Objectives

- At the end of this chapter, the learner should be able to understand the installation of static machines like transformers and rotating machines in the workshop of Electrical Engineering laboratory. A group of students can take a project of electric supply to induction motor and install by preparing foundation, fitting foundation plate, providing earthing checking level in fitting the machine on foundation.
- For handling electrical equipments various tools are required.
- Students will be in a position to use the various tools.
- They will be in a position to understand the importance of earthing and can take us a project of earthing the machinery with workshop or in laboratory.
- They will be in a position to know / check alignments of machinery, which are coupled mechanically. They will be in a position to understand neutral earthing.
- They can find earth resistivity by conducting experiment.
- They will know the installation procedure of different types of transformer sub-stations. They will be encouraged to visit a nearby sub-station.

6.1 Introduction :

All electrical machines are mounted on the foundations so that its static load and also the dynamic load of the rotating machine is transmitted to the ground. The foundation should be strong in construction so as to prevent displacement and vibration of the running machine. A solid concrete structure is essential for foundation. The machine is connected directly to the foundation with the help of foundation bolts, nuts. The basic requirements of foundation are (a) It should be horizontal (b) It should be rigid (c) It should be free from vibrations and displacement.

6.1.1 Common Troubles in Electrical Installation :

W-2010, S-2013

Q. List the common trouble in electrical installation.

W-2013

Q. List out the common troubles and its causes in electrical installations.

(i) Foundation not strong.

(ii) Foundation structure, nut-bolt not aligned properly.

(iii) Concrete foundation if not cured for a period of time may create problems.

(iv) There may not be sufficient space for foundation or around foundation to fix accessories.

(v) Sufficient space around the installation may not be available for the operator to operate the control devices.

(vi) May produce vibration if installation is not horizontal and rigid.

6.2 Factors Involved in Designing Machine Foundation :

W-2010

Q. Explain the factors involved in designing the machine foundation.

W-2011, S-2013

Q. What are the factor to be considered in designing the machine foundation?

S-2012

Q. State factors involved in designing the machine foundation.

S-2014

Q. Which are the factors involved in designing the foundation of electrical machine ?

Foundations help in transmitting static or dynamic load of the machines to the ground. For designing the foundation for the machine the factors like weight of the machine, its H.P. capacity, speed of rotation, type of drive, soil conditions etc. must be taken into consideration. Machine foundations are not based on any definite calculations, but they are dependent on practical, industrial experience and the data available. The machine foundation should satisfy the following requirements :

(a) The foundation should be horizontal in level.

(b) The foundation must be rigid.

(c) It should be free from vibrations.

(d) It should transmit both static and dynamic weight of the machine to ground.

(e) The foundation should be free from defects like cavities, pits, surface cracks etc.

(f) The foundation should be made from concrete mix i.e. cement, sand water in definite proportion.

(g) The design of foundation should ensure against sinking of foundation by distributing the load over as much as soil area, in relation with soil bearing capacity.

(h) The foundation should not slide over the soil due to horizontal thrust of running machine. This is achieved by sufficient frictional resistance between foundation block and soil.

(i) The foundation should be so designed that the resultant force posses within the block to prevent turning of the machine.

Following arrangements can be done to minimize the vibrations.

(a) The machine itself should be isolated from the adjacent structure by vibration absorbing material so that the vibrations caused may not induce any adverse effect on the neighboring structures.

(b) The machine must be rigidly bolted to the foundation.

(c) The insulating material is laid between bed-plate of the machine and foundation block.

(d) The isolation material is laid between the foundation and the ground on which it is supported.

(e) The isolation material in the form of spring is laid between bed-plate of machine and foundation work.

6.3 Requirements of Foundation of Static and Rotating Electric Machinery :

W-2012

Q. State three basic requirements of machine foundation.

W-2012

Q. State function of foundation bolt and bed plate.

W-2013

Q. What are the requirements of installation of rotating machines ?

(a) **Static Machine :**

As the transformers operate without moving parts. Generally a simple foundation is satisfactory. It should be firm, horizontal and dry. Once installed and erected, the transformer shall not move or bed down so as to tilt over. Even small movement of the transformer is not desired as it may break the electrical connections. Perfect horizontal base keeps oil level correct.

