CMR INSTITUTE OF TECHNOLOGY	USN	

Internal Assesment Test - II

Sub:	Testing &Commissioning Of Electricla Equipments							Code:	10EE756
Date:	09/11/2017	Duration:	90 mins	Max Marks:	50	Sem:	7	Branch:	EEE

Answer any five full questions

	Note: **Sketch figures wherever necessary.**	Marks	OBE CO	OBE RBT
1(a)	Explain procedure for foundation of rotating machines.	[5]	CO707.1	L1
(b)	State various types enclosure for rotating machines and type of cooling adopted.	[5]	CO707.1	L1
2(a)	List out the Standard Specification of induction motor.	[5]	CO707.1	L1
(b)	Explain about shaft alignment and balancing of rotor in induction motor.	[5]	CO707.1	L1
3	State the abnormal conditions in induction motor and which is the protection provided against each	[10]	CO707.4	L4
4a)	What are the causes of vibration and how it can be minimized	[5]	CO707.1	L1
4b)	Discuss various faults happening in bearings and how it can be rectified.	[5]	CO707.3	L3
5	Explain the procedure for high voltage test setup of induction motor.	[10]	CO707.2	L2
6	What are the different methods of drying out of an induction motor? Explain in Brief.	[10]	CO707.3	L3

7	Explain the procedure of dismantling of a large rotating machine, dispatched in a fully assembled condition.	[10]	CO707 .2	L2
8	Explain briefly about No – Load, Blocked Rotor and Temperature rise test for Induction motor.	[10]	CO707 .2	L2

FOUNDATION OF MACHINES

Q. 864. Explain the procedure of foundation of electric machines. [Ref. Q. 855]

The static load and dynamic load of running machine is transmitted to the ground via the machine foundation.

Three basic requirements of the machine foundation are :

— Horizontal level. — Rigidity. — Freedom from vibrations.

The foundation plan is usually recommended by the manufacturer.

The total installation comprises the following essential features :

— Foundation made of cement-concrete.

— Bed-plate ; — Foundation bolts.

The machine is bolted to the 'Bed-plate.' The bed-plate is fixed on levelled foundation. The foundation bolts are used for securing the bed-plate to the concrete foundation. Rolled I-sections are placed in concrete on which the bed plate rests.

Concrete Foundation

The machine with or without bed-plate should be securely bolted to solid, firm, level foundation. The foundation may be common for motor-generator or motor and the driven machine. Alternatively, a separate foundation may be provided for motor and driven machine. The design of foundation depends on the size and speed of machine.

The qualities of a good foundation are rigidity and freedom from vibration.

The depth of concrete foundation should be enough. For this excavation should be of enough depth. The depth depends on the bearing capacity of the soil.

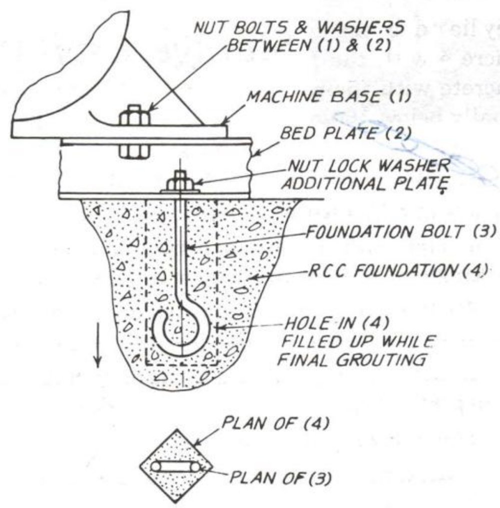

Fig. Q. 864 (*a*). Foundation Bolt Assembly.

Place wooden formers around the edges of the excavation at the floor-level. Also, place I-shaped rolled steel sections in horizontal formation to provide reinforcement to the concrete. This has been described in a subsequent paragraph.

The wooden formers give shape to the concrete plinth of the foundation. The cable ducts or pipe line should be provided by suitable patterns inserted at desired location. Plugs should also be provided for holes for inserting foundation bolts (and their grouting with concrete finally). The plugs should be removed after setting of the concrete.

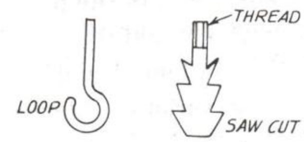

Fig. Q. 864 (*b*). Common Shapes of Foundation Bolts.

The composition of the concrete used for machine foundation is as follows :

Cement : 1 parts ; Broken Stone : 4 parts ; Sharp sand : 2 parts.

The parts should be thoroughly mixed when dry. Water is then added slowly until the mixture is just-sufficiently wet to pass freely in the cavity of the foundation. When the concrete has set, remove the wooden former and plugs and patch off the defects in the concrete foundation. The foundation surface should be levelled. *Allow the concrete to set properly by leaving it for several days.*

Bed-plate

Medium and large rotating machines are installed on bed-plates

— in one piece, or ; sectionalised, or separate for motor/generator.

The bed-plates are secured to the concrete foundation by means of foundation bolts. The machine are bolted to the bed-plate securely. The bed-plates for large machines are fabricated from thick sheet steel or rolled. I-section, large beams. The bed-plate has necessary stiffeners and ribs provided in its structure. The holes are drilled on the top and bottom faces of the bed plate according to the drawing. For bolting the machine and for foundation bolt.

The fabricated bed-plate is generally of rectangular shape (in plan view).

