.	1258-1979
11.Tumbler switch	I.S.	6765-1979
12.Tail lamp	I.S.	897-1982

Sub-lesson - 2 Generating equipments.

1. Brushless alternator	RDSO EL/TL/47.
2. V belts	I.S. 2484
3. Axle pulley/alternator pulley	D.No.- SKEL/3282-3283
4. Flat belt pulley	I.R.S. ET/1972
5. Alternator suspension	I.C.P. SCN 390- 305
6. Flat belts	RDSO/SP/E/TL/44
7. Belt fastener	EL/TL/47 GREY

Sub-lesson - 3 Battery.

1. 110 volts monoblock	RDSO/EL/TL/38
2. Battery box	DRG.No.-ICF/SK/7-306
3. Acid resistant paint	EL/TL/19. 1973
4. SMF battery	RDSO EL/TL/59
5. Low maintenance battery	RDSO/EL/TL/55
6. BCT	EA/21
7. Sulphuric acid	IS.266
8. Distilled water	IS.1059
9. cell connector	IS.6848

Full forms-

1	CRB	- Chairman Railway Board.
2	CEE	- Chief Electrical Engineer.
3	CESE	- Chief Electrical Service Engineer.
4	HRC	- High Rupturing Capacity.
5	MCB	- Miniature circuit breaker.
6	ICF	- Integral coach factory.
7	RCF	- Rail coach factory.
8	SMF	- Sealed maintenance free.
9	VRLA	- Valve regulated lead acid.
10	PCD	- Pitch circle diameter.
11	FRP	- Fir retardant paint.
12	PVC	- Poly vinyle chloride.
13	H_2SO_4	- Sulphuric acid.
14	KOH	- Potasium Hydroxide.
15	RDSO	- Research, Design, and standards organisaton.
16	EFT	- Emmergency feeding terminal.
17	BCT	- Battery charging terminal.

18 RRU - Rectifier cum regulating unit.
19 GM - General Manager.
20 AGM - Aditional General Manager.
21 DRM - Divisional Railway Manager.
22 SMI - Spaecial maintenance instructions.
23 EIG - Electrical inspector to Government.

16 points program for AC coaches-

1. CESE expressed need for strengthening feed back/abnormal position information system between other railways so that necessary reports can be sent to headquarters for suitable action.
2. All A C coaches should be precooled before placing on the platform. This is the time when passngr needs quick and more comfort. Precooling leads shall be available in Underslung as well as RMPU coaches. In every SG coach one lead and in power car two leads moreover precooling points shall be available on the platforms.
3. From primary maintenance depot no coach is permitted with EFT connection or equipment in isolated condition.
4. All shortcomings in the coach shall be noted on arrival of the train and attended. Escorting staff should also note down the position of coach in register and log book at secondary depot with signature. The work carried out sould be entered in the log book.
5. From preimary depot both the alternators should be in working order. If the repairs/replacement of any alternator is not possible in secondary depot then it should be brought to the notice of higher officer and ensure the proper working of the healthy alternator.
6. From primary depot 6+6 V belts and from secondary depot 5+5 V belts shall be available for AC coach. V belts shall be retightened after 300 kms run to ensure its more life.
7. AC coach plant operation knowledge of AC mechanic and attendant should be tested. They should be given one week refresher training.
8. In primary depots Dyno Drive sytem should be available for alternator generation testing.
9. For replacement of unit, Unit Exchange Spare shall be available. Power should be given to every depot and depot incharge to maintain register with signature.
10. All depot should discuss the major failures and analyse it to find out cause so that its recuurence is prevented.

11. AC supply arrangement for precooling should be available as per the number of AC coaches increased.

12. Annual estimated consumption of material required for maintenance of AC coach shall be as per increased number of AC coaches.

13. Ensure proper cleating of field and phase wires of the alternators. It should be checked at primary depots.

14. Full load and no load voltage of every SMF battery should be recorded in abnormal condition in addition to monthly and quarterly.

15. Thermostat working shall be mentioned in the log book. If defective repair/replace it.

16. Ensure the proper working of WRA on arrival and before placing train on flatform.

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