For installing large capacity transformers outdoors, a level concrete plinth is constructed so that its height is above the maximum expected flood water level of the site. The plinth should be of correct size to accommodate the transformer. Any one shall not step on the transformer plinth. Bearing plates of sufficient size and strength are also provided. For high capacity transformers rollers are provided, and the rails are fixed on the plinth. The transformer can be properly installed, shifted very easily with the help of rails. The rollers or wheels are locked after installation of transformer to avoid accidents. The full height partition walls are built, with sufficient clearance between transformer and wall.

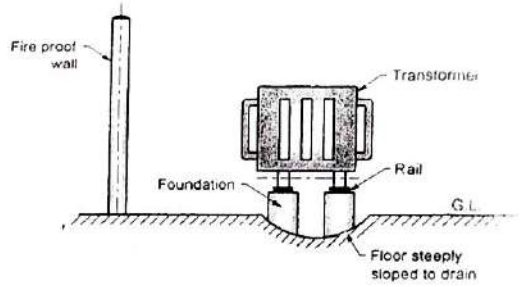


Fig. 6.3.1 : Foundation for static machine

(b) **Rotating Machinery :**

S-2011

Q. What are requirement of foundations for installing rotating electrical machines as per IS 900-1992.

A solid foundation of concrete is provided for the installing of rotating machine. To avoid misalignment of plate proper mounting of the machines, the motor or prime mover and the driven machine are

mounted on the common foundation. Usually the manufacturer put both the machines on common steel base. The size of the foundation is decided from the drawing supplied by the manufacturer. The foundation is designed taking into consideration the dynamic as well as static load. The foundation consists of following :

(a) Foundation made of cement, concrete material.

(b) The bed plate

(c) Foundation bolts.

The concrete foundation should be about 15 cms larger in both length and breadth. The depth foundation is decided taking into consideration the work place, panel height etc. The depth of foundation is dependent on the H.P. rating.

Sr. No.	Rating	Depth
1	75 to 100 H.P.	35 cm to 60 cms
2	50 to 75 H.P.	25 cm to 30 cms
3	20 to 50 H.P.	20 cm to 25 cms
4	10 to 25 H.P.	15 cm to 20 cms

How to make foundation :

The concrete foundation can be made in the following manner :

- The excavation soil is done first, for the depth mentioned in the above table.
- The length and width of the foundation size should be greater by 15 to 20 cms than the machine feet. After excavation of soil, wooden frames are placed, which give proper shape to the foundation. The wooden frame is also called the mould. It is arranged such that provision for cable, earthling pipes can also be provided.
- The plinth is usually tapered. It is larger at the base and smaller at the top. Foundation bolts of proper size are placed in the cement concrete. Sometimes plugs are provided for placing foundation bolts.
- Concrete foundation offer good result with a mixture consisting of one part Portland cement, two parts clean sand and three parts small broken stones.
- The dry mixture is made first and then water is added to it. This mixture with water is homogeneously turned again and again.