Mounting of Bed-plates for Large Machines

In case of large machines weighing above 20 tons of rolled steel are placed in concrete foundation to provide reinforcement and to distribute the load of the machine uniformly over the concrete foundation. It is preferable to sint the I-sections in the concrete. The number of I-sections depends upon size and load of the machine. Some of these I-sections in the concrete are positioned such that they lie under the heavy load points of the bed-plate. The I-sections may be placed completely in the concrete with the bed-plate surface above the ground level or the I-sections shall be placed in concrete with their upper surface slightly above the ground level. The height of the I-sections is usually below 160 mm for machines above 20 tons.

Pads for Mounting Bed Plate

The *packing plates* are placed on the surface of-section at regular intervals particularly at each side of the foundation bolt. These packing plates are also called *metal pads*. Bed-plates are placed on the surface of these pads. Thus the bed-plates are not directly placed on the I-sections, but on the pads placed on I sections. Metal pads help in uniform distribution of load over the foundation after tightening of the foundation bolts. Sizes of the pads are as follows :

Material	*Height mm*	*Width mm*	*Length*
Steel plate strip	5 to 40	40 to 100	*L*
Steel strip for Adjustment	0.5 to 5	40 to 100	*L*
Cast Iron plates	50 to 100	100	*L*

L = Length of Bed plate + 50 mm.

In case of large machine (> 20 tonnes) the configuration of foundation is as follows.

(*a*) Concrete foundation
(*b*) I-sections placed in *a*.
(*c*) Metal pads placed on *b* at regular intervals.
(*d*) Bed-plate placed on *c*.
(*e*) Bed-plate securely fixed onto the *a* by means of
(*f*) Foundation bolts.

[*For small machines item (b) is deleted*]

Foundation Bolts

The foundation bolts fix-up the bed-plate onto the concrete foundation. The lower portion of foundation-bolts has an eye-shape (book type) or saw-tooth shape to provide grip in the foundation.

The size of foundation bolts are as follows :

Sizes of Hook Type Foundation Bolts*

Machine Size	*Diameter of cross section D, mm*	*Length L, mm*	*L/D*
Small power machine with light duty	20 mm	400 mm	20
Small power machine with heavy duty	25 mm	600 mm	24
Light duty Medium Machine	30 mm	900 mm	30
Heavy Duty Medium Machine	50 mm	2000 mm	40
Large Machine 5, Heavy Duty	75 mm	3000 mm	40

The foundation bolt is inserted in the holes of bed plate with the spring washer and plane packing washer between the nut and the bed-plate flange. The foundation-bolt should be located with the bed-plate hole before lowering the bed-plate.

Use crane and slings for lifting bed plate vertically. Position it such that the foundation bolts come exactly above the corresponding holes in the foundation, and

Make a good "Grouting Mixture" consisting of

Cement	:	1 part
Sharp Sand	:	2 parts.

Make a good mixture of above parts then add water slowly to make *thin* paste. Fill the space around foundation bolts by the cement paste upto the surface level of the foundation. Fill-up the cavities by using suitable rod for ramming the grouting. The *grouting* is then allowed to set hard.

TYPES OF ENCLOSURES AND COOLING

Q. 816. State the various types of enclosures for Rotating Electrical Machines (Generators and Motors) and the types of cooling adopted in them.

The method of cooling is closely related to the construction and the type of enclosure of the machine.

1. *Open-pedestal*, in which the stator and rotor ends are open to the outside ambient air, the rotor being supported on pedestal bearings mounted on the bedplate.

2. *Open-end bracket*, in which the bearings form part of the end-shields which are fixed to the stator housing. The air is in comparatively free contact with the stator and rotor through the openings. This type is common for small and medium size motors and generators.

3. *Protected* or end-cover types with guarded openings : the protection may be by *screen* or by *fine-mesh covers*.

4. *Drip-, Splash- or Hose-proof*, a protected machine with the openings in the end shield for cooling. The end shields are designed to prevent entry of falling water or dirt, or jets of liquid.

5. *Pipe* or *Duct-cooled*, with end-covers closed except for flanged openings for connection to cooling pipes.

6. *Totally-enclosed*, in which the enclosed air has no contact with the ambient air : the machine is almost airtight. Total enclosure may be associated with an internal rotor fan, an external fan, water cooling, or closed-air-circuit cooling, in which the air is circulated to a cooler and returned to the machine.

7. *Weatherproof, or watertight.*

8. *Flame-proof,* or *Explosion-proof* for use in hazardous locations such as mines, chemical factories, stores etc.

It may be noted that the ratings of machines are dependent on their respective cooling systems. For complex cooling systems, the machines may have to be derated.

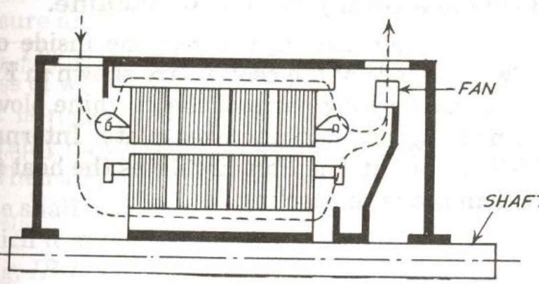

Fig. Q. 817(*a*). Combined axial and radial ventilation.