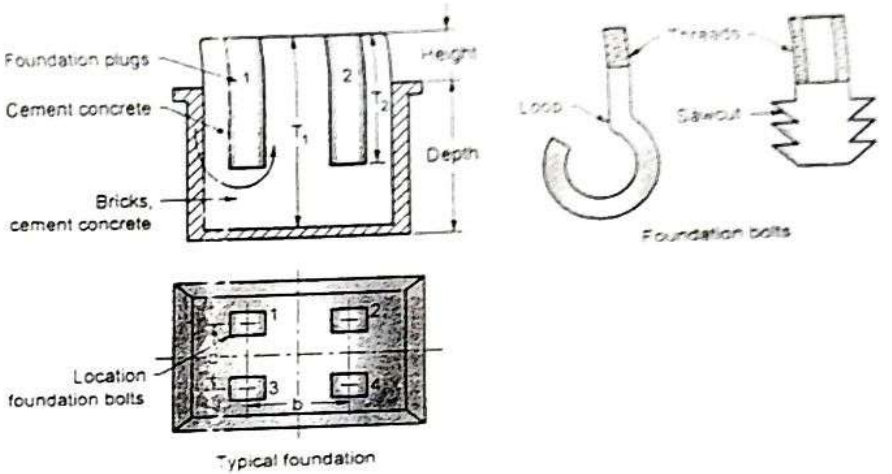


Fig. 6.3.2 : Foundation for rotating machine

- Now it is ready for pouring into the moulds. The ramming for concrete mixture is done, the foundation bolts/plugs are fixed in the concrete. Now wooden pattern mould is kept for 24 hours so that it can take solid form. The wooden pattern is removed the walls of foundation are rough, now they are finished with cement to get smooth surface the foundation surface is also levelled.
- The foundation is necessarily cured for at least one week for increasing strength of cement concrete. The shape of foundation, foundation bolt and machine mounted on bed plate is shown the Fig. 6.3.2.

Precautions :

The location of bolts are to be determined with great accuracy, otherwise they will not be in line with the holes in the base or bed plate of the motor. The foundation bolts fix-up the bed plate on the concrete foundation. The lower portion of the foundation bolts has eye shape or saw tooth shape to provide grip in the foundation, care should be taken in the leveling of the foundation to avoid strain and distortion of motor when the motor bolts are tightened.

Anti vibration machine mountings are provided at the foundation rotating machines.

(i) Resilent block mounting where elasticity is the most important property of cushioning material like mats, felt, cork, rubber slabs, rubber bonded to steel fastenings.

Resilient — स्थितिस्थापक

(ii) Spring mounting of bed plates is provided. Helical springs are provided with or without pre-stressing devices.

The machine foundation can be shown as below. The machine placed on the steel bed. The steel bed is connected through the foundation bolts and nuts to the foundation.

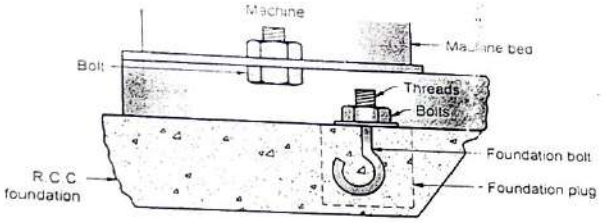


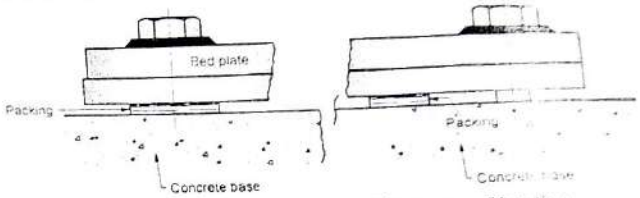
Fig. 6.3.3

6.3.1 Procedure of Levelling and Alignment :

In case of direct drives, the motor should be leveled. The driven machine should be also leveled before commissioning. This is essential condition otherwise under the influence of driven forces, undue loading may occur on the bearings of the motor, even though flexible couplings are used. The shafts of both drive and driven machine are in "Line". It can be confirmed by level bottle. For the gear and pulley drive we should ensure that both the shafts are parallel.

Direct coupled drive :

This type of coupling can be used when it is possible to arrange the motor in the same line as that of driven machine. This coupling also called as **Direct coupling** and **Flexible coupling**. In direct coupling metal flanges are fitted on to the shaft ends. The two flanges are held together by means of bolts. In flexible coupling the bolt ends are covered by means of rubber or leather bushes. It gives cushioning effect to the drive so that vibrations, sudden shocks and heavy loads. With the direct coupled drives the two shafts should be in accurate alignment. The shafts should be aligned w.r.t. to axis. First the axis are leveled, two coupling are then brought close together for leveling. If the driven coupling is lower, driven machine is lifted up by shimming otherwise the motor is lowered by cutting down the top of the concrete foundation. If the motor shaft is lower than the driven shaft, then the motor is packed up to bring the two coupling in the same line. The packing should be inserted close to the foundation bolts. If it is placed far away from to the foundation bolt, the bed plate will bend when the bolts are tightened.



Correct way of leveling Wrong way of leveling

Fig. 6.3.4

To determine the thickness of shims required for the height adjustment motor is placed on its foundation/bed plate. The height of difference between driven coupling and driving coupling is measured. An equal number of shims, are placed below each foot of the motor to raise the axis by approx 0.2 mm above the required height. Then for exact alignment shims are added or removed.

Levelling of Indirect coupled drive or lining up Belt-Drives :

As and when there is no possibility to have motor and the driven machine are not in one line, the indirect coupling like belt, rope or V belts using pulleys and chain drive is used.

The belt drive is very common type of drive used in industry. It is efficient, simple and gives very satisfactory service. The maximum power that can be transmitted by this is about 300 H.P. The general rule when installing a belt drive are (a) The diameter of driven pulley should not be more than six times diameter of the motor pulley. (b) The distance between the pulleys should not be less than four times the diameter of the larger pulley. V-belt, drives with a number of v-grooves are fitted on to the shaft ends, drive and driven load. If one v-belt is broken the load is carried by remaining one till the replacement is made.

For the chain drive, chains running on sprockets are used. It can transmit large power. The operation of chain drive is silent without slip. The only important maintenance for chain drive is that lubricating oil must be sprinkled frequently, periodically as and when required.

For rope, belt, chain drives the alignment should be perfect. The driving and driven shafts should be parallel with each other. It ensures that the rope, belt and chain run centrally on their pulleys and sprockets.

They are also at right angles to the shaft. If it is not satisfied, life of belt, rope and chain may become short and additional thrust is imposed on the motor. Firstly lining up of the indirect coupled drive shaft is carried out by taking measurements from the centre of motor shaft to the centre of the driven shaft at opposite side by metallic tape. If the shafts are in line, these two measurements are same. The foundation bolts, are then grouted, after this lining up final adjustment are done afterwards.

6.3.2 Procedure for Alignment of Direct-Coupled Drive and Indirect Couple Drive :

S-2011

Q. Explain the procedure to be followed in aligned two shafts to be :
(i) Directly coupled and (ii) Indirectly coupled.

W-2011, S-2012, S-2013

Q. Explain the procedure for levelling and alignment of electrical machine.

W-2012

Q. Explain procedure of alignment of shaft of electrical machine.

The alignment of direct-coupled drives can be easily made by the following three steps.

(a) Axial positioning of the shafts
(b) Parallelling of shaft axis.
(c) Centering of the shaft axis.

Fix the motor and driven machine on the bed plate in their final position. Level up the motor and driven shaft with proper positioning of shims. The spirit level can be used to some extent to check the alignment of the shaft. A lining up tool as shown in the Fig. 6.3.5 can be used, which is most useful.

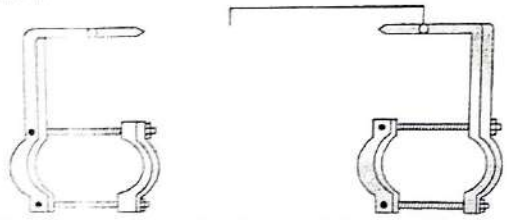


Fig. 6.3.5 : Lining up tool for Alignment of direct coupled machine

After the shafts have linked properly, the lining up tool is bolted in position as shown in the fig. It is so placed that there is a small gap exists between the two points. The two shafts are now rotated together and if the two points do not diverge then the shafts are parallel. When the relative positions of the points remain the same throughout one complete revolution of the shaft, then the alignment of the shaft is correct. It is shown by the following figure.