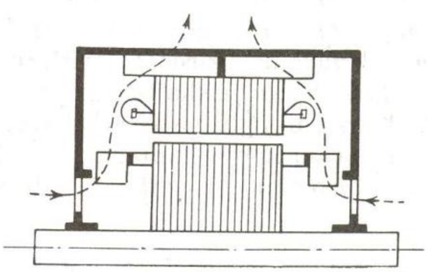

Fig. Q. 817(*b*). Radial ventilation.

...machines having long shafts.

Q. 889. Explain the significance of balancing of rotor. How is the balancing achieved ?

For smooth running without vibrations, the rotor should be mechanically balanced. The rotor here includes complete rotor with slip-rings, couplings, etc.

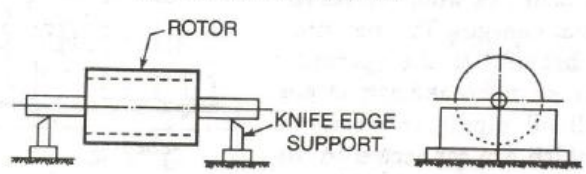

Fig. Q. 889(*a*). Static Balancing of Rotors.

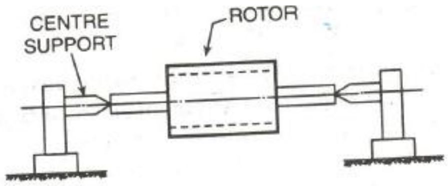

Fig. Q. 889(*b*). Static Balancing of Rotors.

The balancing may be obtained by adding or shifting weights fixed on the rotor for counter-balancing. Or the material from rotor is drilled out from heavy side.

The balancing is of two types.

1. Static balancing. 2. Dynamic balancing.

Static balancing is applied for low speed machines (below 1000 r.p.m.). Dynamic balancing is used for machines above 1000 r.p.m.

Static Balancing

The rotor to be balanced is placed on two knife edges of the balancing rig (Fig. Q. 889(*a*). Alternatively it is held between two centres of lathe.

The centres or the knife edges should be in perfect horizontal plane.

A well balanced rotor will remain standing in any position when turned about the axis in any direction, in any position. It will not oscillate. However, if the rotor is unbalanced, the heavy side will always try to come down and the rotor can not stay in any position. The balancing is achieved by adding weights to portion or drilling out material from heavier portion of the rotor.

Dynamic Balancing

This is carried out by special balancing machines. The rotor is mounted on the axis of the balancing machine and is driven at high speed. If the rotor is unbalanced, it will vibrate at higher speeds. Dynamic balancing machine has bearings supported by springs. If rotor is unbalanced, it will vibrate and transmit vibration to the springs. Supporting the bearing of the balancing machine. To locate an unbalanced portion, one of the bearing is locked and the other is left free to vibrate. Then an indicating needle is gently touched to the rotor and leaves a mark at the point where the vibration is at its heaviest. Now the rotor is rotated in the reverse direction at the same speed, and a second mark is obtained in the same manner. The heavy or unbalanced part of the rotor will lie in between the two marks. To achieve a dynamic balance, a counter-weight is added to the rotor on the opposite side or some metal is removed from in between the two marks.

Next, the second bearing is locked and first is left free to vibrate, and balancing is carried out at the second bearing.

To check the rotor balance the fully assembled machine is placed on a smooth metal surface plate. With proper balance, the machine will not shift on the surface plate, when rotated at normal speed.

...AND THEIR MAINTENANCE

Q. 866. What are permissible tolerances of shaft alignment ?

The radial and axial clearance are measured after alignment. The rotor turned through 0°, 90°, 180°, 270°, and 360° shall not differ by following valves :

0.03 mm for 300 mm dia-coupling 0.5 mm for 500 mm dia-coupling.

Q. 867. Explain the procedure of alignment of shaft of electrical machines.

The shafts of driven and driving machine are aligned by various method. Here, the alignment of flexible couplings has been described. There are three steps in the alignment of the shafts.

1. Axial positioning of the shafts.
2. Paralleling of shaft axis.
3. Centering of shaft axis.

Procedure :

1. Align the motor and the driven machine on bed-plates in their final position with shims under their feet.

2. Mark both half coupling by means of chalk line. Make accurate measurement between the gaps between the faces of the vertical surfaces. Turn the motor shaft through 90°, 180°, 270° and 360° and note the readings of the gap.

3. The excess difference is reduced below 0.05 mm by adjusting the shims.

4. Likewise the difference in the heights of axis of drive coupling and driven coupling is gauged by suitable method. One of the method of gauging the gap between vertical surfaces of couplings and the difference in heights is by using Single Point Turn Point Runover Gauge.

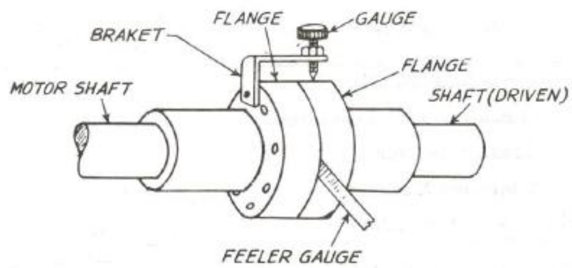

Fig. Q. 867(*a*). Checking shaft alignment.