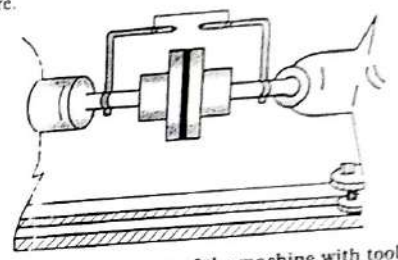
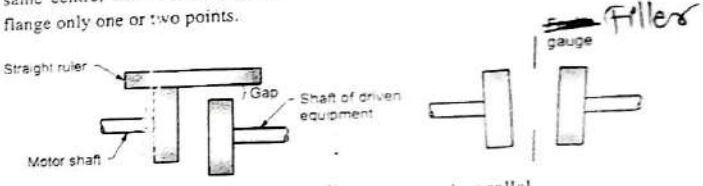


Fig. 6.3.6 : Alignment of the machine with tool

The difference in the height of axis of drive shaft and driven shaft can be checked by steel ruler. The straight edge of the ruler is placed on the two outside flanges of coupling as shown in Fig. 6.3.7. If the centre of heights are the same the ruler edge touches each flange along its whole length then they are aligned. When steel ruler touches only one flange, that will mean that one shaft is lower than other. On the other hand, when the couplings are on the same centre, with the shaft not in line with the edge of ruler touches the flange only one or two points.



Axis not aligned **Flanges are not parallel**

Fig. 6.3.7

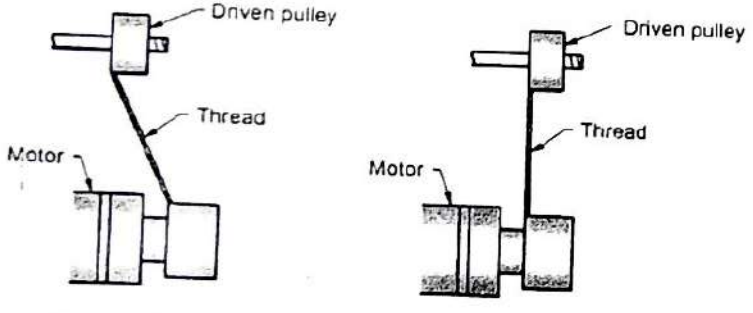
To confirm the running true of two coupling halves the gap between two couplings is checked with the help of the filler gauge. The gap is checked by turning the motor shaft through 90°, 180°, 270°, and 360°. The readings should remain unchanged at all the positions of the shaft. By using the above

methods the alignment is checked. The adjustment in driving and driven shaft is carried out packing shims. The foundation bolts are slowly tightened and grouting is carried out, only after careful alignment of two shafts.

Alignments of Indirectly Coupled drives :

The alignment motor for rope and belt drive is carried out before grouting in the slide rails. The motor is firmly bolted to the rails which stand loose on the foundation and is then aligned. A spirit level is placed across the machined surfaces of rails which are then levelled using shims. Only metallic shims are used instead of wooden once. If wooden shims are used, it yields under pressure and swells when moisture enters into wooden shim, while grouting. The rails are levelled in both directions. The motor shaft is then lined up with the driven line shaft and two the two pulleys, driving and driven are brought into alignment.

For the correct alignment ; the faces of the two pulleys lie in parallel planes. This is achieved when two points on opposite sides of each pulley are connected and a straight line results.



Motor not parallel with driven shaft **Motor parallel with driven shaft**

Fig. 6.3.8

6.4 Effects of Misalignment :

W-2010, W-2011, S-2013

Q. What are the effects of mis-alignment ?

W-2013

Q. What happens, if levelling and alignment of two shafts of directly coupled machines are not matched ?

S-2014

Q. What is the effect of misalignment on the performance of machine ?

The shaft, pulleys, couplings of driven and driving machine need proper alignment. If it is not ensured the following are the effects.

(a) Direct coupled drives : For direct coupling drives the misalignment during installation give rise to :

(i) Increased loading on bearings.

(ii) Excessive vibrations in driving and driven machines.

(iii) Increased stresses on couplings and shafts. The final effects of this is bend or sprung in the shaft, worn out bearings and overloading of driving machine causing its failure.

(b) Indirectly Coupled Drives : For indirect coupled drives like rope and v-belt and chain drives. The misalignment during installation give rise to the following adverse effects.

(i) The life of rope, belt or chain is shortened.

(ii) Excessive end thrust is imposed on the driving machine.

(iii) Produces destructive vibrations

(iv) Increased noise level.

(v) Bent shafts.

(vi) Worn out bearings

(vii) All these leads to early wear and tear of both the driven and driving machines.

6.5 Installation of Floor Mounted Transformer :

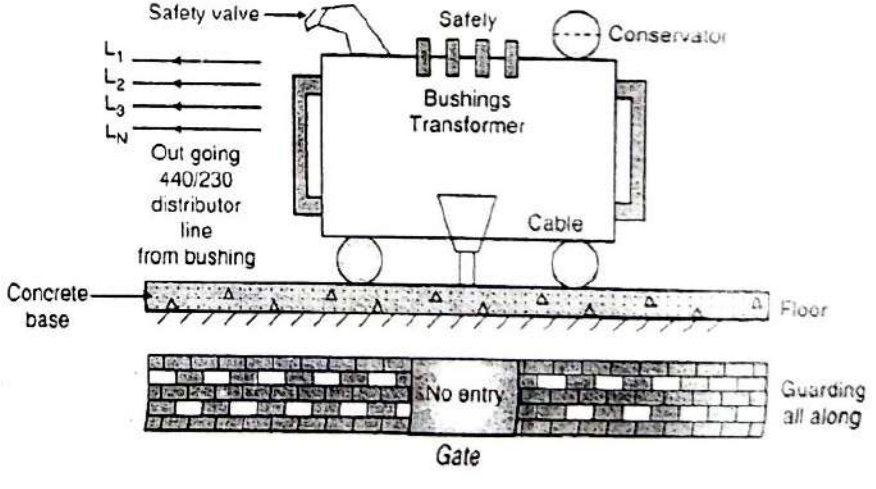


Fig. 6.5.1

6.7 Installation of Rotating Electrical Machines

This portion is covered in the earlier sub section 6.1 to 6.4

6.8 Devices and Tools Required for Loading :

W-2012

Q. State any four equipments used for lifting heavy electrical machines during installation.

S-2011, W-2013

Q. List out the tools required for loading and unloading the heavy equipments. Also state the use.

S-2014

Q. State the various devices and tools used for loading and unloading heavy equipments.

Use of various devices and tools in loading and unloading, lifting carrying heavy equipments are studied in this topic H. They are employed for moving loads in the factories, stores etc. Material handling equipments include lifting (Hoisting), shifting transporting, shifting on required site and fixing on foundation.

Hoist, cranes are also used for moving the load. The hoisting machine is intended either for raising, travel horizontally, turn around and lowering. The components, units of hoisting equipment include :

(a) Flexible hoisting devices – Chain and Ropes.
(b) Pulleys, pulley system, sprockets and drums
(c) Load handling, attachment, accessories etc.
(d) Stopping and breaking devices
(e) Drives
(f) Transmission components, axle shafts, bearings, clutches.
(g) Rail and travelling wheels.
(h) Control devices.

Chain/steel wire rope slings :

Slings are made from welded chains or wire ropes with eyes and hooks. For suspension or with long shaped grips for the object to be lifted. Heavy loads are handled by wire rape slings should be reliably secured so that they may not alter the position during the movement.