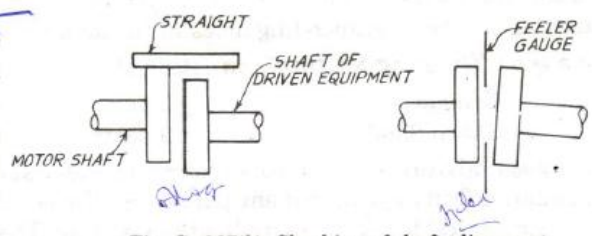

Fig. Q. 867(*b*). Checking of shaft alignment.

PROTECTION OF INDUCTION MOTORS

Q. 1146. State the various abnormal conditions in induction motors and which are the protections provided against each.

Three phase induction motors are very widely used in industry. The abnormal condition can be classified as follows :

(1) *Mechanical overloads*

— sustained overloads.

— stalling.

— prolonged starting or locked rotor.

— excessive harmonics.

(2) *Abnormal supply conditions*

— loss of supply voltage.

— phase sequence reversal of supply voltage.

— overvoltage/undervoltage.

— unbalanced supply voltage.

— under frequency.

(3) *Faults in starting supply / circuit*

— interruptions in phase.

— short circuit in supply cable.

— blowing of fuse/single phasing.

(4) *Internal Faults in Motor Itself* (caused by 1, 2, 3 above)

— phase to phase faults.

— failure of phase (open circuit).

— phase to earth faults.

— mechanical failure.

The abnormal conditions are summarised below :

— *Prolonged overloading.* It is caused by mechanical loading, short time cyclic overloading. Overloading results in temperature rise of winding and deterioration of insulation resulting in winding fault. Hence motor should be provided with overload protection.

— *Single phasing.* One of the supply lines gets disconnected due to rupturing of a fuse or open circuit in one of the three supply connections. In such cases the motor continues to run on a single phase supply. If the motor is loaded to its rated full load, it will draw excessive currents on single phasing. The windings get overheated and damage is caused. The single phasing causes unbalanced load resulting in excessive heating of rotor due to negative sequence component of unbalanced current. Static single phasing relays are becoming very popular.

— *Stalling.* If the motor does not start due to excessive load, it draws heavy current. It should be immediately disconnected from supply.

— *Stator earth faults.* Faults in motor winding are mainly caused by a failure of insulation due to temperature rise.

Abnormal condition	Alternate forms of protections from which choice is made	Remarks
Overloads	— Overload release — Thermal overload relays — Inverse overcurrent relays Miniature circuit-breaker with built-in trip coils for LV motors	— Overload protection given for almost all motors — Should not trip during starting current
Phase faults and earth faults	— HRC fuses — High-set instantaneous over-current relays — Different protection	— Differential protection becomes economical for motors about 1200 h.p. Below this high set instantaneous protection is preferred
Under voltage	— Under voltage release — Under voltage relays	— Under voltage release incorporated with every starter — Under voltage relay used in certain applications
Unbalanced voltage	— Negative phase sequence relays	— Only in special applications — Generally at supply point
Reverse phase sequence	— Phase reversal Protection	— Prevents reversal of running.
Single phasing	— Usual thermal overload relays — Special single phase preventer	— Unbalance protection
Excessive harmonics in supply voltage	— AC harmonic filters connected near motor terminals	— Specific harmonic filter plus high pass filter.
Stalling	— Thermal relays — Instantaneous O.C. Relays	— Instantaneous — Trip
Rotor faults	— Instantaneous over-current relays	— Only for wound rotor motors
Switching surges	— RC surge modifiers — ZnO arresters near motor terminals.	— 100 ohm, 0.1 μF connected between phase and ground.

Q. 909. State the various troubles with bearings and their remedies.

Table Q. 909. Troubles with Bearings and Remedies

		Trouble and Possible Cause	*Remedy*
1.		**Overheated Bearing**	
	1.1.	Inadequate Lubrication	Change to proper grease or oil. Adjust oil-cup height, maintain oil level at centre of lowest ball or roller. Fill grease housing $\frac{1}{2}$ to $\frac{2}{3}$ full. Clean oil holes, filters, and vents. Use a fresh lubricant.
	1.2.	Excessive lubricant churning	Use lower-viscosity oil, lower oil level to centre of bottom ball or roller, full grease housing only half full, use oil mist.
	1.3.	Inadequate internal clearance	Use bearing of greater looseness, allow for differential thermal expansion, reduce interference of shaft and housing fits, correct any housing out of roundness or warping.
	1.4.	High seal friction	Stretch felt or use reduced spring tension with leather or composition seals, lubricate seals, switch from rubbing seal to lowclearance shield.
	1.5.	Excessive preloading	Use gaskets or shims to relieve axial preload with opposed pair or with two held bearings on a shaft subjected to thermal expansion. Change design to use only one held bearing.
	1.6.	Spinning outer ring	Use closer housing fit, use steel insert in soft aluminium housing, use greater spring or rubber holding ring.
	1.7.	Misalignment	Correct alignment by shimming pillow blocks, housings, or machines to get shafts and bearings in line. Check for misalignment of bearing seats and shaft and housing shoulders.
2.		**Noisy Bearings, Vibration**	
	2.1.	Wrong type of grease or oil.	Check the lubricant supplier. A higher-viscosity oil or a better-feeding grease with a higher-viscosity oil may help.
	2.2.	Insufficient lubrication	
	2.3.	Defective bearing	Check for brinelling, fatigue, wear, groove wobble, poor cage. Replace bearing.
	2.4.	Dirt.	Clean bearing housing, replace worm seals, improve seal arrangement, eliminate source of dirt.
	2.5.	Corrosion	Improve sealing at keep out corrosive elements use corrosion-resisting lubricant.
	2.6.	Too great internal clearance	Change to bearing with smaller clearance.
	2.7.	Unbalance	Balance rotor.
	2.8.	Misalignment	Align (See 1.7)
	2.9.	Too loose shaft or housing fit.	Build up shaft or bore with chrome plate or metallize or regrind.
	2.10.	Improper mounting	Correct dirty or off-square shaft and housing shoulders and seats. Avoid brinelling caused by pounding or bearing.
	2.11.	False brinelling	Use vibration mounts for machine to isolate from platform during idle periods.
	2.12.	Seal rub.	Check for metal bearing seal or shield rubbing on shaft, shaft shoulder, or housing.
3.		**Loss of Lubricant**	
	3.1.	Oil leakage through seal.	Adjust oil level to centre of lowest ball or roller, replace seal, use double-seal arrangement with drain between, eliminate any unfavourable air flow by proper baffles and balancing channels.
	3.2.	Leakage at housing split	Use thin layer of gasket cement, replace housing.
	3.3.	Grease leakage	Pack housing only $\frac{1}{2}$ to $\frac{2}{3}$ full, use channelling type grease, eliminate any pressure causing air flow through bearing-keep solvents or water from entering and softening greases use new improved seals.
	3.4.	Dry grease, caked residue	Use silicon or other high temperature grease, use oxidation-inhibited oil or grease, or synthetic oil/grease.