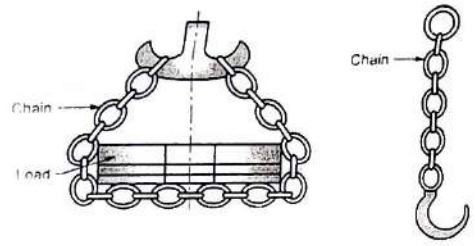


Fig. 6.8.1

Steel wire rope sling :

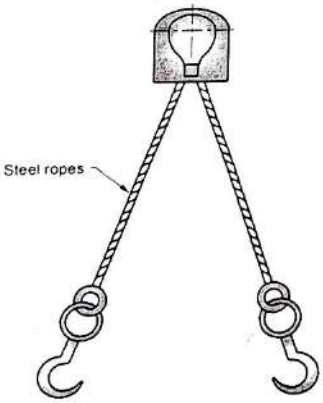


Fig. 6.8.2 : Steel ropes

Pulleys :

They are in fixed and movable design pulleys can be used for gain in speed or force. Pulley system is combination of several movable and fixed pulleys.

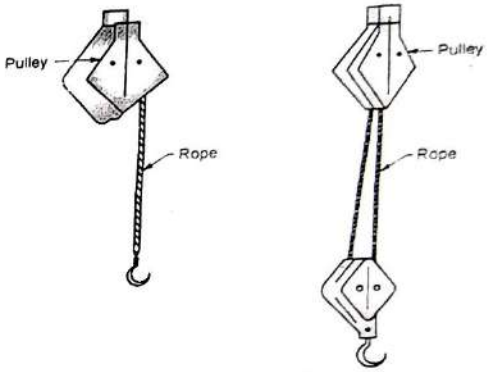


Fig. 6.8.3 : Rope pulleys

Multiple pulley system with four parts is used to carry loads upto 25 tons. Even with increasing the parts it can be used upto 75 tons.

Unloading, lifting and carrying heavy electrical equipments.

Jacks :

It is a lifting device used to raise the equipment for small height while shifting or temporary maintenance, or foundation work. **Mobile cranes or truck mounted cranes** are used for loading unloading of bulky irregular shaped loads for outdoor site. For electrical maintenance of motors, switchgear just trolleys, eye bolt of machine useful and helpful. Trollys are useful for material handling in electrical maintenance shop. Now a day's battery operated vehicles are useful for material handling in electrical maintenance shop. Electrical machines of small and medium rating are handled by attaching the sling rope to the eye bolt provided on the machine. Transformers are lifted, handled with the help of cranes.

6.8.1 Precautions to be Taken while Handling these Devices :

(i) Work should be done by group of persons and not by a single person.

(ii) Observe proper safety precautions and rules.

(iii) Work should be carried out by authorised persons.

(iv) If rules are not followed it may result into accidents, injuries, damaging of equipments.

(v) Wear proper fitting dress and tight the buttons of clothes.

(vi) Use gloves to protect hands.

(vii) Don't allow to stand any body under a lifted load.

(viii) See that the load is properly lung in the crane hook.

(ix) Lifting operation must be directed by only one person (foreman or team leader).

(x) When the lod is applied to the pulley block, none of the turns of the reeved rope should touch to each other and the block should hang truly vertical.

(xi) Check that braking device, load bearing chain and running chain sprocket are in a fit working condition.

(xii) See and confirm that electric trolley mounted hoists have the redable lables as "Up", "Down", "Forward", "Reverse" etc. and pressing the buttons there is a perfect contact of operat on.

(xiii) The teeth on the racks and toothed gears require checking to see that they are all in a fit working condition.

(xiv) Jack screws should be always straight.

(xv) Electrically driven winches have to be reliably fixed in position and their bearing, reduction and other gearings, brake and other vital parts must be in good condition. This is to be frequently checked.

(xvi) Ropes used for lifting must be tied with knots which must not slip off.

(xvii) Sling i.e. hanging ropes must be attached to the electric equipment at the points provided for lifting or they must be passed around the places specified by the manufacturer.

(xviii) Use the eye-bolt provided on the m/c.

(xix) Use lifting lugs provided on the transformer tank for lifting purpose.