HIGH VOLTAGE TEST ON MACHINES

Q. 914. Explain the procedure of high voltage tests on rotating machine.

The tests circuit are conducting a.c. high voltage tests is illustrated in Fig. Q. 914. This test is conducted to check the insulation of windings. The test voltage is of power frequency (50 Hz) and sine waveform. The test voltages for commissioning test is only 75% of the routine test voltage.

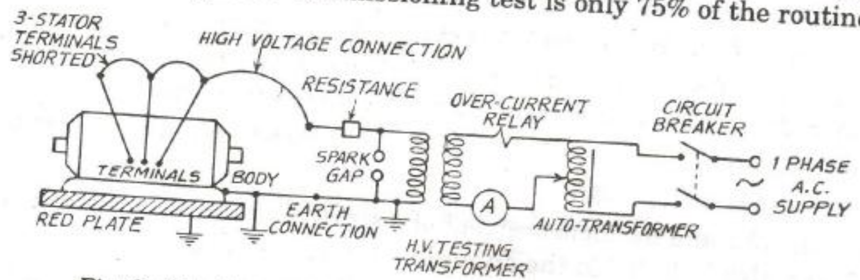

Fig. Q. 914. Circuit for H.V. Power Frequency voltage withstand Test on Stator Windings of 3 phase AC Machines.

$V_{test} \simeq [2\ V_{rated} + 1]$ kV for Routine Test.

$V_{site} \simeq [0.75\ V_{test}]$ for site tests.

The value of Maximum Test Voltage for site tests given by the expressions

$$V_{a.c.} = 75\%\ [2 \times \text{Rated Voltage} + 1000] \text{ Volts}$$

$$V_{a.c.} = 1.5 \text{ Rated Line-to-line voltage.}$$

The connections are shown in the Fig. The three terminals of the motor are connected together to the high voltage terminal of test supply. The body is earthed and is connected to the earth inal of single phase test-supply.

n high voltage a.c. tests, the test voltage is raised quickly to the maximum test voltage. It is at that value for 1 minute and then reduced slowly to zero. The circuit is discharged by ecting it to ground. *The test is conducted on 'go/not go' basis.* If breakdown occurs, the test y is automatically tripped. If the machine fails in the test, it cannot be commissioned without ication.

. 915. State the preferred test voltage for High voltage p.f. test on Rotating Machine) Routine Factory Test ; (b) Site Tests.

ated voltage of Machine U	*A.C. Test Voltages*	
	Routine Test 1 min, 50 Hz	*Site Test 1 min, 50 Hz*
≤ 50 V	500 V	375 V
50-250 V	1000 V	750 V
400 V	2000 V	1500 V
1000 V	3000 V	2250 V
2.2 kV	5.4 kV	4 kV
3.3 kV	7.6 kV	5.75 kV
6.6 kV	14.2 kV	10.5 kV
1.1 kV	23 kV	17.5 kV

1. Refer Relevant Standards.
2. Refer Manufacturer's Instructions.
3. Routine Test Voltage = $(2U + 1)$ kV.
4. Site Test Voltage = 75% $(2U + 1)$ kV.

15.1. State how the continuity of the windings is checked

continuity of a wi

Q. 871. State the various steps in the Drying-out of a Motor or a Generator.

Steps in Drying-out

1. Preliminary preparation of the machine, source of heat, measurements etc.
2. Arrange the set-up.
3. Apply heat by one of the suitable means gradually.
4. Take periodic readings of

— Clock-time — Temperatures of windings, body and air, ambient

— Insulation Resistance values of Megger Reading after 15 sec., 60 sec. and 10 min.

— Winding Resistance (At the beginning and at the end) and during decreasing temperatures.

Note. Megger (Insulation Resistance Tests) is used for measuring the Insulation Resistance between windings, winding and earth. Temperature Measurement is by thermometer or thermocouples or self resistance method.

5. Maintain steady temperature of specified values (winding Temperature not to exceed 60°C or 70°C depending upon insulation class). Measure periodically of the Insulation Resistance values.

6. *Initially, during the first few hours (for medium motors), the values of Insulation Resistance* **reduces** even though the heat is being applied **for Drying-out. Why ?**

During initial heating period, the moisture trapped in the insulation in form of small globles gets released *within* the insulation. Hence the insulation resistance value starts reducing.

7. **Intermediate Stage.** After a span of a few hours (for a medium sized machine having good condition) or a few days (large machine or a wet machine) the insulation resistance *reaches a steady value*. This indicates that the moisture has spread all over the insulation.

The input power is reduced to reduce the temperature rise.

8. **Rising Stage.** *After a few hours of steady value, the insulation resistance* **starts rising.**

This indicates that the moisture has vaporised and is being expelled (released) from the winding. The input power is reduced further.

9. *The drying-out process is stopped when the desired value of Insulation resistance (hot) and Polarisation Index is reached. In case of large machine both the insulation Resistance and the Polarisation Index are equally important.*

The input power is switched-off.

10. The winding resistances are measured for various temperatures as the temperatures start falling.

Q. 881. Explain the procedure of drying out an electrical machine by using drying chamber and resistor heaters.

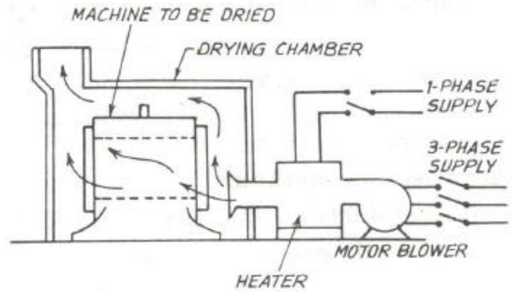

Fig. Q. 881. Drying by hot air.

The machine to be dried is placed in a drying chamber. The drying chamber should be of volume about 4 times the volume of the machine. The air in the chamber is heated by means of resistor heaters. The air is circulated by means of fans and air circulation system. The air temperature is periodically measured by means of thermometers.

The moisture expelled from the machine letout of the drying chamber with outlet air.

Q. 882. Explain the drying out of a motor by radiating lamps. (Infrared Lamps).

This is a most convenient and simple method used for medium and small motors. The infrared lamps are used. The lamps are located in the chamber opposite to the motor winding. (The rotor is removed). This method is applicable to dismantled motor for drying the stator winding and rotor winding separately.

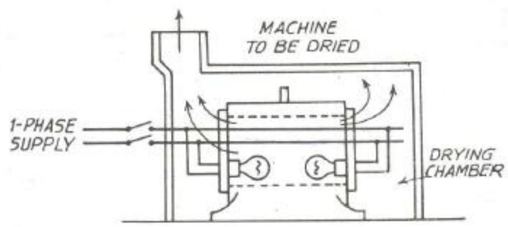

Fig. Q. 882. Drying by radiating lamps.

Q. 883. Explain the procedure of drying electrical machines by circulating short-circuit currents.

This is most convenient method of drying any electrical machine such as generator, slip-ring motor, synchronous motor, d.c. motor, field windings etc.

The machine is connected to low voltage source.

The input voltage, current, power, the temperature of winding, temperature of body, temperature of air are periodically measured. The end shields of the machine are removed. The machine body is covered with trapaulin. No cool air blow shall come over hot winding.

The increase in temperature should be very gradual. The cooling down also be gradual.

Connections for Synchronous machine for drying

There are three alternatives as shown in Fig. Q. 882.

Method 1. D.C. source, stator windings in series with field winding.

The current is adjusted to about 50% of rated field current.

The d.c. current should never be switched off as this would give over voltage and failure insulation. The current should be reduced by means of rheostat.

Method 2. *D.C. source, current through rotor only.*

The current is adjusted to about 50% of rotor rated current. Stator winding gets heat from tl rotor. There should not be switching off rotor current. Rheostat should be used to reduc rotor-current switching off of rotor current gives high over voltage.

Method 3. Single phase a.c. source, current through stator windings connected in series.

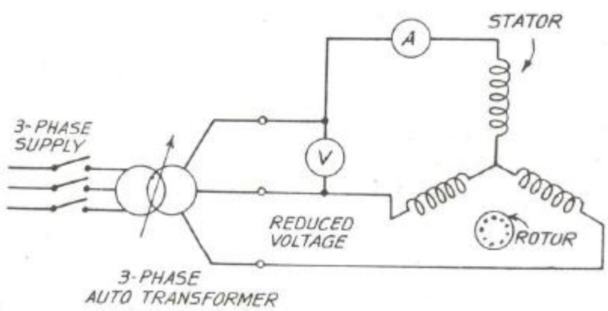

Fig. Q. 883(*a*).

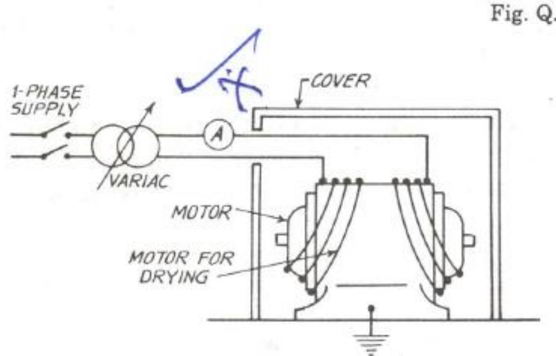

Fig. Q. 883(*b*).

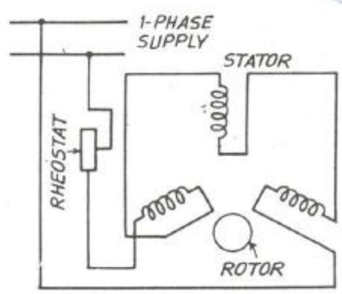

Fig. Q. 883(*c*).

Q. 860. Explain the procedure of dismantling of a large rotating machine despatched in fully assembled condition. What are the checks after dismantling ?

Dismantling and reassembly of electrical machines delivered in an assembled condition should be carried out in accordance with the manufacturer's instructions. For example, to fully dismantle a large synchronous motor the following steps are recommended by a manufacturer :

1. Check all the parts and assemblies for identification marking intended to correctly reassemble the machine ;

2. Disconnect oil pipes at the bearing split joints ;

3. Wrap the slip rings in pressboard to prevent damage and remove the brushes and brush holders ;

4. Take the brush rocker off the bed plate ;

5. Separate the split joints in sequence and remove the end shield with packings and the baffle plates.

6. Remove the side cover plates arranged at the feet and the lifting bolts.

7. Separate the stator from the bed plate ;

8. Fit a pressboard spacer, 4 or 5 mm thick, in the air gap between the stator and rotor, so as to fully cover the stator ;

9. Remove the bearing caps and the upper halves of the bearing shells ;

10. Move the rotor up through 6 to 7 (for the arrangement intended to lift the rotor to a small height).

11. Fit additional pressboard spacers in the air gaps at the stator bottom. The spacers shall be as long as the stator and thick enough to prevent the rotor shaft from touching the bearing shells as the rotor is moved down ;

12. Push the lower halves of the bearing shells along the shaft journals, sets them in the upper position, pull the oil slingers and remove the halves of the bearing shells from the journals ;

13. Fit additional pressboard spacers, 5 or 6 mm thick and as long as the stator, in the air gap at the top of the stator ;

14. Pull the rotor out of the stator.

When only a partial dismantling is required, the following operations are recommended :

1. Disconnect all the split joints one after the other and remove the end shields with gaskets and the baffle plates.

2. Remove the side cover plates of the stator mounted at feet and separate the stator from the bed plate.

3. Mount four stator lifting arrangements (rollers) in the openings of the feet.

4. Mount two stator pulling and lifting arrangements on the bed plate and secure them thereon.

5. Lift the stator by means of the rollers and take out the pads and shims placed between the stator feet and the bed plate.

6. Shift the stator by means of suitable arrangements taking care that its seizure against the rotor be prevented.

7. Release the puller bolts on the rollers and move the stator down onto the bed plate having placed pads and shims under its feet if necessary.

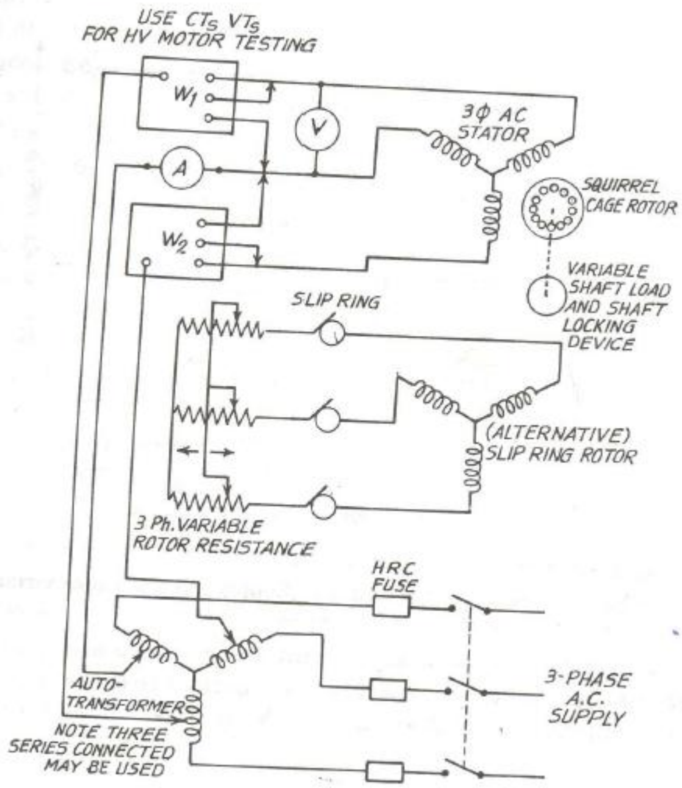

Fig. 1183(*b*). Circuit for Testing 3-phase Induction motors.

where V = Voltmeter reading, phase to phase volts, DC, two phases in series.

A = Ammeter reading, Amps.

... to reach rated speed and the current are noted. ... rated voltage.

Q. 1185. Explain the no-load test on 3-phase induction motors. What data such a test provide ?

No load test. This is a type test and a routine test. This test give the following :

— Core loss. — Friction and winding losses.

— Magnetizing current. — No-load power factor.

No-load test reveals the mechanical out-of-balance and faulty connections.

The stator windings are connected to a supply of *rated voltage and rated frequency*. The voltage, current, power and slip are measured. After starting, the rotor (of the slip ring-type) is short-circuited (as for normal operation). Power and current are noted at 1.0 p.u., 0.9 p.u. and 1.2 p.u. of normal voltage and the test is repeated at lower voltage to the value at which the stator current begins to rise. *At normal voltage the no load current* I_0 *is between 0.2 and 0.5 p.u. of full-load current and the power factor is low* as the reactive (magnetizing) component predominates.

With reduction of voltage, the flux reduces in proportion and the power curve is approximately parabolic, power factor rises as the active current component increases to satisfy the mechanical

Q. 1186. Explain the locked-rotor test on a 3-phase induction motor. What data does such a test provide ?

Locked-rotor (Short Circuit) Test. This is a type test. The rotor (short-circuited), is held stationary by clamps. The stator is supplied at a *Low Voltage* of normal frequency. The applied stator voltage is raised gradually in steps. *Readings of : (1) voltage (2) current and (3) power are taken till the current reaches about twice full load current.* The temperature must be noted for each

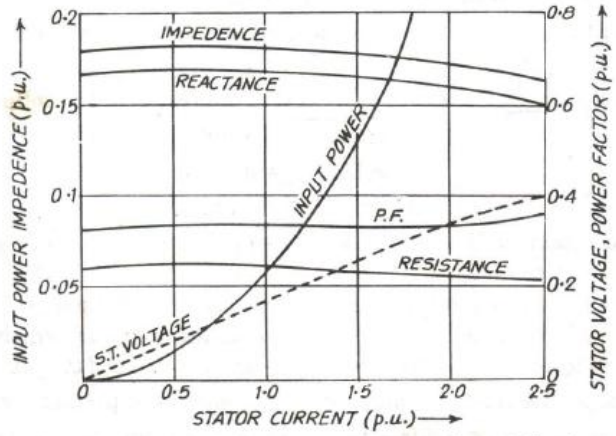

Fig. Q. 1186. Result on locked rotor test on a 3-phase induction motor rotor is held in fixed position, reduced voltage is applied to the stator.

reading so that the conditions can be normalized. Typical results are shown in Fig. Q. 1186. The power curve is nearly a parabola, as the power input is equal to I^2R loss for, say 0.2 p.u. voltage, the flux density is about one-tenth of its normal value and the core loss is very small. The leakage impedance is reduces with higher current as a result of saturation. *Locked rotor test gives copper loss for particular stator currents. Iron losses are negligible.*

Q. 1159. State the important specifications to be considered for selecting three-phase duction motors.

Three-phase induction motors are used in various industrial and agricultural applications. ıtisfactory operation of the complete system depends on the correct selection of right type of motor r a given application becomes important now-a-days. Wrongly selected motor may cause eakdown of the system.

An important step in selection of an induction motor for a given application is preparation of ecifications considering all affecting parameters. Design of a motor is based on following ecifications :

— Output rating — Type of mounting

— Rated voltage and frequency and permitted variation

— Class of insulation and ambient temperature

— Type of construction and bearing arrangements

— Type of enclosure and cooling system — Method of starting and drive details

— Performance requirements in regard to efficiency and other parameters

— Type of enclosure, IP grade — Other special requirements.

Q. 1160. Explain the significance of output rating.

Output rating of a motor should be selected so that the motor does not get overloaded during s operation under various loading conditions.

According to the Indian Standards the motors are to be designed for continuous operation at ıted load. Sustained overloads are not permitted.

There is general practice to keep about 10% margin in motor output rating over that of the iven equipment. Unduly under rated motors have high initial cost and also high running cost as otors run inefficiently at low loads.

For cyclic loading conditions, IS 325-1978 specifies different duty cycles (S1 to S8) for selecting ıuivalent output rating of a motor.

Q. 1161. State the significance of rated voltage and rated frequency of induction otors. What should be the rated voltage for 100 kW, 200 kW and 1000 kW induction otors ?

Rated Voltage and Frequency. Rated voltage should correspond to rated voltage of supply stem. As per IS 325-1978 preferred voltages are 415 V, 3.3 kV, 6.6 kV and 11.0 kV. IS 325- 1978 commends minimum kW rating of motor for given system voltage. (See Table on p. 964)

Rated voltage (U_n) kW	Minimum rated output kW
2.0<U≤3.3	100
3.3<U≤6.6	200
6.6<U≤10.0	1000

Voltage and Frequency Variation. IS 325-1978 specifies voltage variation of ± 6% and frequency variation of ± 3% while CBIP-140 (Central Board of Irrigation of Power) specifies voltage variation of ± 10% and frequency variation of ± 5%. The voltage and frequency variations affect the performance of the motor.

The effect of voltage and frequency on the performance of the motors has been described in the table given below :

Motors can be designed for to wide voltage variations depending upon requirements.

Effect of Voltage and Frequency variation on performance of Induction Motors

	Synchronous speed N_s	*Starting torque T_s*	*Starting current I_s*	*% slip*	*Full load speed N*	*Full load current I_f*	*Full load eff. n*	*Full load p.f.*	*Temp. rise. °C*
110% voltage	No change	+ 21%	+ 10%	– 17%	+ 1%	– 7%	+ 1%	– 3%	– 3
90% voltage	No change	– 19%	– 10%	+ 23%	– 1%	+ 11%	– 2% point	+ 1 point	+6
105% freque	+5%	– 10%	– 5%	No change	+ 5%	– slight	+ slight	+ slight	– slight
95% freque	–5%	+ 11%	+ 5%	No change	– 5%	+ slight	– slight	– slight	+ slight